A CONFLUENCE OF TRADITIONS: 
EXAMINING TEACHER PRACTICE IN 
THE MERGING OF SECONDARY SCIENCE AND ENVIRONMENTAL EDUCATION

by

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Abstract

Embedding environmental education within secondary science curriculum presents both philosophical and practical difficulties for teachers. This ethnographic/narrative study, with its methodology grounded in eco-feminism and realism/constructivism, examines the work of six secondary science teachers as they engage in an action research project focused on merging environmental education in their science lessons. Over the course of several months the teachers examine and discuss their views and their professional development related to the project. In the place of definitive conclusions, eight propositions relating the work of secondary science teachers to environmental education, form the basis for a discussion of the implications of the study. The implications are particularly relevant to secondary schools in Ontario, Canada, where the embedding of environmental education in science studies has been mandated.
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Dedication

This thesis is dedicated to Lischa Tippe, my Oma.

My earliest memories of my Oma are of being outside with her in nature, a combination of farm fields, vegetable and flower gardens, secret pathways through the forest and animals both domestic and wild. She would take me for walks in the woods, spying rabbits and deer, naming trees and flowers and birds. It would, however, be inaccurate to paint this as an idyll, or romanticize my early years as living as a child of nature in a utopian world. A survivor of WWII and an immigrant to Canada, my Oma had a pragmatic approach to the cultivation of her garden vegetables and livestock, recognizing in them her ability to feed and sustain her family. I helped muck out the cow barns, collected eggs, watched calvings and was well aware of how a chicken made it to the Sunday dinner table. For my Oma recycling and reusing were second nature; she used her compost and manure for the flowers and vegetable gardens. She was thrifty, she was mindful and she was grounded. She taught me how to nurture the plants and animals in my care, to feel a sense of loss in the presence of death, a sense of wonder in the presence of nature, and genuine pride in producing food for the table. Now as an adult working and playing in outdoor settings I realize that as I continue to define my understanding of *nature* and *environment* and my relationship to them, those early years with my Oma laid the foundation of an ethic of caring and mindfulness, for which I am deeply grateful.
Chapter One

Introduction

Many years ago I stood on a high vantage point above the confluence of two mighty rivers, the Colorado and the Green, in the Canyonlands of Utah. I marvelled at how the brown, silty waters of one river met and mingled with the dark, clear waters of the other. Eventually further downstream the two rivers merged into one, melding their distinct qualities and strengths, and while neither was the same as it had been, the waters that flowed on from the juncture were more magnificent than before. It was that image that came to mind as I began work on the research project described in this dissertation which explores the confluence of two important rivers in learning: science education and environmental education.

When I first began the journey of doctoral studies I wanted to understand why teachers, who as individuals, enjoy the outdoors and gain significant personal satisfaction from outdoor pursuits do not use the outdoors as a classroom, particularly here in northern Ontario where nature permeates our lives. I had spent a large part of my career with students in nature, as natural interpreter, wilderness activities instructor, teacher in a remote, northern reserve and as a high school science teacher known for out-of-classroom forays. My time at the Ontario Institute for Studies in Education at the University of Toronto, along with the release by the Government of Ontario, of the report titled Shaping Our School, Shaping Our Future: Environmental Education in Ontario School (2007) (also referred to as The Bondar Report) has broadened and reshaped that question such that my research intentions have been nudged toward the complex intersection between secondary science teacher development and environmental education.
Traditionally, secondary science education, consisting of the three disciplines of biology, chemistry and physics, has been well-defined with curricula distilled after years of classroom delivery. Moreover, the three disciplines named above have been generally considered socially and politically neutral; purely objective; rational; and value free (Hodson, 2003). Environmental education (EE), on the other hand, a fringe topic usually attached to either the science or geography curriculum (Greunewald, 2004) most often addresses current environmental dilemmas such as global warming, loss of bio-diversity, depletion of global food resources, and global water issues. Environmental issues are considered politically and socially messy (Greunewald, 2005), not at all like the clean and ordered content of current secondary science classes (Chapman, 2007). Yet many scholars (Greunewald, 2004; Hart, 2007; Hodson, 2003; Jickling, 2001; Stephenson, 2007a) have been calling for a formal inclusion of EE within existing school science curricula specifically to address students’ weak ecological literacy skills (Orr, 1992), and to introduce a more authentic, relevant and action-based curriculum (Bencze & Hodson, 1999; Jensen & Schnack, 2006; Smyth, 2006) in an effort to forestall looming environmental disaster.

Based on my experience in both the secondary and elementary panel, it is my belief that teachers at the secondary level, teaching specific curricula within well-defined disciplines, generally have far less experience than their elementary counterparts with the processes of curriculum integration. Thus an integrated, interdisciplinary approach to environmental education within existing secondary science curriculum (as suggested by the literature cited above and by The Bondar Report [2007] in Ontario) is very likely at odds with how things have always been done in secondary science classrooms. The inclusion of technological, social and
environmental elements in a secondary science curriculum presents new and unique problems for teachers and students (Hart, 2003; Smyth, 2006). Thus the journey undertaken by this dissertation takes the reader to a juncture of two significant traditions of education: the formalized study of secondary science and the largely informal and more recent study of environmental education. The merging of those traditions provides a closer look at two issues that lie at the centre of the confluence: the first concerns the impact of EE on secondary science teachers’ praxis and the second issue explores the philosophical position of EE in relation to science education.

The theoretical framework that underpins this research project relies heavily on an eco-feminist perspective wherein the treatment of environment is likened to the domination of the Feminine and the Other, as is theorized in the feminist tradition (Russell & Bell, 1996; Shiva, 1997). As a philosophy underlying a qualitative research methodology eco-feminism is predicated on a holistic, rather than a reductionist perspective and calls for a recognition of the interconnection and interweaving of human agency with environment (Riley-Taylor, 2002), as well as the removal of hierarchical social structures such that all voices are heard equally (Bennett, 2005). Furthermore, the epistemological foundation for the discussions addressing the work of secondary science teachers is grounded, in this project, on a realist/constructivist paradigm that encompasses elements of realism (knowledge based on facts that have absolute existence) and constructivism (knowledge built upon experience).

The project research takes the form of an ethnographic / narrative inquiry which focuses on a group of secondary science teachers who undertake an action research project that specifically addresses the inclusion of EE in secondary science curriculum. Action research (AR)
is a particularly apt research method for this study because it acknowledges the agency of educators to question the assumptions inherent in their practice and to effect changes therein (Goldblatt & Smith, 2005; Stevenson, 2004). The researcher acted also as the facilitator of the AR group, which poses concerns related to the power structures in the group and the direction of the research (Pedretti, 1996). Those concerns are discussed more fully in subsequent chapters. In addition to its value as an investigative tool, AR is explored as a method for professional development.

The data collected from the research, in the form of transcripts of group meetings and interviews, as well as classroom visits, student work and participants’ writings, provides raw material for subsequent analysis for recurring ideas and themes. A significant stumbling block occurred at the outset of data analysis, whereby, rather than letting the data speak for itself, my review of literature had established a number of expected topics that might emerge from the data and that initially obscured unexpected topics. As a means of identifying and managing a biased data analysis, two categories titled \textit{a priori} and \textit{a posteriori} are employed to identify topics. The caution of the generalizability of qualitative data gives rise to a number of propositions or opinions rather than definitive conclusions, and the propositions in turn, suggest implications for teachers of secondary science who seek to include EE in their programs.

The elements described in the preceding paragraphs provide the point of departure for the following questions that navigated the waters of the research project.

- What theoretical foundations, epistemologies and values underlie secondary science teacher praxis?
- How do secondary science teachers perceive EE? How do they understand it?
• In what ways will EE challenge the classroom practice of secondary science teachers?
• In what ways is action research a suitable medium for secondary science teachers to accomplish the integration of environmental education into their praxis?

This dissertation describing the research project outlined above is organized in the following manner. Following the Introduction, chapter two, titled Review of the Literature Addressing Science Education and Environmental Education, examines in detail the scholarly works that have addressed both of the topics named in the title. Specifically, the disconnect between science curriculum theory and the reality of the classroom is discussed, as well as the problematic nature of environmental education. The last portion of the chapter attends to the contradictions between science and environmental education thereby setting the stage for the four research questions that are the focus of the dissertation.

Chapter three, titled Theoretical Perspectives, considers the philosophical foundations of the research, examining in detail the theories of eco-feminism and deep ecology in order to define a working methodology to frame the work of the teachers as well as that of the researcher/facilitator. The chapter further debates the epistemologies of realism and constructivism as a basis for understanding the knowledge construction of the participants.

The fourth chapter, titled Action Research, comprises a brief history and a more thorough description of the action research model. In addition, the chapter examines some of the criticisms levelled against AR, as well as the use of action research in environmental education, and the problems associated with the researcher who also acts as the facilitator. The chapter goes on to describe methods of data collection in action research and ends with a discussion of the limits of the data in terms of generalizability.
Chapter five, titled *Narrative and Case*, examines the use of story in qualitative research. Distinctions are made between story, narrative, vignette and case studies, with attention given to the generalizability of case studies and their use in teacher development work.

The sixth chapter, titled *Project Overview*, describes in detail the location, the participants, and the phases of the project. The phases are comprised of: (a) the details of the preparation for the project; (b) the collection of data in the forms of transcripts of meetings and interviews, notes on the work of the teachers, student work, and the writings of the teachers themselves, and; (c) the exploration and analysis of the data.

Chapter seven begins the exploration of data with a consideration of the difference between a priori and a posteriori topics and their emergence from the data. Titled *Data Exploration: A Priori Topics*, the chapter is an analysis of the data focusing on the following topics: (a) the issues facing the research / facilitator; (b) the issues of science pedagogy, such as the teachers’ understanding of the nature of science; (c) the importance of content in science curriculum, and; (d) sources of tension in science pedagogy. The chapter next examines the issues of environmental education both in its interpretation by the teachers, and their understanding of how it can be embedded in science curriculum. Further, the chapter addresses issues of action research that are encountered and lastly the power of story in the data is considered.

Chapter eight, titled *Data Analysis: A Posteriori Topics*, begins with a restatement of the argument for the use of a priori and a posteriori as data organizers. Schwab’s four commonplaces (teachers, subject matter, milieu and learners) are used to systematize the data analysis. The contribution of each of the teachers is examined; thereafter attention is given to the use of
textbooks and other documents, the milieu within which teachers work, and the situation of the learners.

The ninth and last chapter of the dissertation is titled *Propositions and Implications* and therein are found eight propositions or tentative assertions regarding the work of secondary science teachers as they strive to bring together science education and environmental education. The eight propositions suggest a number of implications for the repositioning of environmental education in relation to secondary science studies and the use of action research as a teacher professional development tool.

Scholarly works and other resources materials used in the writing of this dissertation are listed in the References section. An extensive Appendices section includes sample letters to education administrators, information and consent forms, a chronology of the data collection, the interview protocols, the activities and readings used during the group meetings, a sample of a group meeting transcript, the ethics review protocol required by the University of Toronto, and lastly, narratives provided by two project participants.

Thus ends the introduction to this dissertation. From this preliminary vantage point one can begin the task of developing both a deeper insight of the complexities and a broader understanding of the sweeping relationships that meet at the confluence of two important traditions in education: science and environment.
Chapter Two
Review of the Literature Addressing Science Education and Environmental Education

Over the last three decades environmental education has been formally analyzed and studied by scholars and practitioners (an assertion based on the bulk of scholarly literature on that topic), while science education has been a topic for research and debate for many more decades. This chapter examines in more detail the literature that addresses both of these topics: science education is viewed in terms of its policy foundations and through the enactment of those policies in classrooms, and environmental education is defined and discussed with particular attention given to its apparent shortcomings. The integration of the two is discussed with a view to their divergent natures, and finally a number of questions stemming from the review of literature are posed as the basis for the research described in this dissertation.

Science Education: Foundations in Policy

At the national level, the language generated by education policy-makers addressing the purpose of teaching science in schools comprises a positive and idealistic over-arching statement focusing on the development of scientific literacy. For example, the Council of Ministers of Education in Canada (1997) stated:

…scientific literacy is an evolving combination of the science-related attitudes, skill, 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. (p. 4)

A decade later, as the language of scientific literacy continued to enter and influence science curriculum development nationally, provincial science teachers and subject organizations in
Ontario strove to develop a working definition of scientific literacy which would more directly impact provincial curriculum development. In a 2006 position paper on the nature of science, the Science Coordinators’ and Consultants’ Association of Ontario and the Science Teachers’ Association of Ontario proffered a definition for scientific literacy (found in the Ministry of Education of Ontario document, *Science, The Ontario Curriculum Grade 9-10, revised* [2008]) which combines the need for technological acumen with critical thinking and decision-making skills, using a tone that has become increasingly pressing:

> A scientifically and technologically literate person is one who can read and understand common media reports about science and technology, critically evaluate the information presented, and confidently engage in discussion and decision-making activities regarding issues that involve science and technology. (p. 3)

The above named provincial policy document describing secondary science curriculum in Ontario reflects and further develops the position of the associations cited in the previous paragraph; it opens with a discussion of the importance of an integrated approach to science, technology, society and environment in developing scientific literacy:

> Science, technology, society and the environment (STSE) – call for students to deal with the impacts of science on society, and this requirement brings in issues that relate to human values. Science can therefore not be viewed as merely a matter of “facts”; rather, it is a subject in which students learn to weigh the complex combinations of fact and value that developments in science and technology have given rise to in modern society.
The secondary curriculum in science in Grades 9 to 12 builds on three basic goals ...that reflect the essential triad of knowledge, skills, and the ability to relate science to technology, society and the environment (STSE). ...Science is approached in all courses not only as an intellectual pursuit but also as an activity-based enterprise operating within a social context. (Ministry of Education, 1999, p. 4)

That is to say that science, as it should be taught in Ontario secondary schools, would not only lay a solid foundation of content knowledge but also reach beyond content to assist students in making sense of the complexity of modern society. The rhetoric is appealing and certainly presents lofty goals for educators.

During the writing of this dissertation the Ministry of Education of Ontario released a revised Science Curriculum for Grade 9 and 10 in which an even greater emphasis is placed on a contextual treatment of science based on the Science, Technology, Society, Environment (STSE) model, therefore it is worthwhile looking more closely at STSE and its implications for science education. STSE, as described by Aikenhead in 1988, was initially a step in science education reform to move beyond lectures, rote memory work and recipe driven lab work, towards a more interactive form of science learning that would include group work and discussion. It was seen as an approach that placed science learning within the context of the real world without diminishing traditional content and skills, in order that students would gain a deeper understanding from their science studies. Alsop and Pedretti (2001) suggest that STS (science, technology and society, the forerunner of STSE) has its roots in such movements as scientific literacy or responsible citizenship however, there is no single definition for this approach in
teaching science. They further posit that STS is a multi-disciplinary perspective that critiques and explores the associations among science, technology and society through lenses that include history, politics, economics and ethics.

STSE, as it is currently positioned, is advocated as a means of achieving scientific and technological literacy. As described by Pedretti, Bencze, Hewitt, Romkey, and Jivraj (2008) STSE is based on a post-positivist perspective and is seen as a means for the transformation of social attitudes and actions by infusing within science curricula elements of socio-political action, decision-making, interdisciplinarity, uncertainty, multiple solutions and ethics. In this form of science education, as explained by Barrett and Pedretti (2006), the teacher models the role of a learner and becomes a facilitator and guide for students as they tackle relevant science issues to which there may be not simple answers. However, Barrett and Pedretti further offer a fly in the ointment: while STSE as critical education is potentially a vehicle for student/social transformation and/or reconstruction, STSE can nevertheless be a method for maintaining the status quo, “...left unexamined, (STSE) education will reproduce the society in which it exists, complete with inequities and power structure, just or unjust” (Barrett & Pedretti, 2006, p. 241). As these authors suggest, if the critique of science and its issues is merely intellectual, then students are being given tools for thinking, but not tools for action, thus enabling students to conform to society rather than disrupt its hegemonic elements.

*Science Class: The Reality*

In my experience the reality of many secondary science classes does not mirror the visions of academia or of policy makers. For example, the revised Ontario Ministry of Education documents describing secondary science curricula place a strong emphasis on STSE
and teaching/learning about the nature of science, but they also continue to include significant amounts of content material, creating what I have come to believe is a slippery slope for many science teachers: teaching content knowledge is seductive because it is a simple transmission of information that upholds the status quo of traditional science education. Barrett and Pedretti (2006) agree, maintaining that historically science teachers have taught whatever content has been set down by curriculum writers without critiquing the goals or visions that a curriculum might be based on, thereby maintaining a traditional version of science in the secondary classroom. Gough (2002) describes similar conditions in Australia’s education system where science educators concentrate on covering content knowledge.

There is no reason or evidence to support the view that a revised curriculum document alone will change entrenched teacher practice, and so without taking (or making) time to examine the philosophical underpinnings of science and STSE issues, teachers will perpetuate the myths that seem to surround a lay understanding of what science is and what it can do. In short, those myths imply that science offers neat and tidy answers to the world’s problems, that scientific method is algorithmic and linear, that technology arises from science and that science inquiry is value-free (Aikenhead, 1988; Bencze & Hodson, 1999; Chapman, 2007; Hodson & Bencze, 1998).

The discipline of science as it is taught in most North American secondary schools is constructed largely from the Western rational, positivist, reductionist position (Bowers, 2002); a position that privileges scientific study and the scientific method by creating the illusion that it is giving teachers and students the most value-free, reliable and secure knowledge possible about
the world (Bencze & Hodson, 1999; Hodson, 2003); a position that regards science as the highest embodiment of human progress (Bowers, 2002). Hodson (2003) emphatically agrees:

…the increasing commercialization, industrialization and militarization of science have shown once and for all that science in not value-free and disinterested. The merger of science and technology into technoscience, the appropriation of the knowledge-making capacity of science to promote the interests of the rich and powerful, and the usurping of the scientific and technological endeavour for the goal of ever-increasing levels of material consumption, have profoundly changed the sociopolitical and moral-ethical contexts of scientific and technological practice. (p. 649)

Traditional science classes, that is, science lessons based on the Western positivist paradigm described above, are replete with right answers; bodies of discrete content knowledge that are considered beyond dispute; and laboratory activities that are not investigations into the unknown, but recipes to be followed (Bencze, 2001; Gough, 2002; Hodson, 2001, 2003; Hodson & Bencze, 1998). Traditional science classes are most often understood to consist of science-based teaching strategies used by a science-trained teacher working within a science department, resulting in an over-valued single-discipline view of knowledge that is very difficult to transcend (Venville, Sheffield, Rennie, & Wallace, 2008). Stephenson (2007a) calls traditional science teaching a “passive assimilation and reproduction of simplistic factual knowledge and an unproblematic ‘truth’” (p. 140) and goes on to describe the real purpose of schooling as “…the pursuit of individual academic achievements. Schools thereby convey norms of individualism, competition, achievement and independence: norms that prevail in the dominant culture and maintain the existing structure of society”. (p. 145)
I believe that it takes no great leap of intellect to realize that such attitudes towards science leave us extraordinarily vulnerable to a naive belief that science and technology alone can save us from the social, economic and environmental troubles that we face locally and globally. Rather than thoughtful, active citizens in a democratic society who might have the capacity for transformation, our schools continue to train students to be skilled workers and consumers who perpetuate the status quo (Gruenewald & Manteaw, 2007; Hodson, 2003).

In fairness, science curricula (for example Ontario Ministry of Education, 1999) have made some efforts to reinvent themselves through attempts to contextualize and place lessons in the real world. However Webster (in Gough, 2002) notes that “The contexts are often social, utilitarian concerns: health, science in everyday life, a nod to environment, and industry. Content still dominates, as does experimentation ...the hidden values and assumptions about the way the world works remain largely unexplored” (p. 1203).

While our society continues to venerate science and technology it is important to remember, as Wallace and Louden (2000) point out, that the Scientific Method has a “short, recent and local history” (p.4) and is only one of many cultural paradigms for explaining how the world works. Even now, as Hodson (2003) suggests, science education is undergoing a shift from a positivist modern view to a post-modern, post-structural position which has led to the consideration that knowledge is socially and individually constructed. Indeed, a constructivist tone is beginning to permeate the language of science education and it is connected to an increase in field work, lab work and out-of-classroom learning (Hodson, 2003) for many students.
Nonetheless, a reshaping of secondary science study is very likely a slow and uneven adjustment of individual praxis, as educators strive to move beyond traditional science teaching practices to develop their understanding of how to address scientific literacy in their classrooms. Stevenson (2007a) discusses several school-related factors that continue to shape science pedagogy at the secondary level. These include: (a) the problems with classroom management that result in more highly structured teaching approaches and focus on content learning; (b) the necessity of evaluation and grading of students is far more easily managed with regards to content knowledge and cookbook activities, and; (d) Stevenson points out that science itself is considered an objective inquiry and thus the teaching (and evaluation of learning) of science has remained very objective. Given the belief that science represents the culmination of human achievement, and that secondary science has been further separated into various disciplines, it is not surprising to find that science teachers might be seen to be disciplinary chauvinists (Gough, 2002; Lucas, 1980) who see the world only through rational, content-based lenses.

Teachers are considered to play a very significant role in the delivery of curriculum (Shulman, 2004), but despite science education policy to the contrary they generally continue in the pedantic tradition of lectures, notes, worksheets, cookbook labs and pencil-and-paper assessments, in the dissemination of as many facts and concepts as possible, no matter that they might be fragmented and disjointed (Gruenewald, 2004; Hodson, 2003; Stevenson, 2007a). How does this happen to individuals who have access to so much current pedagogical research and a wealth of teaching resources? How is it possible that the practice of self proclaimed professionals lags so far behind contemporary research findings?
The answers lie, in large part, in the power of science education as a prevailing culture that can institutionalize and normalize teacher ideologies (Stevenson, 2007a; Venville et al., 2008). The impetus for a powerful enculturation of teacher practice that can thwart attempts at changing that practice can come from several directions. One such direction is rooted in the curricula provided to teachers (Barrett & Pedretti, 2006). For example, in Ontario, while classroom teachers might slightly modify the curricula provided, they are expected to adhere primarily to provincial science guidelines and expectations, thus creating an institutionalized practice. Hodson and Bencze (1998) identified two factors that lead to passivity or even resistance to change among educators: (1) secondary schools are generally grouped into subject departments but actual teacher work is accomplished in isolation and (2) teachers have been described as leading professionally orphaned lives. Teachers are, “isolated from research findings and theoretical debate about key issues in science education” (Hodson & Bencze, 1998, p. 692), and they are given neither the time, the opportunity, nor the facilitation required to fully contemplate their own enculturation, and the necessity and nature of change (see also Sharpe & Breunig, 2009).

In a study with pre-service teachers, Pedretti et al. (2008) identified five key issues impacting a reluctance to teach science in non-traditional ways; because these issues may resonate with experienced teachers as well, it is useful to briefly outline them here. First and foremost was the concern that issues-based and student-directed learning would result in a loss of classroom control and predictability over the outcome of science lessons. This speaks directly to matters of teacher identity and a strong belief among science teachers that they should have all the answers. The second issue was one of apprehension regarding the lack of support from
colleagues, students and parents if a science teacher were to teach in a way that was
philosophically and pedagogically different from the community at the school. Thirdly, the pre-
service teachers expressed significant unease over having enough time to cover the required
content, recognizing that issues-based teaching and learning move at a different pace; the
teachers felt that they lacked both an expertise in sociology, politics, ethics, and issues-based
pedagogy and the resources and time to treat science differently. The fourth issue that arose
addressed the repositioning of science from a positivist to post-positivist perspective which
might opens a space for science students to study science critically and possibly take a
politicized and action-oriented approach; the pre-service teachers felt that this could create a
great deal of tension for them. Lastly, and building on the fourth issue, was a genuine concern
regarding teacher neutrality such that the politicization of science did not become an
indoctrination of students.

Thus it seems to me that the vision of the science curriculum policy makers at the
provincial and national levels, which calls for science studies to incorporate STSE components,
is incongruent with current classroom practices. That is not to say that there are not individual
teachers who have made tremendous efforts to address science topics from an issues-based STSE
position (Hart, 2003). Indeed, there is a growing interest in the environment component of STSE
that is not only a timely science topic, given the disturbing state of the environment, but also
offers a possible pedagogy that holds promise for reconstructing science education.

Environmental Education

In the 1980’s, when I first began to teach an early version of environmental education
(EE) its curriculum concentrated on observing, discovering and naming flora and fauna in
nature. As a way of introducing teachers and students into the natural world it was a very benign form of EE, emphasizing personal relationships with nature and outdoor recreation pursuits, and free of socio-economic and political challenges (Gough, 2002; Hart, 2007; Stevenson, 2007a).

By the 1990’s, prompted by Rachel Carson’s book *Silent Spring* (1962), and with a growing awareness of rampant environmental degradation occurring around the globe, many scholars were analyzing the position of EE inside and outside the classroom. They eventually proposed for it an urgent and critical agenda and a few of the most influential writers are briefly mentioned here. In *Ecological Literacy* (1992) David Orr postulated that schools continue to contribute to environmental problems because they focus on training skilled workers rather than ecologically literate, critical thinkers. Chet Bowers, in his book *Education, Cultural Myths and the Ecological Crisis* (1993), examined the root metaphors that underpin modern industrialized cultures such as ours. He named individualism, anthropocentrism and progress as root metaphors that, left unchecked, will continue to inform an education and a curriculum that works against EE and against a healthy planet. Lucie Sauvé (1996) examined the archetypal conceptions that, in a western society, inform our perceptions of environment and further proposed that those archetypes have led the environmental movement to focus narrowly on the protection of natural environments, without regard for (Third World) human needs and rights. In 1999, Gregory Smith and Dilafruz Williams edited the text *Ecological Education In Action: On Weaving Education, Culture, and the Environment*, a selection of writings that spoke to the tensions between the purposes of traditional schooling and the purposes of EE. Thus in the new millennium, the tenets of EE and its curriculum have evolved into something much more complex than naming bugs in a pond. Lucie Sauvé, in her analysis (2005), identifies fifteen currents running through EE; these
are the theoretical and practical elements that underlie the many diverse pedagogies associated with EE; among them are the naturalist current, the scientific current, the socially critical current, the feminist current and the sustainability current.

Thus a precise definition of environmental education continues to be pursued by its scholars, made difficult in part by its interdisciplinary and diverse nature both in content and pedagogy. Environmental education is described in either general terms (Gruenewald [2004] states its purpose as that of providing experience and knowledge necessary for caring for environments) or in what appears to be a miscellany of topics (Hart [2003] calls it a post-modern study of political, social, cultural, ethical, religious and philosophical issues as they pertain to humans in the environment). Generally it is agreed that through a variety of learning experiences both in and out of doors, EE should provide students with the knowledge and skills to become citizens who are able to work towards finding a balance between human agency and the preservation of the natural environments of the planet (Greunewald & Manteaw, 2007; Hungerford, Peyton, & Wilke, 1980; Smith & Wheeler, 1999; Smyth, 2006). In Environmental Literacy, David Orr (1992) makes the often quoted statement, “All education is environmental education…” (p. 90) and while perhaps an overstatement, it nonetheless provides pause for reflection. Together Orr (1992), Sauvé (1996), Hart (2003) and Stevensen (2007a) agree on the complexity and interdisciplinarity of EE, on the non-traditional pedagogies that it engenders, on its necessity for critical and place-based perspectives, and on its social and political relevance.

Even within these definitions and guiding principles however, environmental education is enacted in numerous ways and in a broad range of venues, from the formal classroom, to outdoor education centres to naturalist clubs and beyond. Environmental education embraces related
fields like outdoor education, experiential education, place-based education and environmental science. These all have at their core the goal of experiencing, learning about and caring for natural environments, including the plants, animals and people that inhabit them. Taken as a group they engender pedagogies that diverge from the traditional practices of science education, which are delineated by content and standards-based systems wherein knowledge has been isolated into discrete disciplines (Gruenewald & Manteaw, 2007; Sharpe & Breunig, 2009).

Greunewald (2004) makes the distinction between an institutionalized form of EE that has been subordinated by formal academic disciplines (see also Greunewald & Manteaw, 2007) and a transformative form of EE that challenges dominant discourse and actions with regard to environmental issues. The pedagogy of a transformative EE is interdisciplinary and contextual. It bases content knowledge in the real world both locally and globally, and calls for action on the part of students and teachers (Greunewald, 2004; Jensen & Schnack, 2006; Stevenson, 2007a, b).

As reflected in the preceding discussion, the hope for EE, by environmental educators and scholars alike, was that it would be a meaningful step towards preparing citizens to understand and act to address the issues of a planet in environmental crisis. In my opinion and that of other scholars like Gough (2002) and Greunewald (2004), that hope continues to struggle on the sidelines of formal education. With due respect to those schools, teachers and students who have made significant contributions to the environmental movement, one need not venture far to see the results of continued material consumerism, wastefulness and disregard for the environment and the plight of people who are impoverished by those acts.

Numerous reasons are cited for the shortfall of EE and two of these are particularly worth considering. First of all, many authors (among them Furman & Greunewald, 2004; Gough, 2002;
Greunewald, 2004, 2005; Jensen & Schnack, 2006; Stevensen 2007a, 2007b) have criticized EE for failing to include socio-cultural and political analyses in a study of the environment and its crises, pointing out that human interactions cannot and should not be separated from the natural systems they inhabit. For example, to neglect the social and cultural ramifications of timber resource extraction in Northern Ontario is to omit an integral piece of the environmental puzzle and dismiss the experience of the people whose lives are directly affected. The language defining EE generally includes reference to social, political, economic, and moral issues (Fien & MacLean, 2000; Paden, 2000), yet in practice EE has not consistently addressed these, as evidenced by current criticisms. Jensen and Schnack (2006) argue that in order to truly deal with environmental concerns, as well as learning the facts about environmental concerns, students need to learn how to take action as active democratic citizens. This idea is echoed by Hodson (2003) who maintains that students need to develop a sense of empowerment in making choices that will impact their environments, and by Breunig (2006) who asserts that “curriculum could be liberating and schools could operate as vehicles for social change…(and) should prepare students to think critically.”

In recent years the term *environmentally sustainable development* (ESD) has entered the literature of policy and curriculum as a result of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992 (Hart, 2007; Stevensen, 2007b). Essentially, ESD, as described in Agenda 21 from the UNCED, is an overlay of EE meant specifically to address the perceived absence of cultural, social, and moral aspects of environmental studies. Taking a page from the eco-feminist perspective, ESD claims to recognize the interconnected nature of environment and human interactions that include culture,
politics, economics, technology and so forth, and parlays those into a more complex model of EE. As Hart (2007) states simply, “it (ESD) is generally defined to mean development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (p. 691).

The term sustainability is nuanced however, by intimation that development in the form of industry, materialism, consumerism and so forth are all acceptable as long as the environmental status quo can be maintained (Sauvé, 1996). Noticeably politicians and policy makers have become increasingly supportive of the term sustainability as it continues to endorse policies of global economic growth and dominance whilst giving the impression of environmental stewardship (Smyth, 2006). Jickling (2001) problematizes the term sustainability as being one-dimensional, enforcing a language that only values what is quantitatively desirable and hiding contradiction; for example, one may be adamant that wilderness should be preserved while at the same time insisting on the taxpaying citizen’s right to drive all-terrain-vehicles (ATVs) through it. As Jickling (2001), Sauvé (1996) and Smyth (2006) suggest, the term sustainability flies in the face of the belief that our environment will only survive if our society undergoes a paradigm shift that moves away from values based on economic growth, consumerism and individualism.

Indeed, an increasing complexity underscores the second shortfall of EE which is essentially its manifold and ambiguous nature (Chapman, 2007; Gough, 2002). Unlike a discipline such as physics or history, EE seems unable to occupy its own space in most school curricula being instead viewed as an add-on component of science or geography (Greunewald, 2004). Chapman (2007) argues that EE lacks basic unifying principles and without these it will
never be considered a true academic discipline. Unifying principles lay the groundwork for the specialization of an academic discipline and it is here, Chapman argues, that EE does not fit into a particular mould. By its very nature EE is a multi-faceted study of real world situations, with its focus on seeing wholeness (Chapman, 2007; Corcoran, 1999; Fien & MacLean, 2000, Orr, 1992) rather than aiming for division, reduction and specialization. Orr refers to the “centripedal effects of academic specialization” (p. 138) that result in a separation of the disciplines and a disconnectedness in how we view and experience the world. In referring to environmental education, Riley-Taylor (2002) has coined the term related knowing which, as a curriculum theory, can be likened to a weaving of many strands together into the whole, (echoing Hart [2003] and Orr [1992] in their definition of EE as complex and interdisciplinary) and providing a connection to the eco-feminist perspective.

Unfortunately it is its interrelated and interdisciplinary nature that most likely has relegated EE to the sidelines when it comes to identifying what constitutes important core curriculum, particularly at the secondary level where distinct disciplines abound. If curriculum does not exist as a specialized and established discipline it lacks prestige (Smyth, 2006) and importance. Subjects such as EE, positioned outside the core secondary curriculum, are currently granted less importance and thus less support (Sharpe & Breunig, 2009). Greunewald (2004) warns, “…ecological discourse, as low-status, marginalized knowledge, is generally not permitted to influence how social and educational issues are framed” (p. 77). (This trend was powerfully enacted in schools in Ontario through the Harris/Conservative years from 1995 to 2002, as Environmental Education courses were stripped from the Ontario Curriculum and funding, for what were deemed superfluous studies, was slashed.) Therefore, as described in the
preceding paragraphs, the two shortfalls of EE, namely its ambiguous nature and its neglect of socio-economic and political issues, continue to plague the validity of EE as an authentic area for study.

However, the standing of EE within curriculum was again elevated, at least in Ontario’s science curriculum when, in 2007 Ontario’s Curriculum Council produced a report titled Shaping Our Schools, Shaping Our Future (also known as The Bondar Report) which examined the state of environmental education in Ontario. The Bondar Report strongly confirmed the importance of EE as a component of Ontario curriculum and made 32 recommendations, all of which were accepted for implementation by the Ontario Ministry of Education in 2008. The report defines environmental education as “education about the environment, for the environment and in the environment” (p.6), stipulating topics arising from Earth’s physical and biological systems and the issues and consequences stemming from our dependency on those systems. The current understanding of EE in Ontario is reflected in the language of the recommendations which call for environmental education expectations and topics to be embedded across all subjects, disciplines and grades (Ontario Curriculum Council, 2007).

The position taken by the authors of the report is that EE is a multi-faceted study comprising content, attitude and context that can inform and transform education. I quote the document at some length as it provides a coherent perspective for the intention of EE in Ontario schools:

Environmental education is the responsibility of the entire education community.

It is a content area and can be taught. It is an approach to critical thinking, citizenship and personal responsibility and can be modeled. It is a context that can
enrich and enliven education in all subject areas, and offer students the
opportunity to develop a deeper connection with themselves, their role in society
and their interdependence in one another and the Earth’s natural systems. The
recommendations contained in this report are seen as critical - and
interdependent- components of an integrated approach to environmental
education in Ontario that will afford students the opportunity to take their place as
informed and engaged citizens. (Curriculum Council of Ontario, 2007, p. 10)

*The Bondar Report* (2007) seems to view EE as a form of education that is able to connect to
and between diverse curricula by virtue of its issues-based and interdisciplinary nature. Such a
perspective addresses in part the aforementioned shortfalls of EE, firstly by acknowledging the
usefulness and importance of its interdisciplinary nature and secondly, by specifically stipulating
its connections to society and citizenship. In my opinion, by calling for an embedding of EE, *The
Bondar Report* renders EE in Ontario curricula into a systemic approach to curriculum
development and teaching, regardless of grade or topic.

But taking a pragmatic stance, what would EE actually look like in a secondary science
classroom? This is a difficult question because EE, as described herein, tends to overlap into
many disciplines and is informed by multiple pedagogies. Based on the current discourse and
operating in an ideal world, I would envisage students and teachers engaged in EE taking an
issues-based approach to an environmental topic; they would likely find themselves outside the
classroom at some point, engaged in student-directed investigation and research, having
discussions, planning and implementing actions to address problems that they encountered.
While it is the intention of the STSE model and the initiatives of documents such as the Revised Science Curriculum for Grades 9 and 10 (Ministry of Education, 2008) and The Bondar Report (2007) that EE become an acknowledged component of curriculum, unfortunately in my experience, neither the venues of secondary schools, nor the traditions of educators in Ontario will easily support an enterprise of that nature.

A Vignette

He hesitated by the door.

“So Miss, are we going to do any work soon in this course, its almost over? I mean, we’re having lots of fun and everything, and I love going outside and doing group work to learn stuff, but when are we going to get an essay or a lab report to hand in?”

“Drew, are you saying that you haven’t been doing any work?”

“Well, we’ve been doing lots of assignments and stuff and we had a couple of tests, but they were pretty easy, I mean we got to use our notes. This is a senior course miss. I was just wondering if it shouldn’t be harder?”

“Drew, you did well on the test, you came prepared. How did your notebook help you on the test?”

“Well the answers to the test weren’t exactly in our notebooks…”

“No, they weren’t”

“We had to use the stuff from our notes to come up with answers, the questions were… well you had to think about them.”
“Yes, and you did that quite well. You’ve learned things in a lot of different ways in this course Drew, and I’ve set it up that way. I think that students learn in many various ways and that traditional pencil and paper assignments are good, but there are a lot more ways to teach and to evaluate what my students learn. I’m really glad, though, that you are bringing this up. Shows that you’re really thinking things through…

“Are we covering enough stuff, miss, like that the other senior students are covering?”

“Yes, I think so Drew, when it’s all said and done I think that you’ll have had a unique and compelling learning experience and you won’t be behind other students.”

“What about our final project? What are we doing for a final project?”

“Well, because it’s a small class of sixteen Drew, I think that each person will have an individual project to work on. Usually the student and I come up with it together. What do you think you’d be interested in?”

“I don’t know… I don’t know”

“You seem pretty interested in the whole teaching and learning thing…”

“Yeah, I am”

“Well, here’s an idea. What if you were to research a topic called alternative pedagogies and present it to me? You know, find out as much as you can about that term and then think about what you’ve been doing in this course, try to connect the two. Want to give it a try?”

“Yeah, maybe. What’s it called again?”

“Alternative pedagogies. New term, big words”

“So then I should write an essay about it?”
“Well, you can if it helps you organize your thoughts, but in the spirit of alternative pedagogies I think maybe we could do an oral evaluation instead, you know, have a conversation about what you’ve researched and how it connects to the course, and then you can also give me some feedback on the course teaching and learning style.”

“Well miss?”

“Well Drew.”

And that is what we did. (May, 2007)

Contradictions

Because environmental science and ecology are found as topic areas in science curricula, as are those, for example, in Ontario (see course expectations in Ministry of Education of Ontario, 2000, 2008), it has long been a general assumption of educators that science dovetails nicely with environmental education. However, taking into account the divergent natures of traditional science education and an evolving environmental education as have been described earlier in this chapter, it is my contention that traditional secondary science and environmental education are in many respects incompatible and that merging them presents significant difficulties for both.

I am not alone in this notion; the dilemma of combining science and EE in some way has been the topic of substantial academic discourse, as described below. The obstacles to a smooth embedding of EE in science education are based on their different philosophies and different pedagogies; while science education is based on a positivist, rational cataloguing of the world, EE stems from a post-modern desire to understand and act upon our relationships within the world (Robottom & Sauvé, 2003). Both Hodson (2003) and Smyth (2006) contrast the
reductionist approach of science with the systems approach of EE; the first takes things apart to see how they work and loses sight of the whole, while the latter considers the whole and its interconnections. Like Greunewald (2004), Hart (2007) asserts that by taking a holistic, systems approach EE can be a transformative pedagogy, able to engender change in dominant politics and economics, (though he doubts that the language of that change has entered the classroom). Smyth (2006) offers these descriptors of EE (as distinct from science education):

…lifelong, interdisciplinary, holistic, learner-centered, locally relevant, concentric...from local to global, emphasis on quality and value, problem formulating, normative rather than empirical, systematic rather than linear thinking, affective integrated with cognitive, flexible and adaptive, forward-looking...anticipatory, interpretive, synthetic, broadening, operating in open situations, issue-based, field-based, action-oriented. (p. 253)

In general agreement, Hart (2007) points out the incongruity between science as knowledge transmission and EE as active deliberation, debate and independent learning. Stevenson (2007a) refers to the contradictions between the two, particularly with reference to their treatment of discrete disciplines: traditional science is balkanized in its disciplines while EE calls for an interdisciplinary approach (Robottom & Sauvé, 2003). Bernstein (in Stevenson, 2007a) suggests that interdisciplinary pedagogy creates difficulties for teachers in terms of teaching strategies and assessment in that single-discipline pedagogies are much simpler to enact (and thus more prevalent). Environmental education adds ethical/moral, political, social and cultural components to curriculum (Hart, 2002) thereby challenging teachers’ views that science should be value-free (Dillon, 2002). In a recent paper Pedretti, Bencze, Hewitt, Romkey and Jivraj (2008) noted that traditional science education has been a review of disciplinary
knowledge and that teachers defined themselves as gatekeepers of that discreet information without much consideration for the messiness presented by real world issues. Pedretti et al. found that teachers were reluctant to broach the social and environmental issues (SE) of STSE fearing that it "devalues the curriculum, alienates traditional science students and jeopardizes their own status as gatekeepers of scientific knowledge" (p.943). Indeed Venville et al. (2008) point out that specialized knowledge gives a sense of order to a complex world and provides specialized problem solving skills, both compelling reasons to sustain traditional science curriculum.

Several years earlier in Australia, Gough (2002) made the observation that science education has been unable to overcome its traditional structures despite mandates calling for social relevancy and scientific literacy; she calls this the *rhetoric-reality gap*. Gough lists five reasons why she believes that science curriculum is a limited vehicle for EE enactment: a) a global trend towards standardized curricula that further removes teachers’ abilities to plan their own curriculum; b) the content of science curriculum as heavily influenced by the science community in its desire to further tertiary studies; c) EE is perceived as another of a long line of topics requiring inclusion in an already crowded curriculum; d) many science teachers are *disciplinary chauvinists* who prefer to teach in their specialization rather than tackle an integration of topics, and; e) most science teachers do not have the same understanding of EE as do environmental educators.

Indeed, supporting these points, Gayford’s research in 2002 found that science teachers did not willingly address social, political or economic issues, even as they related to science topics. The teachers participating in the study were not comfortable with integrating social or
political issues in science and felt that teaching values was not part of their role. In further agreement, *The Bondar Report* (2007) contends that, “many teachers currently lack the knowledge, skills and background in perspectives taking required to teach environmental education effectively” (p.7). In a recent review of EE research Hart (2007) proposed that:

those science educators who understand science from a wider, more encompassing perspective, and particularly those who value the virtue of social values and adopt a pluralist nature of science, may share considerably more ground with environmental educators. (p.711)

In an action research project addressing STS implementation, Pedretti (2001) found that while teachers may find resonance with the rhetoric of STS recommendations (science, technology and society: the forerunner of STSE), their practice was not likely to change due to the inherent complexity of STS and the lack of real time that educators have in their work. With those obstacles to STS in mind, it is disheartening to learn that Hart (2003) contends that it is the E (environment) in STSE science curriculum that will present educators with the most pedagogical difficulty:

Although the notion of STS as an integrating, broadening, more practical and relevant frame for science is not a new concept, the addition of an environmental dimension brings into sharp relief certain epistemological and pedagogical issues involved in changing science curriculum policy and practice. (p. 1240)

In other words, while a study of science and technology is reasonably aligned and can be presented alongside some social issues with minimal effort and fairly positive results, the inclusion of studies of environment, especially issues of eco-social-justice, will challenge the
safe neutrality and conformity of traditional science curriculum. Although EE offers educators
the overt opportunity to question systems of educational hegemony, knowledge construction and
instruction (Breunig, 2005); unfortunately educators who do not have the time or intent to
address an STS focus will be even less likely to tackle STSE. Pedretti et. al. (2008) agree that
teachers’ loyalty to subject matter (which is a large influence on how they form their
professional identity) is precisely what stands in their way of taking an STSE approach to
teaching science curriculum. "Simply put, issues-based STSE education challenges traditional
images of a science teacher and science instructional ideologies” (p. 943). While not directly
related to studies of environment, Rico and Shulman’s (2004) work with two science teachers in
their efforts to incorporate new, non-traditional science pedagogies, based on big ideas and
students-as-researchers, shares enough similarity with the STSE initiative that a mention of their
work is useful. Their project was ultimately unsuccessful but valuable nonetheless as it lends
credence to Pedretti et al.’s (2008) aforementioned statement regarding science teachers’ loyalty
to subject matter. As Rico and Shulman (2004) observed, the teachers in their study understood
the vision and theory of the new pedagogy, but were unable to put it into practice precisely
because they could not shift away from content and unintegrated topic areas.

There is another, somewhat tangential argument that can be made in regards to the STSE
model, wherein science and technology as human centered (anthropocentric) endeavours are
situated in direct opposition to environment. It is, after all, through human science and
technology that we have developed the tools that allow us to shoot a rapid, conquer virgin
territory, exploit and manage resources, rape the countryside, battle the elements, and subdue
the ‘natives’. Our language is riddled with images of human agency in confrontation with nature
and environment, and is an indication of our deeply lodged values (Hodson, 2003). The assumption that studies in science and technology will smoothly ally with EE is, I believe, naive.

So what happens when EE meets secondary science? Will they co-exist in the classroom? Will one dominate the other? Dillon (2002) asks the question, “Should science education give up some of its curriculum time to environmental education on the grounds that environmental education is likely to provide richer and more efficacious learning situations?” (p. 1113). Is this even possible given the aforementioned reluctance of many secondary science teachers to teach beyond knowledge transmission?

Seeking the common ground of compromise, Gough (2002) suggests a form of mutualism in which science education and EE would benefit from each other (science needs EE to make it more culturally and socially relevant and EE needs science to bring it out of its marginalized state) thereby ensuring the survival of both. However, given the past inability of science education to make systemic changes, it is the more likely possibility that environmental studies will be subsumed by teachers into a form of environmental science that most closely resembles the value-free mythologized science still common in the secondary classroom (Greunewald, 2004; Stevenson, 2007b). Gruenewald and Manteaw (2007) assert that as a recognized part of curriculum, EE will have to meet policy standards and student achievement objectives, thereby being reduced to something other than what it should be, “muted, distorted and absorbed by the culture of schooling… los(ing) its ability for social transformation” (p.176).

It is necessary to take brief note that it is not only teachers who show a reluctance to engage in a new pedagogy of science. The vignette related earlier in this chapter is based on an actual incident and suggests the enculturation of the other stakeholder in the classroom, the
student. In my experience, while many students embrace teaching and learning that seem holistic, natural and intuitive, some of the more academically oriented among them worry that they are not learning enough and will not be competitive in their post-secondary studies.

In conclusion then, the successful embedding of EE within science curriculum does not seem highly probable, given their divergent premises and practices that have been described. Nevertheless, education policy in Ontario has mandated the confluence of science and EE in all grades and all topic areas (Ontario Curriculum Council, 2007). It seems certain that the inclusion of environmental education (as environmental educators understand it) will present a variety of epistemological and pedagogical challenges for science educators, whereby change will be inevitable but the nature of the change quite uncertain. The preceding discussion and the context of my own secondary science teaching experience lead me to ask these questions:

• What theoretical foundations, epistemologies and values underlie secondary science teacher praxis?

• How do secondary science teachers perceive EE? How do they understand it?

• In what ways will EE challenge the classroom practice of secondary science teachers?

• In what ways is action research a suitable medium for secondary science teachers to accomplish the integration of environmental education into their praxis?

These questions serve as a focus for the research described in this dissertation and provide a framework for analysis and discussion.
Chapter Three
Theoretical Perspectives

Chapter three is a philosophical deliberation that situates my understanding of humans on the planet Earth, and helps me unravel a personal node of complexity that has been in the making for some time. My beginnings in Ontario’s pastoral, southern farm country gave way to travelling and eventually living in the boreal wilderness of the north; learning to know and understand nature in a wilder, less controlled sense. Therein lay the seeds of my acknowledgment of inherent tensions in the nature/human relationship. My upbringing with the sentiment of human-as-above-nature was challenged by a growing awareness of the relationship of human-as-part-of-nature. It became clearer to me that human ascendancy over environment, based on patriarchal, hierarchical or biblical principles was flawed, as evidenced by the crisis of environment on both local and global fronts.

Eco-feminism

In searching for alternative views, my first readings in eco-feminism resonated strongly with the path I was on; particularly its recognition of women and nature as Others, its emphasis on the interconnectedness of life on the planet, its holistic/systems approach rather than a reductionist/positivist approach, its call for a society based on cooperation and balance instead of patriarchy and hierarchy (Bennet, 2005), and its spiritual/humanist dimensions. Eco-feminism values the embodied experience, the hands-on, in-the-field, wind on your face encounter with natural landscapes, asserting that these are vital to education and to our relationships with each other and with our environments (Abram & Jardine, 2001; Haskell, 2001; Riley-Taylor, 2002).
A succinct manifesto for eco-feminism continues to be a highly debated topic (Gaard, 1998; Russell & Bell, 1996) because it is, as Bennet (2005) points out:

…a widely encompassing ideology, touching on subjects as diverse as nature-based religion; animal rights; women's rights; environmental worries about water, land, and air pollution; wildlife conservation; and the oppression of Third World countries and peoples by the United States and other industrialized nations. (p. 65)

However, eco-feminists do agree that existing First World political, social and economic systems are based on patriarchy, hierarchy and the domination of nature, women and the third world (Gaard, 1998; Gruenewald, 2004; King, 1990) and are “leading us to ecocide and species suicide because it is based on ignorance, fear, delusion, and greed” (Spretnak, 1990, p.9). Shiva (1997) maintains that western cultural values of global resource dominion, the exploitation of third world citizens, the global commodification of knowledge, and industrialization serve to maintain and even widen the gap between global wealth and poverty. The concomitant reliance on science and technology to solve inevitable environmental crises is viewed by Bennet (2005) as an expression of the continued usurpation of power by traditional male attributes like rationality, mechanistic ability, physicality, and analytical and hierarchical thinking over traditional female qualities like, empathy, sensuality, emotion and cooperation.

But the masculine/feminine duality should not be taken at simplistic face value. Russell and Bell (1996) point out that women also use scientific and economic tools, and men often demonstrate traits such as gentleness, spirituality and the capacity to nurture. Thus the authors qualify masculine or feminine ways of knowing as neither universal, nor biologically

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determined, rather as representative of a tradition of western patriarchy that underlies the foundations of the actions of the First World.

Our quarrel is not with men or even reason per se, but rather with the unwarranted pretense [sic] that logic and abstractions are a means to universal and objective knowledge, and that they therefore deserve to be privileged at the expense of other ways of knowing" (Russell & Bell, 1996, p. 175).

_Deep Ecology and Other Eco-philosophies_

Eco-feminism does not stand alone on the front of environmental values. Certainly there are wide overlaps of theory between eco-feminism, deep ecology, friluftsliv and other theories of place. I will briefly describe friluftsliv and place-based theories, since both of these terms emerge consistently in outdoor and environmental studies literature as perspectives that provide a rationale for various curricula. However, I will focus my discussion of theoretical perspectives on deep ecology in comparison to eco-feminism as these two theories not only encompass many of the elements of other eco-philosophies but they also have a strong personal resonance.

Friluftsliv, as described by Henderson (2007) and Gelter (2007), is a Scandinavian philosophy of outdoor life based on developing a personal, spiritual connection with nature through travel and dwelling. The essence of friluftsliv is to live with joy in the natural world. However, more recently in northern Europe, the term has taken more technical or activity-based connotations, and lost a measure of its philosophical foundations (Gelter, 2000). Certainly, friluftsliv parallels both deep ecology and eco-feminism in its recognition of the spiritual and creative links between nature and human.
Place-based theories underlying environmental education extend a contextual attachment, through direct experience, to a particular landscape in both personal and cultural terms (Semken & Freeman, 2008), and are the basis of place-based education. Also sometimes called *community-oriented schooling* or *ecological education*, place-based education is described by Woodhouse and Knapp (2000) as a multidisciplinary, experiential methodology. In addition, place-based education includes a component of service learning for the purpose of connecting persons with their place or community, and furthering ecological and cultural sustainability.

Reflecting various elements of the theories described above, deep ecology is an eco-philosophy that points out the estrangement of humans from their natural roots, a result in large part of the history of western culture: the rise of classic Greek humanism and the Judeo-Christian culture (Spretnak, 1990; Zimmerman, 1990). Moreover, deep ecology theorizes that it is western culture’s self-centered world view (anthropocentrism) that has brought about not only a profound separation of humans from the natural world, but an hierarchical placement of humans above, and in command of it (Kheel, 1990). Deep ecology perspectives maintain that nature has tremendous intrinsic value and must be conserved for its own sake and that humans must learn to place themselves on par with nature and see themselves as part of the natural world. Kheel (1990, p. 128) theorizes this as a deep philosophy because it “calls for an inward transformation in order to attain an outward change” (see also Zimmerman, 1990).

Deep ecology differs fundamentally from eco-feminism in that it takes a gender-neutral stance in its treatment of the causality of environment in crisis (Russell & Bell, 1996). Greta Gaard (1998) further clarifies this critique through pointing to a set of contradictions in deep ecology: although deep ecologists hold that women’s positions are closer to nature, it is through...
their adherence to anthropocentrism that women are thereby made equally responsible for
destroying nature. Deep ecology does not recognize gender difference, Gaard (1998) posits, yet
it encourages one to become more like women, “to appropriate an aspect of feminine
psychology” (p. 149). Deep ecology makes wilderness into something fantastic, surreal, or
iconic and in so doing creates a separation or dualism between nature and culture that should not
exist. Deep ecologists look to nature for healing, yet they equate nature and women as healers,
thus where does that leave women for their healing? Lastly, Gaard argues that deep ecologists
focus on solving the problem of overpopulation through the use of fertility programs, but while
they deplore industrial progress they would use fertility programs provided by industrial
progress.

Eco-feminism as a Position for this Dissertation

While deep ecology offers potent foundations for approaches to understanding
environment, it is the feminine aspect of the eco-feminist philosophy that seems to me to provide
the requisite breadth needed to encompass a thorough study of environmental values and
environmental education. Thus, post-structural eco-feminism informs environmental education
and the preparation of this dissertation in two ways. First of all, as an underpinning for an
educational philosophy for environmental education, it is my view that eco-feminism provides a
firm theoretical foundation for studies that connect and interweave amongst each other; that
remove hierarchical power struggles in order to value all learners, teachers and viewpoints; that
point specifically to the ego-centric and androcentric paradigms as sources of environmental
degradation, and that call for an ethic of care (Russell & Bell, 1996). Secondly, as a foundation
for the qualitative participant-oriented research which this dissertation examines, eco-feminism
warrants the removal of perceived hierarchy between researcher and participants, making them learners and leaders equally wherein all voices can legitimately join the discourse. Further, the scope of what counts as authentic data in AR is increased significantly as eco-feminism recognizes that data encompasses more than the logical/rational and can include voices that speak through media that include prose, poetry, and art (Riley-Taylor, 2002).

**Competing Epistemologies**

The second philosophical element that underpins my research and writing is an epistemological consideration that informs my view and understanding of knowledge and knowledge acquisition. As a science teacher by training and now a doctoral student in the social sciences I am currently caught between the attractions of two opposing epistemologies, both of which offer plausible, even appealing, theories for the nature and acquisition of knowledge. On the one hand post-modern, post-structural views underlie the position that knowledge exists to the extent it is socially and personally constructed. This has led to the current trend in education towards a constructivist approach to teaching and learning (Hodson, 2003). On the other hand, a modern or realist/positivist perspective contends that facts/knowledge exist independently of us and are there to be uncovered; a position that, in my experience, continues to inform much of secondary science classroom practice.

The incongruity of these two epistemological perspectives can, I believe, be a source of tension for teachers attempting to reconcile traditional science teaching with new post-positivist pedagogies. Certainly I stumble at this intersection. Try as I might I cannot reject the idea of pure scientific fact, yet I also understand the potency of social and cultural agency in knowledge
Benson (2001) explains that from a social-constructivist standpoint that individual interpretation and creating is influenced by five features:

…the person’s knowledge of the world’s history as learned in his/her culture, the particular social circumstance in which the learning is currently taking place, the person’s individualized, lifetime experiences, the purpose that the person attaches to the sense-making process, and the act of actively creating meaning. (p. 449)

Where does that leave the secondary science curriculum and its concept of fact? Perhaps part of the answer lies in the multiple ways of interpreting the term fact. For example, gravity is a force that is universal to the experience of almost every individual or group, yet how it is described, used, or ascribed importance is unique to the individual or group. It is a ‘fact’ that on this planet, in my experience, an unsupported object will fall to the ground. However, the knowledge that we construct around the fact of gravity will take many forms. Aerophysicists take gravity very seriously and describe it in mathematical terms; girls playing at skipping rope in the schoolyard take gravity just as seriously, however, their constructed knowledge of it is kinaesthetically intuitive. The Grade 11 Physics course in Ontario treats gravity as force that can be analysed using diagrams and mathematical models, (Ministry of Education of Ontario, Science: the Ontario Curriculum, Grade 11 and 12, 2008, p. 88) and by its inclusion in the curriculum it is given a particular importance.

What rings true for me at this point is an epistemology that recognizes the following ideas: (a) The natural world is comprised of shared sensed experiences that we might call ‘facts’, (b) we all experience these ‘facts’ in different ways and ascribe them different levels of importance, (c) socially/culturally we decide how to describe our shared facts, and (d) socially/
culturally we decide which of our shared facts are more important. Hence the acquisition of certain knowledge is, in a sense, the acquisition of power. Wallace and Louden (2000) write, “...science has been characterized as a form of knowledge constructed and agreed among like-minded groups of people, reflecting the power structures within which the knowledge is created, likely to change when the power structures change” (p. 5).

Teachers need a basis for thinking about how they determine and construct their own knowledge and skill base and then how they deliver mandated curriculum (Shulman and Shulman, 2004). Teachers of secondary science are faced with the ongoing questions of what constitutes important facts, which culturally shared experiences are worth studying, and what kind/form of power (hierarchical or communal) they choose to perpetuate. As Benson (2001) suggests, in the process of determining what constitutes powerful knowledge for students, and how it should be taught, teachers actually base their decisions on their socially and culturally shared experiences and knowledge of the natural world. I suggest that a possible framework within which secondary science teachers operate might be termed a realist/constructivist paradigm in that it encompasses elements of realism, in which facts are universal and have absolute existence, and elements of constructivism wherein knowledge is based on their experience. The Science curriculum outlined by the Ministry of Education of Ontario (based on scientific facts) has been socially (this includes culturally and politically) determined to be useful and therefore included, and the agency of teachers further refines the actual curriculum that students experience.

Indeed, no two teachers teach exactly the same way. Although the natural world perceived by the senses is constant, individual teachers experience it differently, leading to an
individualised realist/constructivist practice. Thus even while teachers encourage and facilitate
the construction of students’ knowledge, they do so within the parameters of their own
constructed knowledge of what is personally, socially and politically relevant and important.

_A Working Methodology_

Thus eco-feminism and a realist/constructivist paradigm together lay the foundation for a
working methodology for this project. Realist/constructivism, as I have described it previously,
serves as an epistemological foundation; facts exist to be uncovered, however, perception of
those facts will be individually shaped. Indeed, realist/constructivism served me well as a basis
for my personal knowledge construction during the project: believing that there are concepts to
be uncovered through the research, yet recognizing that my prior knowledge and experiences
influenced my recognition and understanding of those concepts. While realist/constructivism
might underlie my epistemological position for this research project, it is through eco-feminism
that I understood my task as a data collector and as analyzer of the data. Eco-feminism, as
described earlier, eschews hierarchy, thus all participants, including myself, have an equal voice;
it embraces embodied experience thus recognizing the importance of the experiences of the
participants; it is intuitive, and so validates emotions, creativity and intuition as well as rational
observation.

In my view it is not necessary for the philosophy of eco-feminism and the
epistemological position of realist/constructivism to be closely linked to each other at some
meta-level. As foundational positions they can both inform research, but in different areas and in
different ways. They can complement each other without informing each other. Still one might
argue that eco-feminism is linked to realist/constructivism in the sense that it can act as the

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philosophical lens for knowledge construction; if I perceive my prior knowledge and experiences from the perspective of eco-feminism, then I will likely construct my subsequent knowledge through that lens. Indeed, one of the fundamental tenets of eco-feminism is the recognition of interconnections between diverse topics and ideas.

It is my belief that for the purposes of this research study, the two positions discussed above were not necessarily intended to support each other. At the outset of the project I was exploring two different and unrelated perspectives. However, as the project progressed it became apparent that together eco-feminism and a realist/constructivist paradigm have informed this research project inasmuch as they have influenced the questions asked, the qualitative methods used, the analysis of data, and the conclusions drawn from the experience (Capobianco & Feldman, 2006). As a basis for methodology, eco-feminism offered a foundation for a non-hierarchical personal sharing of ideas and experiences. In recognizing wholeness, eco-feminism allowed for the interweaving of many different idea strands (Riley-Taylor, 2002) taken from science studies, environmental studies, action research and narrative. As a theory that recognizes powerful connections between culture and the natural world (Bennet, 2005), eco-feminism also created a space for the consideration of environment as a critical component of traditional studies, in particular science studies. Moreover, eco-feminism informed this methodology by way of supporting narrative and story as legitimate qualitative sources of powerful knowledge (Riley-Taylor, 2002) and knowledge construction.

The realist/constructivist paradigm likewise laid a philosophical foundation for this research in that it acknowledged the particular dilemma of secondary science teachers in finding
a balance between the transmission of facts and the transformation of students’ understandings as responsible environmental citizens.
Chapter Four

Action Research

Establishing a Context

This chapter, which addresses the use of action research (AR) and its presence in the literature, and the next chapter (chapter five) which focuses on the use of story, narrative and case as qualitative research methods, set the stage for the chapter six in which I describe the details of the research project undertaken for the development of this thesis. However, to give some context to chapters four and five, I will briefly outline the basic elements of the research project as they relate to action research, story, narrative and case studies.

In order to better understand how secondary science teachers perceive the nature of science as part of their teaching practice (and culture), and how they relate science education to environmental education, I enlisted the participation of six secondary science teachers. The six teachers agreed to meet as a group six times over the course of a semester (October to January) with the intent of discussing their practices and participating in action research. Also, the teachers agreed to take part in individual interviews for the purpose of elaborating on their personal views. During the group meetings I took the position of researcher/facilitator in which I introduced topics such as the nature of science and the nature of environmental education, and also encouraged and supported the participants’ collaborative efforts to design and implement individual action research projects for their respective science classes. This chapter (chapter four) discusses the practice of action research both as a research tool and as a method of teacher professional development.
At the outset of the project I told the participants that they would be asked to journal their thoughts and reflections throughout the research process; and that toward the end of the project they would be asked to write a short narrative or case describing their experiences with science and environmental education. While formal journaling and case writing did not materialize to any great extent during the project, nonetheless, it quickly became apparent that the data was teeming with teacher narratives. Their stories emerged as an important means of communication for teachers analysing and developing their practice, as well as a rich source of data for myself as the researcher. While I was disappointed in the limited production of formal cases (only two are included in Appendix H and I) I became very intrigued by the participants’ informal use of story and thus have included a discussion of story, narrative and case in chapter five.

*Action Research*

The qualitative research tradition offers a multitude of methods of data collection, analysis and interpretation. These will not be discussed in any detail here except to place this project within that tradition. This chapter, addressing action research, will briefly consider the historical significance of focus groups, it will outline the connections between AR, ethnographic research and narrative inquiry, and it will also acknowledge some of the criticisms levelled against AR, most important among them being issues of generalizability. Also to be discussed are the role of the researcher in AR and the forms of data and methods of data collection.

*The Focus Group*

Action research arose as an extension of the focus group, which itself has a diverse qualitative research history. Focus groups have been used by the media, military, government
and business as a form of audience analysis for the purpose of creating more effective advertising and propaganda (Kamberelis & Dimitriadis, 2005). Focus groups were used in the feminist agenda for raising consciousness and as a form of research for building feminist theory (Kamberelis & Dimitriadis, 2005). The studies conducted through focus groups are qualitative in nature and based on very ordinary instances of everyday interactions such as conversations and group discussion. Researchers in the humanities and social sciences have since co-opted and formalized them in the Freirian practice of working “*with* people and not on *them* [italics in original]” (Kamberelis & Dimitriadis, 2005, p. 889). Kamberelis and Dimitriadis suggest that people speak more easily in groups than in individual interviews. Groups can be viewed as a safe and supportive place because they “mitigate against alienation, create solidarity and enhance community building” (p. 887). Thus, from a historical perspective the focus group was a forerunner for action research.

*The AR Model*

While a number of action research models exist (Bencze, 2001; Hodson, 2001; Wals & Alblas, 1997) they have in common a cyclical or spiralling form that essentially accomplishes each of these stages:

- identifying a problem or issue in education praxis
- acquiring information and clarifying the issue
- generating response(s) or solution(s)
- implementing response(s) or solution(s)
- observing and reflecting on the results
- redefining the problem or issue
**Ethnographic and Narrative Forms of Inquiry**

Action research, as used in this project, relies on both an ethnographic and a narrative forms of inquiry. As an ethnographic inquiry this project was an observation of and a participation in a specific group over time. Also, as the participants told their stories to the researcher and to each other, the project became a narrative form of inquiry. The focus of this action research project, as formulated and stated by the participants, was to *model a small group approach to embedding environmental studies into science curriculum.* In my role as researcher, I acted in part as the ethnographer who observed the participants as they worked through the action research cycle. However, as a participant, I contributed my own narratives, (which had direct impacts on the direction of the project). A great deal of the data is in the form of transcribed conversations during participant meetings and interviews. These are rich with stories that describe the work and experiences of the participants and their students during the course of the project.

Ethnography, as described by Denzin and Lincoln (2000) and Creswell (2009), has its roots in the field work of anthropologists in the early 20th century who observed and described other cultures in an attempt to theorize about race origins and cultural evolution. Creswell explains ethnography as a “description and interpretation of a cultural or social group or system” (p. 58). Further, he clarifies that *culture* is an inference made by the ethnographer, and is based on evidence of behaviours, stories, rituals and artefacts. As the researcher/facilitator of an action research project, I took on the role of ethnographer of a small group of secondary science teachers. In that sense I immersed myself in the culture of the participants and I gathered data consistent with ethnographic research in the form of conversations and stories (meetings and

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interviews), observations of behaviours / teaching practice (classroom visits) and artefacts (student work and teacher writings). Finally, as ethnographer, I both recorded and analyzed the data which led to a set of generalizations or propositions about the culture of secondary science teachers.

Narrative inquiry was informed by the feminist tradition (Kamberelis & Dimitriadis, 2005). The feminist tradition brought a humanism to ethnographic research in two significant ways: 1) feminist researchers developed the idea that the stories people told were important not only as sources of historical or social information, but that the subjects themselves were active players in their own lives with attendant emotions and interpretations (2) the feminist tradition questioned the researcher’s position in terms of voice, authenticity and representation (Chase, 2005; Kamberelis & Dimitriadis, 2005). Narrative inquiry finds importance in the stories that people tell as well as their interpretations of those stories. However, the position of the researcher/facilitator (ethnographer) in a project using the action research model blurs the boundaries between the observer and the participants who are being observed and complicates the researcher/participant relationship. (My specific experience as researcher/facilitator is examined in detail later in this chapter.)

Knowledge building

According to Capobianco and Feldman (2006), the purpose of AR is to develop knowledge and understanding of one’s practice that can be shared with others. Action research occurs in real time (to take a phrase from the digital age). It is contextual such that the knowledge and understandings derived from it are understood to be personally and socially constructed (see also Goldblatt & Smith, 2005; Stevenson, 2007). The quality of AR, as
suggested by Capobianco and Feldman (2006), requires the teacher/researchers to function as a community of practice, intent on a set of goals or objectives that will require reflection and serious conversations; testing of ideas in practice; and knowledge generation and warranting, with the ultimate goal of improving practice. As described by Zuber-Skerritt (2002b) the core values of AR include a systems approach that allows one to see the big picture, a sense of synergy or willingness to share, a sense of permeability in that collaborators are receptive to criticism, an openness to new ideas, symmetrical communication, and trust in the abilities of one’s self and in co-researchers.

Action research by practicing teachers has been described as learning about learning in a format that encourages personal knowledge construction, rather than knowledge transmission (Zuber-Skerritt, 2002a). It interweaves reflection and action such that teaching improves (Goldblatt & Smith, 2005). In many ways professional learning is a social process (Altrichter, 2005) inasmuch as working with a group of teachers in an AR project offers “discursive support, practical support, dissemination of teacher knowledge, building up a community of professionals, and... a critical forum for research” (p. 13). Moreover, AR is accomplished amidst changes in praxis and has been deemed a powerful component in effecting that change (Altrichter, 2005). As teachers ask questions like, “What am I doing and why am I doing it?”, they are actively engaging in analysis and revision. According to Cotton & Griffiths (2007, p. 159), “In describing our world, we change it”. Wals and Alblas (1997) describe AR as a blending of theory and practice such that those who must implement curricular change are deeply involved in its determination, and Goodnough (2008) refers to ‘active, ongoing learning that is embedded in the everyday practices of schools’ (p.16). Postholm (2008, p. 1721)
discusses how the emphasis on reflection in AR encourages “looking forward as much as looking backward” thereby connecting learning and action.

Criticisms

Action research is not without its criticisms, particularly from those who rely heavily on traditional quantitative scientific method modes of research. Roulston, Legette, Deloach, and Pitman (2005) summarize criticisms levelled against AR in terms of teacher knowledge, skill and focus. Essentially they argue that teacher-researchers produce an inferior form of knowledge grounded in practice rather than theory, they have neither the skill nor the vision to adequately conduct research within a critical inquiry model and by conducting research in their own classroom they exploit their students and themselves rather than attending to the work at hand.

In their discussion of ethnography, and by association the position of the researcher/facilitator of action research, Denzin and Lincoln (2000) consider the limitations inherent in this type of research. They identify both the crises of legitimation (that the traditional criteria of validity and reliability are inadequate for qualitative research) and representation (that the researcher/writer is not separate from the observed experience). These crises echo the concerns raised by Chase (2005) and Kamberelis and Dimitriadis (2005) regarding the equivocal role of the researcher/facilitator/ethnographer.

Yet, based on the commendations of scholars such as Altrichter (2005), Goodnough (2008), and Wals and Alblas (1997) I believed AR would provide a particularly apt research method for addressing the questions posed in this study; although problematic, a participatory form of AR would afford the researcher/facilitator/ethnographer to be at the same time a part of the experience being researched, as well as the observer and recorder of the experience.
Moreover, inasmuch as a post-modern epistemology interprets knowledge and theory
collection as localized and contextualized, AR seems to offer educators an opportunity to
learn their way forward (Stevenson, 2007) through complexity. The ethnographic element of AR
provides forms of data collection that grant the researcher entrance to the epistemological
processes of learning forward, and though individualized and situated, can nevertheless provide
rich material for analysis.

*Environmental Education Research*

Robottom and Sauvé (2003, p. 120) warn that:

In our experience, it can never be assumed that participants come to the project with a
common “default” construction of what counts as research in environmental
education...This is one of the reasons why it usually takes time to build a research culture
within any new project community.

Robottom and Sauvé (2003) point out that a research culture must be constructed around
integrity, honesty and humility on the part of the researcher, and that the participants must share
in the production of knowledge through self and collaborative reflection and through questioning
the dominant discourses and philosophical assumptions upon which the research is based.

Setting the stage for this project required that the participants discuss and develop
understandings of discourses surrounding the nature of science and science teaching, the nature
of EE and the action research model. In addition, through their discussions the participants and
the researcher/facilitator had to establish a culture of honesty, reflection and confidentiality.

A number of researchers have used AR in an EE context with favourable outcomes. Wals
and Alblas (1997) worked with four instructors at an agricultural college in the Netherlands to
develop a list of guidelines for implementing EE in other schools. Chris Gayford (2002) looked at the inclusion of global climate change studies in science curriculum by science teachers in the south of England. He found that while the teachers had very high ideals regarding teaching science, they were reluctant to engage students in political or social issues relating to science. In their work with science teachers, Capobianco, Lincoln, Canuel-Browne, and Trimarchi (2006) engaged in an AR project from a feminist perspective that helped teachers redefine their views of science, and how they could empower all of their students to participate in it. The current situation in Ontario, wherein EE is to be embedded in curriculum including secondary science, offers a remarkable opportunity to continue to understand how teachers will engage with EE.

My Role as the Researcher

Carr and Kemmis (1986) outline three forms of AR when a researcher/facilitator (RF) is part of an AR project: technical, practical, and emancipatory; the latter giving the greatest degree of autonomy to the participants and the least degree of authority to the RF in terms of controlling the direction of the group’s learning. Pedretti, Bencze, Hodson, DeCoito, and Di Giuseppe (2003) describe a form of practical-emancipatory AR in which stake-holders, including teachers and university-based specialists, collaborated in their curriculum work, with the ultimate decisions regarding curriculum given to the teachers. They state, “It is our belief that this kind of collaborative action research… is a sound form of curriculum and professional development” (p. 220). The role of the RF is a precarious one that must be carefully monitored and mindfully enacted.

The intentionality of the AR project described in this paper was not originally located with the group of teacher researchers. In fact, I had brought them together to address what were
first and foremost *my* professional research interests in teacher development and environmental education. They agreed to work within my intentions (purposes) using an AR framework. While the AR ideal would be for a group of teachers to come together of their own accord for the purpose of researching questions regarding their professional practice (Altrichter, 2005; Altrichter, Kemmis, McTaggart, & Zuber-Skerritt, 2002; Cotton & Griffiths, 2007; Zuber-Skerritt, 2002), in the context described in this paper, it was upon my (the university researcher’s) initiative that the group came into existence. Thus, the teachers engaged in what Capobianco et al. (2006) calls *first order inquiry* into their own teaching practices while I, the ethnographer, engaged in a *second order inquiry* for which the primary goals were to facilitate, observe and interpret the work of the teachers. It is important to recognize these layers of inquiry as they raise questions regarding the location of ownership (Capobianco et al. 2006) of the research: Does one research set take precedence over the other? Do they function separately or in hierarchical relation to each other? A post-structural, eco-feminist approach to the research would advocate for all layers of research to be equally important and valued and allow for their lateral or interwoven construction (Chase, 2005). Indeed, recognizing the second level inquiry of the facilitator/researcher/ethnographer is important, according to Pedretti (1996), because it addresses the power structures within the group and it enhances the AR experience for all participants.

Facilitating action research can be a form of professional inquiry and/or self-reflection (Pedretti, 1996) in which the facilitator takes on many roles, each of which have to be enacted in such a way as to maintain a balance of power between teacher/researchers and the facilitator/
researcher(s). Pedretti (1996) lists some of the facilitator roles as: catalyst or change agent, teacher of action research, critic, resource person, observer and recorder.

The following principles, proposed by Pedretti (1996) (see also Hodson & Bencze, 1998; Hart, 2003) can guide the work of the researcher/facilitator: (a) teachers are viewed as experts and therefore act as leaders in many aspects of the research, however the researcher/facilitator can enable and enrich their experience (b) while each group is comprised of unique and possibly idiosyncratic individuals, it remains the work of the researcher/facilitator to set the tone (c) the composition of the group benefits from heterogeneity but issues of compatibility may arise and must be mediated (d) the groundwork for trust and motivation are laid by the researcher/facilitator (e) the facilitator may feel a dilemma arising from a sense of responsibility for each teacher to benefit from the AR experience, however, each teacher is responsible for her/his own learning.

It is at the point of data analysis and interpretation that the researcher’s voice becomes truly distinct from the voices of the group inasmuch as the researcher chooses what to include and write about. Chase (2005) considers the implications of the researcher’s voice and suggests the importance of mindfulness in recognizing the multiple possible meanings in the transcription text. She encourages researchers to explore their relationships with the participants in order to understand how they might influence their interpretations, and to include extensive quotations from the text in order for readers to develop their own interpretations. Chase also suggests that before identifying distinct themes across the transcript texts, the researcher listen for the voices of each individual participant to understand her/his narrative strategies. Kamberelis and Dimitriadis (2005) add this cautionary note to forestall the crisis of representation: researchers
must be mindful that their explanations and understandings are not premature, that they are not seduced by an easy grand narrative, but rather that they listen carefully as others make sense of their own lives and work.

The Data

Qualitative research, such as AR, relies on the collection of empirical data from a variety of sources: transcripts of group meetings; transcripts of individual meetings, documents that teachers themselves collect as part of their normal classroom activities; teachers' journal entries that document the progress of each participant in the AR process, and facilitator/researcher journal entries that record the events of the project; as well as detail personal thoughts (Creswell, 1998; Denzin & Lincoln, 2000; Goodnough, 2008; Roulston, Legette, Deloach, & Pitman, 2005). Indeed, the researcher herself is a source of data in the sense that her thoughts, conversations, and journal materials contribute additional material as representational of the condition being studied. “The concept of the aloof observer has been abandoned [in the post-modern period]… The search for grand narratives is being replaced by more local, small-scale theories fitted to specific problems and particular situations” (Denzin & Lincoln, 2000, p.17).

Just as the type of data and its methods of collection differ between quantitative and qualitative research, so too do their position as to what can be regarded as good data. The qualitative tradition within which AR is situated requires that data be authenticated in ways other than reliability and validity, which are the cornerstones of rigorous quantitative data. Louden and Wallace (2001) examine legitimization and representation as elements that establish the rigor of qualitative data and its analysis, where legitimization refers to the “authenticity and trustworthiness of claims being made in the text” (p. 68) and representation concerns “the
problem of how researchers represent others without reducing them to objects of the researcher’s gaze” (p. 68). They conclude that both legitimization and representation, while useful perspectives on qualitative data and analysis, require significant and explicit explanations by the authors of research texts in order to underwrite their trustworthiness. “Objective reality can never be captured,” write Denzin and Lincoln (2000, p. 5), and go on to argue that one can, however, begin to understand a thing through its many representations. It is these many forms of representations that will authenticate qualitative data, “The combination of multiple methodological practices, empirical materials, perspectives, and observers in a single study is best understood, then, as a strategy that adds rigor, breadth, complexity, richness and depth to any inquiry” (p. 5).

In keeping with dense, rich data collection and analysis, Denzin and Lincoln (2000) offer three apt metaphors: the quilting of many bits of fabric together into a larger piece (bricolage); a crystallization process wherein the crystal continues to grow and change as new perspectives are added; and a form of triangulation in which (as orienteering enthusiasts will know) a minimum of three points of reference are required in order to determine an in-depth orientation to location, and, in this case, understanding. The metaphors and the discussions surrounding qualitative work are necessary because, as Wallace and Louden (2000) point out:

…no method can guarantee the truth in a postmodern [sic] world. Whatever emerges from a program of disciplined inquiry must be constructed within a web of inter-subjective agreement, reflecting the preconceptions of the authors and the power structures within which the knowledge is constructed. (p. 6)
Generalizability

Lastly, in this chapter I will examine the efficacy of AR as a method for data production suitable for drawing general conclusions regarding teacher learning and teacher development. Generalizations, considered requisite components of positivist/quantitative research conclusions, are difficult in the qualitative tradition as they imply a grand narrative or rational explanation, neither of which fit a post-modern perspective (Wallace & Louden, 2000). The ethnographer, as researcher and facilitator participating in an AR project, is faced with what Denzin and Lincoln (2000) refer to as a crisis in representation, in which post-positivist sensibilities question the legitimacy of generalizations based on qualitative research. In other words, can the ethnographer actually draw any over arching conclusions, or will the study remain only a rich but isolated description of localized events? Positivists argue that qualitative researchers “write fiction, not science, and that these researchers have no way of verifying their truth statements” (Denzin & Lincoln, 2000, p. 8). Given the controversies surrounding the generalizability of qualitative data, it is not surprising that the issue has been side-stepped, ignored or marginalized by researchers (Larson, 2009). Similarly, faced with such criticism AR might result in no more than reams of observations from a variety of sources, recorded in narrative text, that lead to a description and analysis of a relatively small and isolated event in time, but unable to further our broader understandings of teaching and learning.

And yet the human tendency to generalize reflects a need for coherence and sense-making; humans tell stories as a way to connect with one another and with a view to transferring the usefulness of their experiences and knowledge to other settings and for other people (J. Wallace, personal communication, April 28, 2009). Larson (2009) concurs:
What is indicated by words like 'transferability' or 'generalization' is fundamentally part of everyday life. Our language is permeated by taken-for-granted generalizations. People generalize, researchers generalize and even the postmodernists ... generalize. (p.27)

According to Larson (2009) generalizability in formalized qualitative research is made possible under certain conditions, the most important of which is recognition that generalizations must be thoughtfully reasoned. Larson offers five lines of reasoning to underpin generalizability, three of which are relevant to the AR project described herein: (a) a wise selection of participants in order to maximize the variation among them such that the data covers not just one case but a set of varying cases (b) similarity in contexts, communicated through rich, thick descriptions between that of the participants and that of the audience whose role it is to judge levels of generalizability (c) a recognition of patterns in new cases, wherein the process, not the context, is similar. The AR project described in this dissertation has elements of each of the criteria for generalizability mentioned above: the participants vary in their gender, experience and interests; the context of secondary science classrooms is generically recognizable; and the AR process has a recognizable and transferable pattern.

In a similar vein, Wallace and Louden (2000, p. 6) refer to an intersubjective agreement between the researcher and the audience wherein the story being told is recognized as truthful because there is a high degree of agreement regarding what counts as important. In fact, Mulholland and Wallace (2003) believe that it is the reader who ultimately makes the determination of authenticity for a case or narrative. Larson (2009) takes a different view, arguing that by giving the reader authority or control, the researcher risks losing the ability to make meaningful generalizations based on her work. To ameliorate this possibility, Larson
suggests that it is up to the researcher’s skill with language and rhetoric to persuade the audience of context and generalizability of interpretations. Wallace and Louden (2000), like Larson, advocate that the researcher attend in a disciplined way to how the data is presented and assert that, “To make too little of data, to expect that it can speak for itself, is as much to be feared as the over-determined Enlightenment legacy in science education” (p. 12).

Thus, generalizations are not conclusions; alone they do not provide firm footing for unequivocal theory, rather, a generalization is a statement of potential or possibility. However, generalizations based on AR data, analysis and interpretation, when presented by a researcher who is mindful of representative, contextual and recognizable elements, may indeed be offered as outcomes of qualitative research and as such inform educator praxis. Larson (2009) concludes, “In the final analysis, every researcher as well as every reader must strive for wise estimates of, or sophisticated discussions on, the limits of the use of a specific study” (p. 36).

An ethnographic account of an action research project, as described and discussed in this chapter, seems to offer a useful method for qualitative inquiry in the field of secondary science teaching, as long as issues surrounding the role of the researcher and the generalizability of the data analysis are recognized.
Chapter Five
Story and Qualitative Research

I once dreamt I was telling stories and felt someone patting my foot in encouragement. I looked down and saw that I was standing on the shoulders of an old woman who was steadying my ankles and smiling up at me.

I said to her, "No, no, come stand on my shoulders for you are old and I am young."

"No, no," she insisted, "this is the way it is supposed to be."

I saw that she stood on the shoulders of a woman far older than she, who stood on the shoulders of a woman even older, who stood on the shoulders of a woman in robes, who stood on the shoulders of another soul, who stood on the shoulders… (Estes, 1995, p. 19)

Anyone who has ever read a bedtime story to a child knows the allure of a good story; it entertains, it informs and it teaches (Estes, 1995), and some stories remain with us for a very long time. Paul Hart (2003) wrote, “A story is never simply a story. It is a statement of belief containing messages in what is said and what is not said. It represents or embodies a philosophy or worldview, a theory by which our practices are made intelligible” (p. xvi). Every culture has its stories through which it explains itself, and by which it teaches its children (Estes, 1995). I have noticed that stories are common elements in teachers’ daily lives; used as tools for teaching students, as well as for sharing and examining teacher practice. In this chapter I will identify the types and uses of story as they might be used in qualitative research and teacher development. I will discuss in some detail the form of story known as a case, and further, argue that story and case are a trustworthy form of data collection in the qualitative research tradition. Lastly, I will describe the particular roles that stories played in this research project.
**Story**

Terms such as *story, narrative, vignette, case* and *case study* are used interchangeably at times and indeed their meanings often overlap, however, for purposes of clarity in this dissertation, I suggest for them the following interpretations. (These interpretations are informed by personal communication with J. Wallace, April 27, 2009).

A *story* is a piece of prose that has a beginning and an end, in which protagonists act out a plot and through which the reader or listener receives a message. Story is a comprehensive rendering of experience and meaning.

*Narrative* then, can be understood as a fragment or excerpt of the larger story, but lacking one or more of the elements of the full story; it may be in the form of snippets of conversation or a cursory recollection. In a similar way the *vignette* is a very brief yet evocative account of an episode within a larger story; the vignette may be rich in detail and description, but lacking the breadth of story. The *case* usually refers to a ‘case of something’ or an example of a particular situation, such as a case of misunderstanding. The extension of case, the *case study* is a formalized form of story that is bounded by a particular set of parameters. It is very deliberate in setting boundaries of time, location, characters and events and is used with intention, such as to generate discussion amongst its reviewers.

It is not surprising that forms of story, such as the case study, the narrative and the vignette have entered the realm of education research and analysis (Wallace & Louden, 2000) as a means of continuing the complex work of understanding teaching and learning “through articulating our own stories and through hearing the stories of the multiplicity of others who act and work with us in educational settings” (Cotton & Griffiths, 2007, p. 547).
For example, in a broad study of Canadian elementary teachers who incorporated EE into their classroom practice, Hart (2003) and his fellow researchers found teacher narratives useful to both the researchers and the teachers in that they were seen as a method of sharing the materials and teaching approaches that teachers found productive. In addition, the researchers searched within the teacher narratives for “beliefs and perceptions that underscored their use of these materials and strategies” (p. 51), treating the narratives as gateways to the identification of the epistemological frameworks of the teachers.

Indeed, the research data informing this thesis teems with vignettes and narratives through which the participants describe their work as teachers and their experiences associated with the action research project. Appendix H offers a case study, prepared by a participant, in which she examines her experience during a specific science lesson.

**Issues of Trustworthiness**

We continue to live and work in a world that has one foot firmly planted in the positivist orientation which assumes that research will produce simple algorithms with which to solve problems and write policy (Stevenson, 2004). The other foot continues to seek firm ground in the complex orientation of qualitative research as it continues to evolve and define itself. The traditional, positivist paradigms associated with quantitative research required strict attention to elements of reliability, validity and generalizability in legitimizing data (Cresswell, 2009). However, the qualitative research tradition, with strong ties to contemporary post-modern sensibilities, brings with it what Denzin and Lincoln (2000) call the crisis of legitimation wherein the terms reliability, validity and generalizability must be re-theorized. A number of scholars have addressed the issue of establishing criteria to describe qualitative data that can be
trusted and considered representative of specific contexts (Connelly & Clandinin, 1990; Creswell, 2009; Denzin & Lincoln, 2000; Eisner, 1991; Glesne & Peshkin, 1992; Mulholland & Wallace, 2003), and while their work is not definitive, there is general agreement that qualitative ethnographic data can be considered trustworthy through: prolonged engagement with participants; member checking through peer/text review and discussion; thick description of data; clarification of researcher bias; and triangulation whereby data is gathered from a variety of sources. Moreover, the external validity of qualitative research is achieved when the data and the analysis are accessible to the reader, that is, when the reader recognizes and resonates with a context or a situation.

But are various forms of story worthwhile to researchers and teacher/practitioners beyond their immediate context, that is, do they have generalizability? Richardson and St. Pierre (2005) argue that it is through language that we construct our world, which exists for us only within the discourse available to us. By naming something it comes into existence for us (see also Peräkylä, 2005). In this way, it is not only the recipient, but also the creator of the story who experiences powerful engagement. The process of story creation can

…evoke new questions about the self and the subject; remind us that our work is grounded, contextual and rhizomatic; and demystify the writing/research process and help others to do the same. (It) can evoke deeper parts of the self, heal wounds, enhance the sense of self - or even alter one’s sense of identity. (Richardson & St. Pierre, 2005, p. 965)

Research through story/narrative is not a frivolous pursuit; it calls for stringent and careful work on the part of the teacher/storyteller/researcher in order that the values and
assumptions held by teachers, most often tacit and poorly articulated, can be expressed (Hart, 2003) and further accessed by other practitioners. For the story/narrative/case to have authenticity, Wallace and Louden (2000) warn the researcher not co-opt the words and intent of the teachers to fit into their own arguments such that “the participants’ voices are drowned out by the researcher’s voice” (p.10).

**Case Studies**

For the task of reworking a narrative into a formal case, Shulman (1992) provides a framework of shared characteristics that mark teaching narratives: they have a plot; they are particular and specific (not generalized); they are locally and temporally situated; they speak of human agency and intention; and they reflect social and cultural contexts (p. 21). A case that is crafted from a story or narrative must coherently connect its content to theory, and/or be rich enough to generate theory. It must also have the potential to connect with the reader in a transformative manner (Cotton & Griffiths, 2007).

As with all research methods, case studies have their share of critics. It is argued that case studies are: biased/selective, often idealized, often too lengthy, lacking in scientific rigor and generalizability; and thereby rendered unable to produce useful knowledge (Stevenson, 2004). As products of qualitative research, and because they are based on only one (or a very few) events, some researchers argue that case studies cannot in themselves be used to create generalizations pertaining to all teaching everywhere (Carter, 1993; Wals & Alblas, 1997); one would be “unable to claim that all teachers will share identical or even similar ideas and preferences” (Wals & Alblas, 1997, p. 255).
But case studies, like the stories from which they derive, can be considered powerful tools for theorizing if we realize that “the point is not to tell some universal truth about the world, but rather to tell particular truths in order to allow us all, tellers and hearers, to reassess what we understand of the world and so of our own possible actions within it” (Cotton & Griffiths, 2007, p. 550). In further answer to the criticisms of case studies Heikkinen, Huttunen, and Syrjälä (2007) outline five principles that they believe, when considered in the crafting of case studies, address issues of validity, reliability and generalizability. These are: (a) the principle of historical continuity that informs the logic and coherence of the narrative (b) the principle of reflexivity that questions its ontological and epistemological presumptions (c) the principle of dialectics which is concerned with the voices in the narrative (d) the principle of workability that examines the pragmatic quality of the work in terms of its ability to empower others and, (e) the principle of evocativeness that touches on emotions, mental images and memories that the narrative might elicit.

As Wallace (2001) points out, a case is based on real life experiences and is diligently crafted by a researcher/teacher. A case provides multi-layered learning opportunities to both the writer and the reader (Shulman, 1992). Case studies allow the researcher to demonstrate different or contrasting perspectives on the experience being observed and analyzed (Creswell, 2009). A case may be used simply to demonstrate exemplary practice. Secondly, it can be used as a model against which to compare one’s own experiences. Thirdly, it can be used to generate theoretical discussions that move well beyond the particulars of the case. Because each reader brings their own level of experience and understanding to a case, each reader will engage in individual knowledge construction (Wallace, 2001).
Shulman (2004) asserts that a case is “not simply the report of an event or incident. To call something a case is to make a theoretical claim— to argue that it is a ‘case of something’” (p. 207). Likewise, Peräkylä (2005) counsels that, based on the work by David Armstrong, the interpretation of text should be very conscious of placing the work spatially and temporally, the analysis should be informed by theory, and the texts and practices associated with them should be understood to be inseparable. As Shulman further explains, “Generalizability does not inhere in the case, but in the conceptual apparatus of the explicator. An event can be described; a case must be explicated, interpreted, argued, dissected and reassembled… there is no real case knowledge without theoretical understanding” (p. 209). This echoes the post-structural, eco-feminist view that rejects a single meta-narrative to explain the world and instead gives voice to all equally in the telling of their own stories and the construction of their own understandings (Stevenson, 2004).

*Cases, Narratives and Teacher Development*

Case studies lend themselves to educational research in that they provide rich, storied descriptions of the specific, well-documented events being studied (Shulman, 2004), and this makes them particularly accessible to practitioners. The gaps between the ivory towers of academic research, curriculum development and the front lines of classroom teaching are often so great that well-founded research and well-intentioned curriculum changes are never implemented by teachers (Hodson, 2001). Teachers do however, often base personal learning on classroom anecdotes and experiences, as these seem to encompass more of their reality and be sensible and useful (Bolster, 1983, in Hodson, 2001). As Carter (1993) argues, “teachers’ knowledge is… event structured and stories would therefore seem to provide special access to
that knowledge (p. 7). For Alsop, Pedretti and Bencze (2005), the narratives of teachers offer empirical data for both practical and theoretical consideration of exemplary teaching practices. The authors contend that “teacher-narrative(s) offer a richly detailed portrait of a particular social phenomenon. Teachers’ written reflections about their practices are readily accessible and serve multiple audiences” (p. 10-11), including, for these authors, the professional development of science teachers.

Thus a strong argument can be made that the narratives that the science teachers in this project created for each other, in their effort to share and describe their work, were cogent and compelling, serving the intentioned purpose of creating a window through which to observe and perhaps understand each other’s praxis. As Cotton and Griffiths (2007) posit, by describing our world we change it, thereby suggesting that by engaging in such description and analysis the teachers actually challenged their limits and found new avenues for teaching and learning.

Indeed, story, narrative, vignette and case comprise a significant portion of the data upon which this dissertation is based. The six teachers involved in the project frequently used narratives and vignettes to provide context and detail to the points under discussion. They acknowledged the importance that story holds both for teaching and for reflection and this is dealt with in more detail in chapter seven, in the section Issues Related to the Power of Story.

In addition, towards the end of the project I made a general request that the teachers in the project consider writing a narrative piece to reflect their learning journey throughout the project. Two teachers did so and their narratives were reviewed and discussed by the entire group, whereupon both pieces were rewritten and salient discussion questions added. The two narratives, now having some likeness to case studies, can be found in Appendices H and I.
The original intentions for the individual teacher narratives were to provide a method other than journaling, for reflection and discussion; and also to yield narratives that might form the basis of formalized case studies for inclusion and analysis in the dissertation. Both of these intents were met, albeit only by two of the teachers. Both pieces, while very different in their content, are rich and engaging cases. They were certainly used in the data analysis for this project, and each one can also stand alone as an authentic and meaningful starting point for discussion amongst teachers.

In summary, then, stories are not only informal conduits to teaching and learning for students and teachers; stories can also be used in formal contexts, such as trustworthy data for ethnographic research and narrative inquiry, and for case studies as an intentioned method of professional development.
Chapter Six

Project Overview

The following is a general overview of this project. The description of the project focuses on: its geographical location, each of its participants, the role of the researcher/facilitator, and the phases of the project. The phases, as distinct periods or stages in the research process, are further examined under the headings of: Preparation, which details the solicitation of the school boards and teacher participants; Data Collection, wherein the various forms of data-gathering are outlined, and Data Analysis, which includes a description of how the data was treated for emergent themes and explains the rationale for using the headings a prior and a posteriori to categorize topics. A full description and analysis of the data is presented in chapters seven and eight, with a discussion of the findings in chapter nine.

Location

Northern Ontario is an intriguing region, perhaps moreso for me because I did not grow up here but have come to love the boreal forest and the kind, enthusiastic and generous people who have made it their home. I chose to do my research project in a small northern town (population approximately 60,000) for a number of reasons. Most importantly, I consider it my hometown, the place where I live and work, and thereby have developed relationships with school administrators with whom I could negotiate arrangements for the project. In addition, education in Northeastern Ontario, by virtue of its location, receives relatively little professional development through university-based research studies, thus my project was viewed very positively. In comparison to Southern Ontario, the amount of educational research focussing on Northeastern Ontario is quite limited and so provides a fresh alternative perspective. Lastly, I felt
that the lifestyles and underlying values of northerners might provide different insights into
issues in education.

Participants

Due to the size of the town there are only three English-speaking high schools. These fall
under the jurisdiction of two different school boards: the English speaking public board (District
School Board Ontario Northeast), and the English speaking Catholic board (Northeastern
Catholic District School Board). A significant consideration for my project was the actual
number of secondary science teachers in the city from whom I could form a group of interested
and dedicated participants. With only three small/medium sized secondary schools, the number
of science teachers is limited (approximately 16). As a consequence of working in a small town,
I was acquainted with three of the six teachers before the study; however, I made a point of not
selecting any teacher with whom I had developed a personal friendship over the years.

Knowing that the work of secondary science teachers is demanding and time consuming,
and that therefore teachers were not likely to volunteer for the project as an add-on to their
normal work hours, the directors and/or superintendents of the two local English-speaking
school boards were approached regarding their interest in participating in the research project by
providing teacher release time. This was critical in attracting teacher participants to the project,
particularly since there was no compensation or benefit to be gained other than the possibility of
improving their personal practice. Fortunately the administrators of both the District School
Board Ontario North East and the Northeastern Catholic District School Board were very
generous in their endorsement of the project and agreed to release four teachers and two
teachers, respectively.
Next, I met with the principals of each of the three high schools in order to explain the research project and the type of work that the teacher/participants (as yet unselected) would be doing. At two of the high schools, I was given permission to meet with the teachers of the science departments; explain the project; and encourage participants to apply. Eventually there were two applicants, male and female, from each of those two schools. At the third high school, the principal made it clear that he would suggest two teachers, a male and a female, for the project, and I felt that I was not in a position to insist on self-selection by the participants. As it turned out, the two teachers from the third high school were delighted to have been named to the project, and their participation was enthusiastic and committed. Through this process, six participants who eventually formed the group were either suggested by their school administrators and/or self-selected secondary science teachers.

Because it is a small town, many of the teachers already knew each other as acquaintances through school activities such as Science Fair and athletics. Although it was not a goal of the study to create a research group that was equally gendered, and with a wide ethnic diversity, I was certainly hoping that the group would not be homogenous in its experiences and perspectives. As it turned out, the group consisted of three males and three females; all but one of them was white and Caucasian, the sixth being of Arabic heritage. While perhaps not a diverse group when compared to the Canadian demographic, it seemed fairly representative of the overwhelmingly Caucasian population of the town. Missing was aboriginal representation, however, there are no aboriginal secondary science teachers in the city. It was suggested to me that a group of four or five teachers would be an ideal working group, but that I endeavour to enlist six participants in the event that one or two would drop out. As it turned out, all of the
initial six participants remained with the project, and only one participant missed one meeting for work related reasons. Within a very short time, they together formed a strong commitment to the project and to each other.

During the first meeting the members of the group introduced themselves, and in subsequent meetings we came to know each other quite well. Following is a synopsis of that information, particularly in terms of each member’s experiences with science and with the natural environment.

*Harvey*

Before becoming a teacher in his mid-30’s, Harvey completed a Master of Science degree which gave him the opportunity to work in a genetics lab analyzing data on wolf populations, and preparing papers for publication. Realizing that he was not committed to the life and work of a research scientist, Harvey decided to enter the teaching profession as a science teacher. He completed an outdoor and experiential education course at an Ontario faculty of education, an experience that he believes taught him a great deal about facilitation. Harvey then taught overseas in Israel, Guatemala and Korea before accepting his current position in an Ontario public secondary school. He is an avid birder, fisherman, and hunter; holds several outdoor skills certifications; and is the teacher-advisor for his school’s environmental club.

*Sharon*

Sharon began her teaching career with three years at the elementary panel. Since then she taught secondary science for 7 years, and is currently the head of the science department in her high school. By her own admission she loves to teach science, particularly when students ‘get the connections’. Her undergraduate degree in the health sciences continued to influence her
teaching at the secondary level such that she enjoyed teaching anatomy and physiology but was not enamoured of topics such as plants or weather. It was only after her move to Northern Ontario that she came to appreciate the outdoors; however she felt that this had not been connected in any large way to her teaching practice. Sharon described herself as more of a ‘take charge’ teacher than a facilitator; however she came to all of our discussions with a very open mind.

Bart

Bart spoke with amusement of his early years camping with his family in the pop-up trailer, his first experiences with the natural world. While doing his undergraduate work, Bart loved the study of microbiology but intensely disliked the lab work, and so, like Harvey, he decided not to follow a career in research, but opted for teaching instead. In his early years of teaching in Brampton, Ontario, he developed an environmental awareness through working with the outdoor club at the high school. After a year of teaching in Bogotá, Columbia, Bart returned to his hometown in northern Ontario, and had been teaching secondary science for eight years.

Tess

Tess was in her second year as a high school science teacher. She completed her Bachelor of Education degree at a northern university, and was very happy to acquire a teaching position close to home. Tess described herself as not being all that interested in nature until quite recently, when she began getting outdoors through personal activities such as running. Tess brought to the project her a raw enthusiasm; a willingness to learn, and share; and the academic perspective of someone recently graduated from a faculty of education. Tess’s teaching assignment included a
particularly difficult class of grade 10 Applied students, of whom all but two were boys. This class came to figure significantly in Tess’s experience with the group.

Jane

Jane considered doing graduate work after completing her undergraduate degree in chemistry, but found the field too competitive and so she ‘fell into teaching’. She had been teaching science for 22 years at the same secondary school, and that, in her opinion, gave her a strong sense of history in that school. Despite being a ‘northerner’, Jane cringed at the idea of hiking or camping, and she disliked teaching ecology; yet she had serious environmental concerns with respect to the health and well being of her family and students. Jane expressed repeated unease at being in a group whose purpose was to learn about embedding EE in science curricula because she felt that she had virtually no foundational knowledge of environment and natural history. Despite her initial sense of misplacement Jane’s contribution of her extensive knowledge of science curriculum, understanding of students, and honest insights figured significantly in the work of the group.

George

George had been teaching secondary science for 13 years, and admitted that he loved teaching Ecology. George completed a Master of Education degree 11 years ago, and continued to be struck by ‘the positive power of doing’ so it was no surprise that he was very involved with extra-curricular activities at his school. George brought a wry humour to the group and lived up to his self-described love of story-telling.
Because I was so much a part of this group as we constructed knowledge together, I have chosen to include myself in the description of participants. I had been teaching at the secondary level for almost 20 years, mostly as a science teacher but also in geography and art and with Aboriginal student groups. Prior to that I lived and taught at the elementary panel for three years on a fly-in reserve in Northern Ontario, and previous to that I was an instructor in an outdoor education/therapy program for incarcerated youth for three years. I also taught academic upgrading and life skills courses at the college level for a couple of years. That remarkable collection of experiences most certainly shaped the educator that I have become. Now that I have gained some very unique life and educational experience it is with great pleasure that I am engaged in doctoral studies with a focus on my two passions, teacher development and environmental education.

It feels as if I have been outdoors walking, running, hiking, skiing and paddling my whole life and that is likely true. As a teenager, I developed a delight in being outdoors in a physical way, and that has never left me. I have intentionally brought the outdoors into my classroom on many occasions, and have most definitely taken my classroom outside as a normal part of my praxis.

Early in my career, during my time as an outdoor instructor of incarcerated youth, it was our practice as instructors, at the end of each work day, to debrief and discuss the events of the day, focusing not only on the behaviours of the students but particularly on our actions as instructors. It was a time for honest and constructive feedback for every instructor, and certainly a critical time of professional growth as I found myself on the steepest learning curve of my life.
(matched only many years later by my doctoral studies). It was also the time when I came to realize that instructor (and teacher) development were key elements in successful student learning. Consequently, over the last thirty years I have taken numerous opportunities to involve myself with teacher professional development.

When taken collectively, the descriptions of the participants portray a group that had a diversity of teaching experience both in years and in locales, including teaching overseas as well as in Ontario. The group displayed a variety of personal and professional perspectives on environment; ranging from Jane’s distancing herself from it, to Harvey’s high comfort level in it. Despite differences in experience, perspective, age, and personality; the group members very quickly and intentionally sought coherence as a group, evidenced by their ability to both laugh and work together. Between them they were familiar with and had taught the full range of secondary science courses offered in Ontario, and were able to speak knowledgeably about specific provincial curricula. These were all teachers who had agreed to place themselves in positions of risk, in that they knew that their opinions would be challenged, and they would be asked to work and share with each other. However, they also were confident that the risk would exist only within the group; confidentiality outside the group was explicitly understood.

It was my intention that the research would take the form of practical-emancipatory AR (Pedretti, Bencze, Hodson, DeCoito & Di Giuseppe, 2003); collaboration between me as researcher/facilitator, and practicing science teachers. As researcher/facilitator of the group my role was to be twofold. Initially, I would act as facilitator to set the ground rules for the group, and identify the specific issues of including EE in science curriculum. I intended to set the agendas of the first meetings, and facilitate activities and discussions, with the intent of giving
over ownership of the agenda to the participants as expediently as possible. I was also to act as
observer and documenter of the individual and group processes, as the action research
progressed through its different stages. In my multiple roles as researcher/facilitator/observer/
documenter/participant there lay a certain dilemma: how could I fulfill all of those roles and yet
give ownership of the project to the group? This remained problematic throughout the project
and led to continued reflection and readjustment of my role. Nonetheless, my relationship with
the group was collegial and collaborative, with each participant’s contribution equally valuable
and valued, and wherein I endeavoured not to hold a privileged position. We were all
researchers/travelers together.

*Phase One: Preparation*

As a requirement of the Ontario Institute of Studies in Education at the University of
Toronto, it was necessary at the outset of the project to acquire approval from the University of
Toronto Ethical Review Committee. The salient points of the approved ethics protocol covered
issues of: conflict of interest, my experience as a researcher, participant recruitment, risks and
benefits of the research, informed consent and withdrawal of participants, and confidentiality
and privacy of participants. Most notably, all data collected through group conversations and
interviews remained confidential; such that no comments made by participants regarding
specific schools, administrators, colleagues or students might put themselves or others in
jeopardy. In addition, all participants are referred to in this dissertation using pseudonyms. The
full *Ethical Review Application* is included in *Appendix G*.

As described earlier in this chapter, participants were recruited from the science
departments of the three local English-speaking high schools, through a series of school
principal and science department meetings which outlined the project and the nature of teacher participation in it. As a result, two science teachers from each of the three high schools agreed to take part in the AR project. Prior to participating in the project each of the six teachers was required to read and sign an *Information Consent Form (Appendix B)*, which clearly outlined the project and acted as an informal contract. The terms of the consent form addressed the following: (a) the project would span the fall secondary semester (September 2008 to January 2009) and meetings would occur every two to three weeks for a total of six half-days, with exact dates to be determined by the group (b) the respective school boards would consider their involvement as professional development and provide release time for each of the teachers (c) participants were expected to attend the meetings, participate in discussions, keep a reflective/learning journal, write a reflective narrative, and maintain a strict and professional level of confidentiality concerning all matters discussed or contributed during the project (d) participants knew that their conversations would be audio-taped and that the data, and at times direct statements under pseudonyms, would be included in the analysis of the ensuing dissertation (e) participation was voluntary, and so they could withdraw from the project at any time without penalty of any kind.

Through a fortuitous lack of meeting rooms in any of the educational buildings to which we would ordinarily have had access, the AR group met regularly in the board room of the local Family YMCA. The YMCA is currently housed in a large, old elementary school; however it has been sufficiently renovated to remove much of its institutional character. Our meeting room was a comfortable, bright space with modern furniture, and windows overlooking the city towards the river. (Action research that is separated from the usual workplace, institutions and power
structures is supported by Capobianco, Lincoln, Canuel-Browne, and Trimarchi [2006] and Zuber-Skerritt [2002] as it enables participants to separate themselves, to some extent, from the influences of those entities.) Teacher participants mentioned, on more than one occasion, how much they appreciated being out of their immediate work environments for our meetings.

Having received approval from my thesis committee, the University of Toronto Ethics Committee, and the local school boards and having both recruited participants and secured a meeting location; my last preparation was to develop agendas for the first meetings. I recognized that these meetings would be crucial to the project, as they would set the tone for whatever would be accomplished during our time together. Thus, I decided to take a similar route to the one that I had on in terms of reading and thinking about the nature of science, the nature of environmental education, and the merging of the two.

Phase Two: Data Collection

The Participants’ Data

Initially, I had proposed two layers of data to be collected during the project: the data for my research and dissertation, and the data deriving from the action research which the participants were undertaking. However, the participants’ data collection was problematic, in that they did not recognise systematic evidence as a necessary aspect of the action research cycle. (This was due largely to our collective inexperience with action research; a problem which is further discussed in chapter nine, Proposition #8.)

That is not to say that the participants yielded no evidence of environmental education being embedded in their science lessons and the responses of their students in that regard. Both Bart and Jane provided student-generated posters on the topics of energy resources and

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environmental hormones respectively, as samples of classroom work. The posters from Bart’s class were part of an assignment in which groups of students were assigned an energy resource, such as wind power or coal-fired generators, which they had to defend before the class. Bart brought his students’ posters to the fifth meeting, where the participants were able to discuss the posters, and the lesson linked to them. Jane’s posters remained in her classroom where I was able to converse with her students as they worked on them.

During my classroom visits on *Shh! Environmental Day*\(^1\), there was an abundance of student work; for example worksheets on the chemistry of groundwater, lists of organic products in the local grocery store, and tally charts of vehicle use and fuel consumption. However, the participants made no consistent or structured effort to compile these as pieces of data to substantiate their descriptions of their experiences in the research process.

Instead, the evidence that they found useful for their action research resided within the animated and enthusiastic discussions that they undertook during each of the six meetings. Throughout the transcripts evidence can be found that each of the teachers, to varying degrees, cycled through the AR model in terms of identifying an aspect or issue of EE in secondary science; clarifying their thinking through conversations with colleagues; together generating ideas for a suitable lesson; implementing that lesson; and then describing and reflecting on the results. More specifically: (a) George’s AR project on *Shh! Environment Day* was to use story to inspire students to take environmental action (b) Jane’s project was to facilitate a lesson on

\(^1\)The participants decided to choose one day on which all of their science lessons would have strong elements of environmental education; they collaborated on the individual lessons they would teach and afterwards discussed the outcome of each lesson. They chose to call this focal day of their action research project *Shh! Environment Day*. It is described more fully in chapter eight.
environmental hormones using newspaper and magazine articles rather than a lecture (c) Bart’s project was to teach about sound through a study of dolphin morphology and behaviour (d) Sharon’s project was to study nutrition by way of a field trip to the local grocer (e) Tess’s project was to teach a junior chemistry lesson through a study of local vehicle use (f) Harvey’s project was to teach a senior chemistry lesson through the lens of water use and purification.

Each of these project lessons were discussed in great detail by the participants, both during the developmental stages (meetings three and four), and in terms of debrief and reflection (meeting five). Also, while each of their projects might have generated substantial concrete data in the form of student work and/or journal entries, for the participants in this study, the data was tacitly understood to be largely situated within their meeting conversations.

The Researcher/Facilitator’s Data

It was intended that the data gathered during the project, for my purposes as the researcher/facilitator, should be sufficiently rich to address the two themes of the research questions stated earlier: the theoretical foundations, epistemologies and values of secondary science practitioners; and the changes that might impact them at the confluence of EE and secondary science. In the tradition of ethnographic research (Cresswell, 2009; Denzin & Lincoln, 2000), my data was collected from a variety of sources and in several forms.

Although I had hoped and expected each teacher to keep a reflective or learning journal during the course of the project, the participants did so only for the first two weeks, after which they ceased, citing reasons to do largely with time. I however, did keep a journal in which I recorded the events of the project; as well as my thoughts and impressions before and after each of the meetings, interviews, and classroom visits. Audio recordings were made of all six
meetings, each of which lasted 2.5 hours. Audio recordings were also made of the initial individual interviews, each of which lasted 20 to 40 minutes, and occurred for most participants shortly after the project had begun. Other data included documents that the teachers themselves had created or collected, as part of their normal classroom activities and as part of *Shh! Environmental Day*, to provide evidence of their practice and of student learning. In the form of posters, assignments and lesson plans, these data spoke to the enactment of EE within secondary science. This enactment was further evidenced through my visits to each of the participant teachers’ science classes during the *Shh! Environmental Day*, and the notes that I took during those times. And lastly, although meagre, the teachers' first journal entries that documented their initial progress in the AR process, and the reflective narratives prepared by two of the participants, served to give further voice to the experiences of the participants.

In keeping with the requirements of trustworthiness in data outlined in chapter 5 (*Story and Qualitative Research*), there was diligent attention given to data collection for this project: (a) the project spanned several months (b) consideration was given to member checking and thick description (c) data derived from various sources (meetings, interviews, classroom visits and teacher writings) ensured triangulation.

Data collection and analysis were ongoing throughout the project. Digital audio recordings were transcribed after each meeting and interview. These, along with my field notes and journal entries, were sorted and analysed for common themes. A complete schedule of data collection can be found in *Appendix C (Chronology of Data Collection)*, while the readings used to elicit comments and discussion are included in *Appendix E (Readings for Meetings)*. The process of data analysis is discussed in detail in the section titled *Phase Three* of this chapter.
The Meetings

It was my intention to set structured agendas for at least the first three meetings in order to establish the general topics and direction of the action research project. Toward these ends, and because I felt that we were working in a short time frame, it seemed important for the participants to develop collegial relationships and a clear focus fairly quickly. With this in mind, each of our first three meetings began with a group activity, meant to act as ice breaker and/or introduction to one of the topics for the meeting, after which the participants would engage in discussions based on readings that I provided.

At the outset of the first meeting the group had to perform an initiative task called *The Nuclear Reactor Game* which required the participants to collectively use strings and rubber bands to position containers of water in a certain configuration, thereby beginning the process of communicating and working together. During this meeting, all six participants and I introduced ourselves; spoke briefly about our science teaching and personal backgrounds; and described the reasons for our participation in the project. We then read about and discussed the nature of science in contemporary education.

The second meeting began with an activity requiring the identification of local conifers based on their needle structure. I brought real twig samples of indigenous trees to the meeting as a means of setting the tone for the topic of environmental education, and to provide a teaching and learning opportunity for the participants. Indeed, the participants spent some time discussing not only the types of trees present, but also how strongly the outdoor classroom figured in their practice. We then proceeded to an examination of the many ways of defining and understanding environmental education, as well as the ramifications of the report *Shaping Our Schools,*
Shaping Our Future (Ontario Curriculum Council, 2007), for their schools, classrooms and colleagues.

The third meeting began with an activity meant to contextualize natural phenomena in order to connect it to our experiences and those of our students. Participants were shown a series of animal tracks (see Appendix E), and asked to determine not only which animals made them but also to speculate on the nature of the event; they were encouraged to ‘tell the story of the tracks’. The resulting stories served to spark a discussion on how often context is the factor that engages students. It was during the third meeting, having been grounded in topics of science and EE and upon examining the teaching strategies suggested by Smyth (2006) (found in Appendix E), that the group decided on a plan of action for their research, and an agenda for the remainder of the project. Their exploration into the embedding of EE in science lessons would culminate in a full day of EE/science which they named Shh! Environment Day. The day is detailed in chapter eight.

It had been my intention to withdraw from a position of leadership by this point in time; however, it was apparent that the group perceived this project as my responsibility much more than theirs. Perhaps this was due to my inexperience with action research, or my subconscious desire to remain in control of the project, or perhaps it was a result of the participants’ inexperience with this type of professional development. In any case, I found myself continuing to set the agenda for meetings, preparing readings, and presenting introductory activities.

The fourth meeting served as a time of preparation for the environmental lessons that the participants intended to teach on Shh! Environmental Day. To set an STSE (science, technology, society and environment) tone for their planning, I presented to the group a small light fountain
consisting of a battery operated light emitting diode and a cluster of thin clear plastic fibres, which together demonstrated the simple physics of fibre optics. The discussion over the light fountain ranged from its underlying physics, to how fibre optics have impacted local and global societies, and what effect they might have environmentally. This focused our discussions, during the first half of that meeting, on how matters of science and technology are inescapably connected to issues of society and environment; and provided a framework for the second portion of the meeting during which the participants worked together on preparing their lessons for Shh! Environment Day.

The fifth meeting was almost entirely taken up with a thorough debriefing of each participant’s lessons on Shh! Environment Day. I was pleased that I had been able to visit their classes on that day, as those visits allowed me to contribute additional observations of student engagement and teacher practice that had gone unnoticed by the teachers who were busy with their students. During the second portion of the meeting we discussed the importance of story in our personal lives and in our teaching, and the use of formalized case studies was introduced. I then asked the participants to consider writing a reflective narrative examining some portion of their work or learning during the project.

The sixth and final meeting began with reading and discussion of the narratives prepared by two of the participants. Suggestions were made by group members for revisions and questions in the style of formal case studies. As it was the last meeting, the participants discussed the ramifications of embedding environmental education into their science practice, and how they might adapt the AR process to suit their individual situations. Lastly, we reviewed the
recently released *Science Curriculum for Grades 9 and 10* (Ontario Ministry of Education, 2008) which calls for the inclusion of EE in its units and topic areas.

*The Interviews*

Towards the onset of the project all of the participants were interviewed individually, as one of several methods to gather data to develop rich, contextual understandings of their personal epistemologies and practices, and to provide opportunities for them to speak outside of the influence of the group. The participants were encouraged to speak to their *inward* feelings, hopes, and values, their *outward* individual contextual situations, and their *backward and forward*, or past, present and future thoughts regarding science education (Clandinin & Connelly, 1998). Interviews took place at the teachers’ convenience, in their classrooms or working spaces, and generally lasted between 20-40 minutes. The questions in the initial interviews explored individual beliefs about science education and environmental education, and were meant to provide insight into how I could further enhance or facilitate the action research process for the participants. For example, the questions included: What do you think are some of the most important aspects of science that secondary students should learn? and What are are your initial impressions of the action research project?

Although I had also hoped to interview all of the participants during the spring semester, two months after the completion of the project, in order that participants would recall and speak to the most salient aspects of the project and identify any changes evident in their practice in their new classes, only one of the participants answered my emails and found the time to be interviewed. Questions asked during the secondary interview included: Has participation in the project changed your views on what students should know or learn in science? and Was the
collaborative approach of the project a positive one for you? The questions for both the initial and secondary interviews can be found in *Appendix D, Interview Protocols*.

*Classroom Visits*

As an additional form of data collection, I requested permission from each teacher to visit their classrooms during the project, particularly on the day on which they were teaching an embedded EE lesson in one of their science classes. The classes were generally 70 minutes in length, and were held in various locations in each of the three schools that I visited, including the school chapel, the chemistry lab and the school roadside. In each location I was able to join the class and participate in the activity.

After I was introduced as a researcher of teacher practice, rather than a student evaluator, the students seemed very comfortable with my presence as I circulated throughout their classrooms and discussed their various lessons with them. They were eager to show me their work, and easily discussed with me their thoughts about the lesson. As a science teacher by training and experience, I was able to participate in a small way in the various lessons that I encountered, and I was also able to observe ways in which environmental issues were being integrated through the verbal messages of the teacher, through the information found within the lessons and through the work of the students. During Tess’ lesson I took on more of a teacher persona since the students in that class were particularly unruly and Tess and I had agreed beforehand that I could assist with management issues while the class was outdoors.

Science classes are generally very busy for teacher and students, so as a second observer I felt that I might notice different situations, or possibly notice them in a different way, than the classroom teacher. The class visits provided an opportunity for two observers (the teacher and
the researcher/facilitator) rather than just one and thus offered two perspectives on how EE impacted science curriculum and pedagogy on *Shh! Environment Day*. These visits are discussed in more detail in chapters seven and eight.

*Journals and Narratives*

As mentioned in the previous chapter, the teachers did not produce significant reflective journal writing; however they did have an additional opportunity to engage in a similar activity. During the fifth meeting, after a brief discussion of the personal and professional importance of story, the participants were asked to write in story form about an aspect of their own learning journeys during the project. The purpose in this request was threefold: by writing with intention about their experiences, the teachers would have an opportunity to reflect on and analyse their experience in the project; secondly, their narrative writing would constitute yet another source of research data addressing participant epistemology and experience and lastly; if rich and compelling, their stories would provide unique learning opportunities for other science teachers faced with implementing EE within secondary science curriculum.

During the sixth and final meeting two of the participants shared their narratives, whereupon the other participants were asked to comment and provide suggestions as to how the simple narratives could be developed into cases. Both narratives proved to be quite interesting as they juxtaposed the experiences of the least experienced and most experienced science teachers in the group, a contrast that furnished additional material, beyond the scope of EE and science, for discussion.

As discussed in chapter five, for the purposes of this dissertation, a narrative is understood to be a portion of a larger story lacking in one or more elements such as plot,
character development, etc.; while a case is a very specific intentioned narrative about a particular topic or event, usually accompanied by questions to focus reflection and discussion by the readers. As a form of professional development for teachers, the development of a case is often equally as useful as the study of that case (also covered in detail in chapter five), and as such, the case development activity proved to be an important element of the project for the participants. The two narratives were further developed to a point where they might be considered rough drafts of cases. In this form they can be found in Appendix H and I. Both narrative cases were considered as part of the larger data set of journal and reflective writing, and as such, were used in the data analysis.

Phase Three: Data Description and Analysis

The data collected over the course of the project, which spanned several months (September 2008 to April 2009), was largely in textual form, including transcripts of meetings and interviews, my journal entries, posters and lesson plans, and two narrative cases. The transcriptions of audio recordings were usually completed within one or two days of the recording; however data analysis did not begin until after all six group meetings had occurred.

Organizing the Topics

In order to analyze the data I first had to organize it. To do so I decided to use a simple, but very intuitive software called OmniOrganizer which allowed me to sort, list, categorize and cross reference pieces of text. Upon my initial reviews of the data I decided that my view of what would constitute a significant theme or topic would share several common characteristics: (a) the topic had been discussed in the literature review (for example: the various perspectives of EE that educators might hold) (b) the topic was discussed by the participants at great length at
least once (c) the topic appeared briefly on numerous occasions in the data (for example: the use of textbooks in science classes) (d) all, or almost all, of the participants held an opinion on a topic (for example: the importance of content knowledge in science was discussed more than once and by all of the participants) (d) a resonance in the data with my personal experience (for example: EE as a concern of the white middle class). Based on these criteria I began the analysis by organizing a section in OmniOrganizer that I titled Themes in the Research. Under this heading I established the following subheadings: (a) science content is important (b) science is being taught in traditional, positivist, reductionist paradigm (c) EE is interpreted in different ways (d) embedding EE (f) action research is a powerful form of professional development (g) the power of story (h) RF issues (i) other issues.

Within the above categories I collected and grouped specific references in the data, both in the form of short notes and phrases and also full quotes, as they related to each of the various subheadings. For example, under the subheading science content is important I noted that Jane, George and Tess all made mention of their view that ‘people who never took a grade 9 or 10 science course could still be good citizens, but maybe need some basic science’. At the same time I created a corresponding section, with identical subheadings, in which I cut and pasted specific quotes from the data that confirmed my notes.

Initially, I named the topics that I had expected to find a priori topics because I felt that I had knowledge of them prior to the experience of data collection, through my survey of literature, and through my personal experiences as a secondary science educator. Indeed, I anticipated finding evidence of the a priori topics when I first asked the four research questions that underpin this project, several months before the work of the teacher participants even began.
However, I began to notice that the data offered insight in a number of directions that my review of the literature addressing science education and environmental education had not covered, but nonetheless spoke clearly to the research questions. For example, on several occasions the participants spoke of their reliance on textbooks to interpret curriculum, but the literature I had read had not addressed the importance of textbooks in this regard. Therefore, I compiled notes and quotes referring to these unexpected pieces of data under the general subheading other issues. Eventually the subheadings under other issues included: (a) textbooks (b) gender (c) building relationships with students (d) EE as a white, middle class concern (e) not all school expectations are equal (f) responsibilities of teachers (g) fuzziness of EE (h) teacher resistance to change (i) demands on students (j) taking students outside (k) teacher experience and comfort level (l) other initiatives like the Catholic graduate expectations (m) classroom management (n) Tess’ class. As with the a priori topics, I created a corresponding section of direct quotes from the data.

Naming the Data Streams

The category of other issues continued to grow, and I realized that I would have to consider more fully the emergence of unexpected ideas from the data. I began to use the term a posteriori as a means of juxtaposing the unexpected emerging ideas from the a priori topics which I had expected to find.

This naming of the two topical streams was rooted in my earlier concern that I not overlook meaningful issues in the data because I was too focussed on the expected; I needed a way to guard against such omissions in the analysis. However, the New Oxford American Dictionary (2005) offers these definitions: “a priori: reasoning or knowledge that proceeds from
theoretical deduction rather than from observation or experience” and “a posteriori: reasoning or knowledge that proceeds from observations or experiences”. At the point of actually writing the analysis for this dissertation I realized that perhaps the terms a priori and a posteriori were, by virtue of their exact definitions, no longer the most appropriate headings for chapters of the analysis. The overlaps of my many observations and experiences; before, during and after the project made the accurate identification of topics inexact. The two terms, a priori and a posteriori, had served their function of vigilance for me. However, my search for suitable alternate headings did not yield much beyond the expected and the unexpected, which seemed remarkably uninspired. Thus, I was faced with the dilemma of using my working terminology which had become imprecise but held resonance and meaning for me; or bowing to the precision required by the conventions of dissertation writing. I chose to retain my working terminology.

Once I had reread the data several times and felt that I had identified both the expected topics and unexpected ideas revealed therein, I was faced with organizing the raw analysis in a meaningful way that would facilitate further exploration, discussion and possible implications. I decided that the a priori topics, while somewhat diverse, were nonetheless straightforward and so I examined each of these in turn; they are found in chapter seven. The emerging ideas that had originally been listed as other issues presented more of a problem: they were a scattering of ideas that overlapped in some respects (teacher experience, comfort level and resistance to change) and in other ways were quite diverse (Tess’ class and EE as a white, middle class concern). In addition, I believed that each of the participants had made significant individual contributions that should be separately examined. After some deliberation, I decided to use Schwab’s (1973) four commonplaces (subject matter, learners, milieu and teachers), required for
the curriculum creation process, as a method of reorganizing the scattered ideas in other issues; to identify them as topics, and as a means of including an analysis of each of the participants. In some instances, what had seemed to emerge as an issue or idea was subsumed by a larger topic area. For example, the issues of Tess’s class are explored in the section titled Teachers that deals specifically with Tess’ work in the project. A full exploration of the resulting a posteriori topics, based on Schwab’s framework, is found in chapter eight.

In summary, this chapter describes in detail the components of the project, including its location and participants, and the role of the RF. In addition, the project comprised of three phases which are also explained: the first phase entails the preparations in advance of data collection; the second phase involves the various methods, chronology and description of data collection; and the third phase addresses the methods of data exploration and analysis. The following chapter will continue the examination of the categories a priori and a posteriori as a preamble to the subsequent exploration and analysis of the collected data.
Chapter Seven

Data Exploration: A Priori Topics

Chapter seven begins with a restatement of the argument made in chapter six (Phase Three: Data Analysis), wherein I make a case for using the terms a priori and a posteriori as suitable categories for an exploration of the data. The opening argument is followed by an analysis of the emergent a priori topics which include: the concerns faced by myself as the researcher/facilitator; the issues surrounding the teaching of secondary science as they relate to the nature of science, the importance of pure content over STSE, and a discussion of various related pedagogies; the issues surrounding environmental education including its interpretation and its delivery by teachers; the issues that arose from the action research model; and the power of story as a source of student and teacher learning, including two narratives written by teacher participants.

The A Priori Dilemma

As a result of the preparation of an extensive literature review preceding data collection, and because of the specific directions towards which I focussed the work of the group in the first two meetings (the nature of teaching secondary science and the nature of environmental education (see Appendix C), I could not help but assume and expect that a number of well-established topics would present themselves in the data based on the scholarly literature upon which the project had been built. For example, my first review of the data revealed supporting evidence for the power of action research, and a focus, by the teacher participants, on science content. As explained in chapter six, I decided to label the group of expected topics a priori topics, as they stemmed from my experiences prior to data collection. The a priori topics
included: the teacher/participants’ understanding of science content and pedagogy; their understanding of the nature of science; their interpretation of the form that environmental education would take; their experiences with action research; and the power of story for both students and teachers.

However, as I continued to identify a priori elements in the data, I was becoming increasingly concerned that my focus on what I already expected to find would blind me to any new themes or ideas that might otherwise be found. Such was my dilemma and my journal reveals this apprehension:

So here’s my muddle… I don’t want to be looking for things that I know I will find, yet I have been ‘informed’ by the current literature and some of the things that I am looking for… rather I should be reading the data and identifying ‘trends’ in the data. So its kind of a bind between knowing what to look for and hoping to find something that I’m not expecting. (Personal Journal, January 5, 2009)

Fortunately a number of unexpected and interesting topics, not readily evident in the literature, did emerge from the data and I decided to name that group of ideas and themes a posteriori topics. I did not anticipate finding them prior to data collection. The a posteriori topics became known to me, not through a review of literature, but through my direct experiences in the project. The a posteriori topics are dealt with in detail in chapter eight, and include: the development and contributions of the six teacher/participants, the importance of textbooks and the internet as curriculum makers, difficulties arising from embedding EE, the impact of the revised science documents, an EE/administrative disconnect, the multiple responsibilities of teachers, and the difficulties of student engagement.
One might argue that both the a priori and a posteriori topics were generated by the project and are therefore inappropriate as designations, nonetheless, I have chosen to use the two terms with some license; as they provided me with an initial structure for identification, and labelling of elements in the data; and came to have some enduring meaning for me. Indeed, a post-positivist perspective suggests that data, particularly qualitative data, is both collected and presented through the subjective lens of the researcher’s personal position, regardless of efforts to remain objective and neutral. Therefore, attending to the subjective lens will be the first task undertaken in this chapter; and will necessarily inform the subsequent analysis, description and discussion of the data.

**Issues Related to My Role as Researcher/Facilitator**

One of the most prevalent ideas in the literature on action research was the complexity of the role of the researcher/facilitator in an action research project. As the researcher/facilitator (RF) I found that my role was manifold and difficult; made moreso by my desire to share my experiences and insights, and my personality which is somewhat bold, outgoing and easily dominates conversation in a group. It was an exercise in self-restraint for me to remain outside the discussion except to facilitate lightly, when appropriate, trying to find a balance between leading and following. While it was my initial intent to engender within the group significant freedom in their topics of discussion, foci for research and curriculum development; I found that the participants were quite content to have me take a leadership position. For example, both Brad and Sharon commented on the goals of the group:

Sharon: Because bringing it back and having a purpose and goal, and your goal which became our goal, you know, I think that helped frame it…
Brad: We were able to get so much done in six weeks because we had a facilitator and we had a direction right from the get go. (audio-recorded meeting, January 13, 2009)

The data reveals that the dynamic of the group, and my position and role, changed over time. During the first two meetings, as the RF, I set the agenda with readings and discussion focussing largely on the nature of science and the nature of EE. These meetings proceeded in a predominantly technical form of AR (to use Carr and Kemmis’ [1986] term), in which the participants had very little autonomy, and the RF controlled the group’s learning. This was intentional on my part, as I felt it was necessary to build a foundation of philosophical and epistemological understanding, before embarking on a research project intended to challenge entrenched science teacher culture and curriculum enactment. An excerpt from my journal speaks to this:

This idea that teachers prefer practical, technical, procedural pd is interesting, and that a group can gravitate in that direction without a lot of thought given to underlying theory and understanding foundations … this group is, I think, trying to tackle both but to different degrees in each individual… for example George tries to connect to theory but gets himself caught up in ‘stories of the day’. (Personal Journal, October 31, 2008)

During the third meeting, upon discussion of STSE initiatives, and the difference between student activities and student action; the group took on the task of designing the research component of the project. At this point I deliberately remained a silent observer as they struggled with creating what would constitute for them a reasonable and interesting project. In the subsequent meetings, as RF, my relationship with the group evolved towards a practical-emancipatory form as described by Pedretti, Bencze, Hodson, DeCoito, and Di Giuseppe (2003),
which became collaboration between the RF and the teacher participants as they worked through
the design, implementation, and analysis of their project. Nevertheless, I believe that the group
never took full ownership of the project, a familiar and comfortable position for most teachers
involved in professional development.

However, project ownership and project direction were not the only issues that presented
sources of tension for me as the RF. I also felt that in the course of securing significant teacher
release time from two school boards, I had made a commitment to provide valuable and ongoing
professional development opportunities for the teachers involved, thus my focus on current
literature and discussion in the first two meetings. This perceived obligation was coupled with
my own belief that secondary science teaching needs to move towards a more issues-based
approach, especially at the grade 9 and 10 level; certainly I had a personal agenda
notwithstanding my desire to facilitate objectively.

Another tension that became quickly apparent was the disconnection between the
language of the teachers and that of the researcher. Two of my journal entries are reminders that
we were often communicating from different positions:

Remember that they are speaking as teachers, not scholars or researchers, and they
haven’t been thinking about science in the same terms that I have…

...once again obvious that teachers tend to speak and think in terms of their practice, very
rooted in day to day events, whereas I’m trying to link that to more metaphysical
thinking, trying to tweak things out of what they are saying. (Personal Journal, October
19, 2008)
Fortunately, my classroom experience is not far removed from my doctoral studies; an orientation that allows me access and insight into their positions of communication, and into finding the connections between the teachers’ very practical, pragmatic talk, and my own academic/scholarly/philosophical requirements for this dissertation.

**Issues Related to Science Content and Pedagogy**

It was gratifying and encouraging realizing the strength and potential of a project firmly grounded in theory. There was readily apparent evidence in the data of topics that had surfaced during my review of the literature that informed this project, as clarified earlier in this chapter, a priori topics. It is important to note at the outset of this examination of the data that for almost every point that the participants discussed, they struggled with the consequences it held for their students. In this sense the conversations that they had were by nature reflective and critical of their praxis, rather than defensive of their teaching practices.

*The Nature of Science*

In an introductory conversation about the nature of science, when the participants were asked what image came immediately to mind upon hearing the word scientist, the characteristics they offered pictured a male with messy hair, in a lab coat with goggles and test tubes. Sharon observed, “I’m embarrassed to say he’s male even though I know better.” (audio-recorded meeting, October 2, 2008) When asked to comment on the nature of science, George offered this explanation in which he separates science from the real world and suggests that the real world is full of misconceptions and preconceptions:

For me, in science we should be following lots of patterns, lots of rules to follow, scientific method, lots to follow, whereas in the real world, knowing some of that,
knowing the rules, I still get sucked into real world interpretations of events. My example was that we teach in the old heat unit that cold is simply the lack of heat, cold doesn’t exist. However, I say to the girls, “Girls close the door, you’re going to let the cold in”, like it exists. You know I teach in period 4 about heat and then I go home and tell them not to let in the cold. (audio-recorded meeting, October 16, 2008)

Another intriguing view of the nature of science versus the nature of teaching science was articulated in a conversation with Harvey, in which he explained his decision to leave research and enter teaching. He makes the distinction that science itself never seems to find definitive answers, whereas the classroom allows him to work with answers that are currently deemed acceptable science content.

Harvey: Science to me is about questions.

George: Seeking answers.

Harvey: Yes, seeking answers, and that’s why I got out of research because I realized it totally wasn’t about finding an answer. It’s about finding the next question. So I realized I could be there thirty years, but I was never actually going to solve it.

RF: So you went into teaching because you thought that would be more…?

Harvey: Yes, I could give them the answers I had. (audio-recorded meeting, October 16, 2008)

Indeed, the participants all agreed that what is currently taken for granted as scientific fact will very likely be outdated and possibly completely wrong in the future; they appreciated the transient nature of scientific fact. Tess in particular, felt that scientific literacy would ameliorate any damage:
George: Yes, a kid today said, “You know I bet you in fifty years they’ll talk about this cell part and it won’t even do the job that we think it does.”

RF: What did you think about that comment?

George: I’d send them to the office! [laughter] No I said, “You’re right, as you said, we are always answering the next question, and so yes you’re right, what we believe now, particle theory is another example, we thought this at the beginning, now we know more and more.”

RF: So I’m really playing devil’s advocate here. So when you give a test of cellular organelles, structure and functions and some kid fails, in fifty years they may not fail because your facts are wrong.

Tess: But they were just doing the best they knew how. We are doing the best with the knowledge that we have now, right? So that’s all we can really do, and just hope that we pass on enough scientific literacy so when they do go to the next level … that they can have an understanding of what they need to understand. (audio-recorded meeting, October 16, 2008)

In further discussions about the nature of science, the participants made it clear that their understanding of science as a social undertaking was that it is neither neutral nor apolitical. In their discussions defining science the participants acknowledged that social and political policies drive science research and that the reverse is true as well:

George: (science is) seeking understandings and explanations of phenomena.

Tess: Policy driven, like a lot of the policies that exist are because of science.

RF: You mean like political policies?
Tess: You know like there’s no smoking in restaurants because smoking causes cancer.

RF: Is that what you mean? Science underlies or drives social policy? Would you agree with this?

George: It’s not the only thing driving it. But it can drive it.

Jane: Social policy drives science.

George: You’ve talked about that Harvey, in the lab, the competition and seeking grant money and that it was not easy.

Harvey: And I wasn’t in a very competitive field but I’ve heard that people who are involved in cancer research for example, were so competitive that they actually had to put lists of people not to send their papers for review because they wouldn’t approve their publication just because they’re doing the same research and they’ll take their ideas, steal their ideas. ...Its so competitive and there’s so much money involved. Because we were linked with the Ministry of Natural Resources too I heard of a lot of policies that were passed based on political agendas and not on science, like the spring bear hunt.

(audio-recorded meeting, October 16, 2008)

Harvey also made reference to the egocentric or selfish position that science takes in its dealings with nature. Following are two quotes from the same conversation:

Well science to me is any way that you interact with the world around you, right.

Whether it’s physically, whether it’s chemically, whether it’s biologically. It could be that you are on a walk and you find something and you’re not sure what it is, and the question is what is that? What does it do? What’s that animal doing?
... And one thing to add is that it (science) has a very egocentric view. It’s about humans in general, but I think it’s an explanation of how things relate to us, or how we interact with things around us. (audio-recorded meeting, October 16, 2008)

*Science Content as the Primary Component of Curriculum*

This group of science teachers seemed to have somewhat post-positivist understandings of the nature of science, and yet despite their views, for very well-defined reasons, traditional content material was the overriding component of their secondary science studies. Primarily, they felt that students required content; specifically the content of the three elite disciplines of physics, chemistry and biology, in order to proceed to the next grade level and that this need should dictate curriculum:

RF: Why is the weather unit not as important?

Bart: Because they never see it again, which I know that’s it, and the same with the astronomy unit, it’s something they live with every day but...

RF: You mean they never see it again academically?

Bart: Yes.

George: They’re not going to be responsible for that.

...

Sharon: I’m spending like 7-8 weeks, at least, on one unit (chemistry) at the expense of something else.

George: Well that’s why the space unit doesn’t get attention and that’s why the weather unit doesn’t get attention. (audio-recorded meeting, January 13, 2009)
Sharon suggested that the expectations listed in the Ministry of Ontario science curriculum documents, along with her own comfort level, were partially responsible for her pedagogical choices:

Sharon: I think it’s these expectations, I don’t want to blame it on that but that’s my comfort as well.

RF: So expectations are leading you more towards...

Sharon: ...more towards scientific fact, not scientific discovery and how to techniques.

(audio-recorded meeting, October 16, 2008)

Indeed, Sharon and Jane both expressed discomfort with teaching content material with which they were not thoroughly familiar, and cited this as their primary reason for not attempting to teach some topics or tackle certain activities and teaching strategies. They also felt certain that they were not alone in this regard, and that a teacher’s comfort level generally plays a significant role in what and how topics are covered in the classroom.

However, curriculum decisions were not always theirs to make alone. The culture of an entire science department could come to bear on what content would be taught, despite individual teacher’s misgivings.

Sharon: It was a department decision and we looked at the curriculum and space (unit), they will never see space again so don’t do the space unit. And it’s too bad because we might have the next astronaut sitting in our classroom. Why would we ignore that, the knowledge? Even though we might not see it going much further in the courses that we have (here), in university they could go very far with this, so I think it’s very limiting.
We’re not the only stake holders in those decisions. (audio-recorded interview, October 17, 2008)

It is interesting to note here, that Sharon’s argument for including space in the curriculum was to encourage university study for some select students. However, the study of space topics such as satellite orbits and emerging technologies are relevant to all students. In this comment there is a seeming lack of knowledge of the STSE aspects of space studies, as well as an underlying assumption that science studies serve the university bound student primarily. As another example of teacher culture impacting curricular decisions, George, in describing his practice, explained that he spends a great deal of time teaching topics that fascinate him personally which results in enthusiastic and engaged students who, unfortunately, do not cover the entire curriculum. This was deemed unacceptable at the senior science level and resulted in a threat by his department head, that he would not be rescheduled to teach the senior courses that he enjoyed the most.

George: I was told that if I didn’t cover all the units I would not be allowed to teach the course [grade 12 university biology] again. (audio-recorded meeting, October 1, 2008)

This led to some discussion of the merits and necessity of content in a science curriculum.

Harvey pointed out that it was difficult to tackle issues or problems without some foundational knowledge:

I think knowledge is important. I don’t think its the only thing but I definitely think that introducing a problem to students without them having any knowledge, well you’ll get something out of it, but I don’t think you’ll get nearly as much as if they had good background knowledge. (audio-recorded meeting, November 19, 2008)
Many of the teachers also expressed their sense of obligation to senior students in particular; the need to arm them with enough content knowledge that they would succeed at the university level.

Harvey: What’s the goal, right? Is it getting a high school diploma and then going on to university? A lot of it is knowledge-based, these are the facts they need to know, this is the information we need to disseminate. There’s no real demand for a person to take that one step further into problem solving situations. Very few anyways, so there’s not demand later on, then [that’s] the preparation in high school.

Tess, as a second year teacher, was still learning many of the fundamental lessons of classroom management and curriculum delivery, and as an added challenge she was teaching a class of 18, grade 10 applied level students, 15 of whom were boys. This class proved difficult for her and was often the topic of conversation for the group, as she frequently described incidents that occurred in the classroom, and was grateful for the advice of the more experienced members. In a way, the project became a mentoring session for her, and I believe that although she was often overwhelmed by the demands of her work, she remained with the project because it provided such strong support for her practice. Nonetheless, it was through some conversations with her, that it became clear that the teachers believed that content was much easier to teach and to evaluate than STSE lessons, and that transmitting content lends itself to a traditional structured classroom in which students remain quietly at their desks, and complete structured text-based seat work.

The importance of science content for these teachers was also demonstrated in their conversations around assessment and evaluation, wherein the prominence of the unit test became
evident. Traditionally, the pencil-and-paper unit test is the ultimate measure of the students’ understanding of the science content covered; while other assignments based on activities, regardless of their thoughtful design and implementation, are considered secondary indicators of achievement. Unfortunately, not all students do well in formal pencil-and-paper testing. In discussion the value of such tests was questioned:

Sharon: That’s what gets me, it’s the assessment at the end, sometimes it drives me crazy that I have to mark them [the students], because we’ve done activities for two or three weeks. Like with microbiology we’ve done tons of stuff with the grade 11 [college] class. We had fun, we grew bacteria, we checked antibiotics. Very hands on and I wish I didn’t have to test them because they’re not that good with testing, but in the everyday activities they were active. That part you know, where you have to generate a mark, its too bad you just can’t say, “They did well”. You know, just as a participation mark.

RF: You could have a lot of that built into a rubric.

Sharon: Yes probably.

RF: And make your rubric count as much as your written test.

Jane: And you don’t have to do it (the unit test),

...

Harvey: But if there was a shift though, are we doing students a disservice if we know their endpoint or their potential endpoint? We know they’re going to university and they’re going to have to write a test; they’re going to have to write a multiple choice test…”

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Tess: But even if they do go to university, chances are they have had experience writing tests. And maybe for one unit you don’t do a test, even in your 4U class. They’re still going to have tests in all their other units.

Harvey: Oh, absolutely. You could cut back your number of tests and you could diversify your evaluation so it doesn’t just focus on their test marks, but I’m asking can we eliminate those things? (audio-recorded meeting, November 19, 2008)

By the end of this conversation it became clear that the teachers were willing to give up some of the importance of the unit test in favour of other assessment strategies, but it is noteworthy that their decision-making was based on the supposed needs of the university bound student; a genuflection to the academy. Ironically, the number of students from all three high schools, who go on to study science in university, is a very small percentage of the overall student population.

Sharon pointed out that as a result of the content-based nature of secondary science, teachers can confuse scientific literacy with scientific terminology. This is an insightful statement as it alludes to the difference in pedagogies between content-based teaching perspectives versus issues-based perspectives. Not only do teachers sometimes prefer content-based traditional pedagogies; it was pointed out that students often prefer a version of science that is structured and ruled and has conclusive answers.

Harvey: It goes back to the classroom...how many times have you asked students to go seek the answers to something, right, and they just really look at you and say, “Can you just give me the answer, just give me the notes?” rather than go search for it themselves. So maybe we’ve programmed our students.
George: It’s more efficient for us to give them the work and then get the test done.

(audio-recorded meeting, November 19, 2008)

Given this reasoning, it was interesting that the participants also commented that they believed that most students did not remember much science content after their exam was over, but they did tend to remember activities and the teachers involved. The irony of this dilemma was not lost on the participants, and it created a segue into an exploration of the uncertainty that all of them felt at one time or another when making decisions regarding pedagogy.

*Science Pedagogies as Sources of Uncertainty*

Early in the project, Jane, who had two children attending school in the elementary panel, asked the question, “Where does the joy of science go between elementary and secondary?” referring to the comparative apathy of many secondary science students. She, of course, had a vested interest in the quality of science education, as her own children were soon to enter high school. George introduced *the groan* that erupted from students in his class upon beginning a new science topic, and others in the group were readily familiar with that student response. We asked George to pursue the reason for the groan with his students. Their responses pointed to boredom brought on by heavily text-based, teacher driven science lessons. As recounted by George, one student offered, “Well we wrote so many notes and so many definitions and it was so much paper and you know I don’t write very well and it takes me so long”… George himself continued, “So your suspicion was accurate, that yes it was the traditional, he had gone through so much paper and pencil work he was anticipating more of that.” (audio-recorded meeting, November 5, 2008)
And students are not alone in their groaning; these teachers also wondered why certain topics cluttered a curriculum that they felt was already too detailed to cover thoroughly, prompting teaching strategies that approached an enforced march through curriculum. Tess, in the midst of teaching the grade 10 applied science course to a group of unruly boys, questioned the usefulness of topics such as nomenclature or cell theory, and together with Jane and Sharon agreed that the content of the curriculum was inappropriate for a large number of students at their respective schools. All of the participants felt that student response to this situation was to abdicate responsibility for learning, and an expectation for the teacher to simply give over required information.

The participants often focussed their discussions around their concerns about conveying science content. In one such conversation, Sharon voiced her anxiety that the ‘curriculum police’ would come after her if she deviated too far off the prescribed course of curriculum. Cases illustrating this point are science lab activities, and the formal lab reports often associated with them. During our first meeting the participants spoke of labs as part of the secondary science culture; they had to be covered in a certain traditional way. Yet the participants questioned the value of ‘cookie cutter’ labs, with full text-based recipes that did not elicit much thinking on the part of students but were much easier for the teacher to administer. Keeping in mind that the six teachers in the project were from three different schools, two different boards and, working in a relatively isolated northern community; it is easier to understand that they were delighted to discuss their practices in detail within a trusted circle of peers who were not immediate colleagues. As their conversation circled the topic of science labs, they were pleased to find that the culture of science teaching was not definitive; formal labs and their lengthy
reports could be set aside in favour of student-based labs and smaller assignments that assessed students’ understandings of the lab. In the second meeting George declared:

Well after we left last week and other people said, “Oh no, we’re not doing those long labs, those big formal labs.” All right! I’m not going to either. This is awesome! (audio-recorded meeting, October 16, 2008)

The participants proudly recounted a wide variety of what they termed, “interesting science lessons”, which included bringing a freshly killed grouse and fish into biology dissection, designing golf courses and taking field trips to wilderness areas. The participants’ conversation frequently indicated that they were often torn between engaging students in interesting science versus covering curriculum. These two were not seen as one and the same; and doing both separately was not deemed viable given limitations of time, resources and scheduling. Any tangential lessons, no matter how timely, could cause the inexorable march to ‘lose a day’.

The topic of student-centred teaching eventually led to a conversation in which group members described how they preferred to control the outcome of lessons and labs; lending a covert teacher and content-based slant to what was intended to be perceived by the students as an experimental student activity.

George: All the time I have to reassure the kids I don’t have all the answers. That’s why we’re talking about this. But they kind of think you do. By grade 10 or 11 they still think I should know about every topic under the sun.

Sharon: I don’t know, maybe you’re not the resource person that you often are with academic knowledge.
Harvey: You’re sending them off to solve a problem but you kind of already know the answer to the problem.

...

Harvey: So you’re hoping that they go towards where you already know.

Sharon: And you usually know the endpoint.

RF: And you’re usually the one who mixed the solutions to start with and you probably cranked those solutions to make sure that they got…

[laughter]

Jane: ...Long ago when we had the dialysis tubing, it used to be in the grade 10, and I’d make sure I’d add glucose you know, as the things were sitting on the side. Add some stuff to make sure they get the right colors because otherwise when a lab doesn’t go right, oh! (audio-recorded meeting, November 19, 2008)

School or board initiatives also seem to impact how teachers view their flexibility with curriculum; in a discussion about student-centred curriculum, in which the content and direction of study is not entirely determined, Jane pointed out that, “Our school board is pushing backward design though, so you couldn’t do that at all, you’re supposed to have an endpoint and then work backwards.” (audio-recorded meeting, November 19, 2008) Her statement suggests that content was still her perceived endpoint, rather than skill development or attitude, both of which could be accommodated with a student-centered approach in backward design.

Although mentioned earlier in this analysis, the issue of teacher confidence deserves additional attention because it continued to surface throughout the project, particularly in reference to undertaking issues-based pedagogies, as advocated by the revised Science
Curriculum for grade 9 and 10 (Ontario Ministry of Education, 2008). (I confess to a certain surprise that the teachers did not perceive their roles with more emphasis on being learners in issues-based pedagogy, rather they viewed themselves almost entirely as bearers of information for student use. My career and experience have been such that I have been, on occasion, in a position where I had to learn content information one step ahead of the students, and quite possibly learn it at the same time or from one of them. It seemed appropriate to me, at those times, to model what might be termed good learning behaviour; giving up my authority over knowledge while remaining the supervisor and facilitator for the group. I suppose that I assumed this to be the case as well for peers and colleagues.) In one conversation between Harvey and Sharon, they discussed the concept of student-centered, issues-based teaching strategies:

Harvey: I was thinking even from a political standpoint, you look at Stephan Dion and he was going to assess the issues, and they were going to work together and figure out a solution, identify the problems and figure out a solution. He got crucified because he didn’t have a plan already saying, “This is what we’re going to do”. So there’s a lot of impatience because people want to be told what to do and the second you don’t, the second you say, “Well we’re going to see what the problem is,” you get crucified for that. I don’t really like him but still I thought it was pretty unfair for somebody who said, “I’m not going to jump the gun, I’m going to see how things work,”

RF: yes

Sharon: Ok, take that into a classroom, but would students lose, not necessarily respect, but confidence in a teacher, and if students don’t have confidence in you I don’t know, I think I’d feel a little more vulnerable. (audio-recorded meeting, November 19, 2008)
Harvey, who tends to have considerable confidence in his practice, pointed out underlying resistance to the value of working through issues using a political example, but Sharon expressed her dismay at not knowing the outcome of an issues-based, possibly politically coloured approach. Later she commented:

Sharon: That’s what I was going to say, that because of who we are we’re not necessarily activists, so are we always able to identify problems? And is that why I’m not always comfortable with all sorts of issues sometimes?

RF: Political?

Sharon: Political? No absolutely not. I don’t have that background. (audio-recorded meeting, November 19, 2008)

As it turned out, the term political was misunderstood between us and upon clarification, a conversation ensued that pointed to the Harvey and Sharon’s intuitive understanding of the importance of democratic citizenship as a curricular expectation:

RF: Let me define my meaning when I say ‘political’. I mean helping the students to become democratic citizens in a democratic society, so the sense that they can effect change.

George: They can make a difference.

RF: They can make a difference. Active citizenship. So that’s what I mean ‘to act politically’, not necessarily to...

Bart: Civic duty.

RF: Does that fit into a science class?...
Harvey: It is the most important thing, because I think if they can develop their own views on any issue and support it then that’s what’s going to effect change in anything they’re involved in. If they’re just going to sit there and take in information and do what they’re told then that’s what you’re going to get...

Sharon: ... I mean, technology, discovery, all of this does advance human kind so that is a powerful tool. Not only do you want to be able to create it, you want to be able to think about its implications or its need or its much more than just creating it right?... Like science can cure disease, it can get us to the moon and beyond. I mean that’s powerful information. So you don’t just want to inform them, you want them to know what to do with it. (audio-recorded meeting, November 19, 2008)

Discussion of issues-based teaching approaches to science provided an opportunity for me to present short excerpts of scholarly literature as reading material intended to further encourage critical reflection of individual practice. One piece that made a particular impact was based on a comparison by Jensen and Schnack (1997) of student activity versus student action. This article maintains that it was only the latter that would have valuable and lasting effect on student learning. The response from the group suggested that they had not considered this dichotomy or its implications, and they were both deflated and defensive when faced with the suggestion that they should be doing more with their students:

Tess: It makes me feel stupid.

Harvey: Yes it does, because they’re saying things like action versus activity.

Tess: Yes.

Sharon: It’s not just saying this is one and this is the other, its also judging it.
Tess: This is why it’s wrong,

George: When we were talking, I was thinking, “Oh my gosh [sic], I was so happy when those activities have worked and you know you feel like it was a great lesson and the activities worked”. Well (the activities) didn’t (teach) anything because (the students) didn’t change their behaviour...

Harvey: You know I think that this idea of activity versus action is more problem-based work; problem-based thinking where you have a problem, you don’t just figure out what the problem is, you actually take the steps to figure out what the solution could be and what you could do, right? But for the most part that’s not really demanded of students at higher levels, so it’s definitely not demanded at lower levels.(audio-recorded meeting, November 19, 2008)

Harvey was particularly affronted by the premise that student action had far more value than student activity, and argued that student action was based on a complex array of factors beyond the scope of a single teacher.

Harvey: I just had an issue with action. To me comes from interest right? If you’re interested in something, you’re more interested in the action part of it. If there’s something that you’re passionate about, even at a young age, you’re more likely to get involved in solving problems about it, whereas, as long as we have a curriculum that’s telling students that they have to take two sciences and a math and an english, and you’re expecting them to step up and get really into a topic from an action standpoint, I don’t know if you really can do that… I found it really insulting in that way because I thought that it said you should interpret the curriculum and be flexible with it and most teachers
aren’t. That’s the way I interpreted some of what you were saying. Which I think, if we look at the curriculum expectations and the fact that you have to do your job, I’m not sure that you can. (audio-recorded meeting, November 19, 2008)

Issues Related to Environmental Education

At this point in the AR project, after careful deliberation of issues of science, and how they impact teacher practice, we moved on to a series of readings and discussions regarding environmental education and what the participants understood that to encompass.

The Interpretation of Environmental Education

We began with imagining an environmentalist. The initial reaction of the group was to describe a hippy, with tie-dyed t-shirt and long hair, laying down in front of a bulldozer or chained to a tree. They immediately realized that this was actually the image of a fringe activist, and that possibly environmental education (EE) carried this connotation as well. A discussion followed in which each teacher tried to describe their personal understanding of EE, and how it might already be present in their lessons.

Initially, their views of EE mirrored significantly the existing grade 10 curriculum unit that addresses environmental science topics. Jane mentioned biological and chemical interactions, nutrient cycling, and human interactions. Sharon added concepts such as nature appreciation, minimizing environmental impacts and ecological footprints. George wondered about what constituted the term ‘environment’. It was Harvey who took the conversation to another level in trying to articulate his sense that, in teaching about the environment, teachers often do so as if they were not actually part of it. In fact, Harvey suggested that he holds a
certain personal view of EE that stands separate from the EE that he teaches in school, the latter easily becoming a very negative portrayal of human enterprise on the planet.

Harvey: Well I have these two views: from the school perspective, EE to me is more ecology, its more observing things in the natural world and humans are more on the outside watching how things happen, whereas what I really think is that EE is really no different than just science in general. That it’s how we interact with the world so there should be no difference, but I find when I go in the classroom and talk about environmental stuff I almost think of us as on the outside looking in ... when we teach about natural cycles and we teach about natural systems I always feel like we are not really a part of that, the only part that we seem to play in that is when we disrupt those natural cycles. So it’s almost a negative. Its a negative role that we play in that system and that’s why maybe people feel like they are being preached to when we talk about it...

(audio-recorded meeting, October 16, 2008)

Prompted by Harvey’s comment that EE was often viewed negatively, the group spent some time considering the reasons why EE was not a more popular topic amongst students and teachers.

Jane: You know when we start the ecology unit, you know that’s not my favourite unit but the kids always groan when we start the environmental stuff.

RF: Why do they groan?

Jane: I don’t know and I say, “This is the stuff that affects you more than anything. This is what you should really be interested in. It’s going to affect your whole life whether
you never see science again”. But they do groan. It’s, “Ooohh”. (audio-recorded meeting, October 16, 2008)

Perhaps, it was as Harvey suggested; that environmental studies was, for most students and teachers, a study of the negative with significant finger-pointing and preaching about the gluttony of a Canadian lifestyle. This standpoint is driven home with regularity, beyond the classroom, as different forms of media not only influence what qualifies as an issue, as Tess maintained, but bombard subscribers with ‘green’ information. Small wonder that students are neither interested or excited by what has become the mundane, and which amounts to a condition over which they have very little personal agency or control.

However, another possibility put forward for the negative response to EE in classrooms was the nature of EE itself, and its systems approach to understanding environment which contrasts with the reductionist nature of most science content knowledge. Many students (and their science teachers) are uncomfortable with a perceived lack of rigour in EE; the group called this quality its fuzziness acknowledging that environmental studies was not as cut and dried, nor as neatly packaged as most other parts of the science curriculum.

Jane: But kids hate that (fuzziness) too. They are uncomfortable when there’s not a right or wrong.

George: Because it’s all justification of their position at that point, which some students struggle with.

Sharon: Do you think that in 4U, a lot are math people? They don’t like the non-math part of ecology. They don’t like the reading and the writing and the explaining. It’s like,
“Gimme [sic] that and I can do that, I can solve these things”. (audio-recorded meeting, October 16, 2008)

Individual interpretation of EE is influenced by knowledge and experience; a great EE lesson is limited in large part by teachers’ comfort zones of knowledge, skill and management abilities. When asked what they thought would be a perfect EE lesson, the teachers all described lessons that had some components linked to critical thinking and multiple perspectives. Their lessons included: role-playing food webs, online ecological footprint calculators, sustainability comparison posters, ecosystem tag, and golf course surveys. All of the participants mentioned taking these activities outdoors but it was Jane who lamented:

Jane: Ok, I think a great lesson would be just taking the students out somewhere. You people have taken them out to Duck Lake and done a field study. They’ve brought stuff back and I would love to do something like that but I am uncomfortable out there because I really don’t know what things are, so that would be a great lesson to me.

(audio-recorded meeting, October 16, 2008)

It is noteworthy that none of the teachers’ activities had overt STSE elements; despite its existence in the science curriculum documents (Ministry of Education, 1999) for the last decade, STSE had not entered the daily work and language of these teachers. In a similar way EE was treated in their discourse as a subset of the larger enterprise of pure science, requiring special strategies for its inclusion in their lessons. In my role as RF, and continuing in the vein of exemplary EE lessons, I shared with the participants a partial listing of teaching strategies compiled by Smyth (2006) that are often associated with EE (Appendix E, meeting #3). The list
included terms like: lifelong, interdisciplinary, learner centered, locally relevant, systemic, issue and field-based, and action-oriented.

The participants discerned that these approaches were not restricted to EE alone, and as Bart pointed out, they would be considered the hallmarks of any good science teacher.

Bart went on to register surprise that the list made no mention of nature or the environment, at which point Sharon made, what I considered to be, a remarkable comment. She suggested that EE is a way of thinking about teaching; the quintessential EE teacher is one whose every lesson is permeated with a sense of place.

Bart: Actually I’m just looking at the list right now. I don’t know if I’m missing it but there isn’t really anything in there... but this list of EE doesn’t seem to have anything about how you can impact the environment.

Sharon: It’s more like its not EE about the environment. It’s EE as a way of thinking about teaching. Teaching style... it’s not necessarily about the environment. (audio-recorded meeting, November 19, 2008)

While the rest of the group did not share Sharon’s enthusiastic insight, they all agreed that by using the listed teaching approaches, issues of environment would naturally surface in a lesson.

One last matter bears mentioning concerning the perceived nature of EE. At one point in the conversation I offered my personal perspective:

RF: I see EE as kind of an umbrella term and under the umbrella are all these other things like environmental science, outdoor education, where you go snowshoeing. And there’s adventure education and experiential education, where you just go out and try it and see how it works. And all those problem solving things. So for me EE is all that
stuff, as well as understanding the interactions, the environmental ecology, the human interactions of how we affect the environment. It even includes some politics. So for me EE is sort of an umbrella term that covers all these bits and pieces. (audio-recorded meeting, October 16, 2008)

At the time this description was met with nods, and I thought that I had stated the obvious, but as we were getting ready to leave the meeting, Sharon commented on how she had been surprised by my placement of components in the model of EE that I had described. She realized that, based on teaching the unit on ecology almost exclusively from her textbook, she had come to think of the scientific study of ecology as the larger umbrella under which EE was a smaller piece; most of the time an add-on to curriculum from the back pages if time allowed. This brief exchange served to remind me that not only could I make no assumptions about what other science teachers understood or thought about science or EE, but that I had to continually and proactively seek out each teacher’s viewpoints if I was to gain any real understanding of the circumstances of this project.

*Embedding Environmental Education*

I have included a description of the research project, designed and implemented by the participants, here in the a priori topics, as it was certainly one of the outcomes that I had envisioned and expected as part of the work of the group. The ideas and insights generated by their work on their own project, while new and interesting for our group, are not unique to the curriculum development and teaching experiences described by other action researchers (for example Hodson & Bencze, 1998; Pedretti, 1996).
After the first meeting, which had served to introduce the topic of environmental education within secondary science curricula, the participants spoke often of being keenly aware of the unplanned EE opportunities or teaching moments that presented themselves during most of their lessons. Jane was delighted to report that she and her students had embarked on a lively conversation about the use of cars and freeways, during a chemistry class. Each of the participants reported similar examples of impromptu EE in their science classes. However, I pointed out to them that action research was premised on an intention: it required that they plan, design and implement, observe, and reflect on an investigation of some kind. Thus, during the third meeting, the group was nudged along the AR cycle and encouraged to design and implement a research project addressing an aspect of their teaching of science and embedding EE.

It took them some time to narrow their ideas to a realistic and workable project; since initially they felt obliged to include their colleagues in their learning journey. Wisely George pointed out that doing something small but doing it well was preferable to the opposite. After great deliberation the group decided on a project that would enable them to explore the challenges presented by *The Bondar Report* (Ontario Curriculum Council, 2007), and its call to embed environmental education in every topic and every grade level. The statement which they constructed, and which formed the basis for their project was: *Can we model a small group approach to embedding environmental studies into curriculum?*

They chose to designate a day during which each of them, at their respective schools, and in their respective classrooms would continue to teach the curriculum they were currently involved in, but to do so from a decidedly environmental perspective. This was to be,
simultaneously, a group project and an individual exploration, inasmuch as they would help each other with lesson ideas and strategies, but each of them would be teaching a different lesson in a different science course.

Sharon: Because in the end what do we want? What’s our goal? At the end of the lesson do we have a common goal? ... Because if we keep that in mind then we can all go in the same direction even if we are doing different things.

George: Like education for the environment through this environment day. (audio-recorded meeting, November 5, 2008)

As their project idea began to take shape and they set a date, they were extraordinarily excited, and worked enthusiastically with each person to assist in lesson planning. The knowledge that they would all be engaged in their research project on the same day across the city was a form of agreed-upon mutual support. As George put it, “Strength in numbers even though no one else knows.” (audio-recorded meeting, November 5, 2008)

We had talked at some length about what it meant to teach about the environment (knowledge), in the environment (outdoors) and for the environment (leading to student action or activism). They questioned whether it would be possible to meet all of these criteria in one lesson, and quickly realized the inadequacy of such a plan. However, as their lesson planning progressed they continually looked for ways to address teaching about, in and for the environment, as well as attending to the list of Smyth’s (2006) teaching strategies mentioned earlier.

Concerned that their efforts to integrate EE into existing science curriculum would be met with the student resistance which we had talked of in an earlier meeting, and eager to tackle
a realistic embedding of EE such that it no longer was discernible as a distinct topic, but rather an integration of STSE, the participants decided to make the project a covert operation. They would not mention to students or colleagues that their lessons on that day were specifically designed to embed EE; no one but our group knew that it was to be an environmental day. The challenge was made greater by their intention that the lessons on that day would not veer far off the course of the planned curriculum, yet contain substantial embedded elements of EE.

Harvey: To slide it in without them actually realizing that it’s something related to the environment.

RF: So don’t even tell them.

Harvey: Yes, don’t even tell them. ... It should be something that just somehow flows naturally. (audio-recorded meeting, November 5, 2008)

Thus the day came to be known as *Shhh! Environment Day*.

While not a topic for this dissertation, certainly the idea that environmental lessons, and by extension environmental attitudes, have to be covertly included in curriculum seem somehow flawed. Yet the line of reasoning that led to the decision was reasonable, and as the idea caught on it lent a measure of humour to the project and assisted with cohesion of the group.

*Issues Related to Action Research*

The literature addressing the action research model (see chapter four) informed the agenda of this project, particularly as a mode of collegial professional development, and a strategy for qualitative research in education. Also, as suggested by the literature, the action research model can engender certain issues and deliberations. There was, for me, an ongoing consideration of who was doing the action research. By definition and intention it was the
teachers who were researching an element of their practice while my research entailed an ethnographic observation of their work.

However, the teachers’ research was lacking in concrete evidence; except for Jane and Tess who storied their experiences in the narratives that they wrote.

Surrounding the discussion of formal lab reports, a sense that teachers can give each other permission to do things differently, and make changes in their practice arose; a nod to the underlying culture of secondary science teachers, and the desire to remain within the values and practices of that culture. Nonetheless, Harvey appreciated that in this particular group, he felt the participants were able to say what they really thought, rather than what others wanted to hear, which he felt was not normally the case among colleagues. This illustrates a certain level of trust among the participants which, I believe, arose out of their original agreement as participants in the project, to respect the confidentiality of the group, and was shored up by their common respect and appreciation of each other.

Both Tess and Jane admitted to feelings of isolation as teachers, and appreciated the opportunities to simply share good ideas with colleagues from other schools. In particular, Jane, who has been teaching science for over 20 years, commented:

I’ve been teaching for a long time and, you know I think I’ve taught every grade 9 science course over and over and over, and I can just go, “Ok where am I at?” and I can just go, right? And it’s boring. And being in this group, it’s just refreshing me, and I’m actually, like Sharon is saying, I’m thinking now and I’m thinking from an environmental point of view and it’s just making things more interesting for me and I think for the students as well. (audio-recorded meeting, December 4, 2008)
Indeed, discussions of lesson plans were peppered with teaching ideas and science trivia, making for very engaging conversations that required timely redirection by the RF. It was most evident to me at those times that the group would have been content to continue to share teaching strategies without the added work of pursuing action research, and that this was very much my project that I was urging on them. I wondered at times if I had properly framed the action research model for them; if I had given them enough autonomy in the project; if I had drawn them sufficiently into critical epistemological reflections that their practice might be impacted. Then towards the end of the project Bart commented:

I’m actually looking forward to teaching the 3E (science) next semester. Never taught it before. I don’t know anyone who’s every taught it before. I have nothing in terms of resources, so its going to be interesting after doing this, its going to kind of change my philosophy going into the course, you know integrating stuff into it... just the idea of every day how can I make them think about the impact of environment. I’m looking forward to seeing how it works out.

Harvey added:

Even the value of coming up saying, “This is what I’m thinking of doing with my environment day class,” getting feedback, like suggestions, sharing the outcome and getting feedback. Imagine if you could do that on a weekly basis, with a new activity you wanted to do with your class, right? Or a new project. Just being able to talk to another teacher ... how often does that happen? (audio-recorded meeting, January 13, 2009)

Essentially all of the participants voiced their appreciation for being given the time (and to a lesser extent, the facilitation) to share their experiences and expertise. Rooted in the sharing
was individual reflection that ultimately impacted practice. Discussion of their positive AR experience led inevitably to a critique of their respective professional learning community activities (PLC’s) as implemented by administrators in each school. The potential for professional development for teachers in PLC’s is akin to that of AR projects; the intention was that time be set aside for teachers to share ideas and work on school, grade or subject-based projects. Yet according to the participants, this potential was not being met for a variety of reasons and in a number of ways. Harvey described his experience:

> It’s a professional learning community, right? That’s what it’s supposed to be, but I don’t know how many times you guys have worked on school goals and things of that nature, ... basically I would frame them as administrative tasks pawned onto staff. ...If you’re going to take an hour that’s not going to be instructional time, you’re going to use it for something then, most valuable would be this, learning from each other. (audio-recorded meeting, January 13, 2009)

It was Sharon who said “your project became our project” and Bart who added, “We were able to get so much done in six weeks because we had a facilitator and we had a direction right from the get go (audio-recorded meeting, January 13, 2009)”. The role of the facilitator is certainly vital, I believe, particularly for groups such as this one, for whom the AR model is new. In my journal I noted that giving teachers the lead was a rocky road, even when the groundwork for a project had been diligently laid out. Teacher dialogue can remain mired in the frustration and excitement of daily work without the epistemological and philosophical considerations of that work, and therefore an inability to move forward in the AR cycle. Teachers have been named as curriculum experts and leaders in AR (Pedretti, 1996), yet they can come perilously
close to fulfilling Pitman’s (2005) criticism that they produce a lesser form of knowledge grounded in practice rather than theory. It became my role in this project to continuously make the effort to move the participants beyond the recounting of school events to consider underlying theory, and also to teach and review the tenets of AR.

While teachers may be considered content experts in their area of curriculum (Hart, 2003; Pedretti, 1996), I could not assume that because they were science teachers, the participants would necessarily have a firm grasp of qualitative research in general and action research in particular. Consider the circuitous path that they took to settle on a research question, and to agree on what would constitute their actual project activity. First, they suggested the most familiar activity for many teachers; that of sharing lesson plans. Then, they discussed the creation of a resource data base of environmental lessons to share with their colleagues, as well as school-wide environmental study days. I continued to remind them of the following: that the action research model requires a common goal, problem or question that needed to be addressed; that they should try to keep their project small, confined to the participant group; and that they needed to be able to generate and reflect on some sort of data. It was after an animated but exhausting exchange that they finally settled on their goal statement (Can we model a small group approach to integrating environmental studies into curriculum?), and subsequently the day of environmental lessons.

Again, because this was a group of science teachers, I expected that they would realize the importance of data; however, the data that they might have generated through journaling was disappointing as they simply did not make the sustained effort to record their reflections on their research. Neither did they bring a great deal of student work to meetings, although it was evident...
through their descriptions of the lessons on environment day, and my own observations in their classes, that quite a bit were generated. Once more I wondered if I had, through my inexperience as an action researcher, not been insistent enough regarding the importance of rich and varied data. I had explained my view that there were at least two layers of research being conducted in the project: my research into their work as a group, and their research into their personal practice. Perhaps confusion arose as to sources and uses of data; they knew that I was gathering data for my research project through our meetings, but I believe that they did not see their work as essentially research oriented and so did not see the need for careful data collection on their part.

**Issues Related to the Power of Story**

The lack of data collected by the participants was ameliorated in part by the narratives that two of the participants, Tess and Jane, wrote towards the end of the project. Their writings came about as a result of the group’s examination, during meeting #5, of the importance of story as a basis for teaching and learning. Harvey asked the question, “Do stories need to be real in order to learn from them?” There is no simple easy answer to this and my response was to question how ‘real’ any story was since it is a subjective representation of something; every person’s version of the same event will be different. Stories in the oral tradition have been the keepers of human history, culture, and knowledge since a time long before hieroglyph or text; we respond to story in powerful ways. Stories connect us to our families and our cultural values (Estes, 1995). Stories were the source of moral lessons and acceptable behaviours when I was young. George described how story seemed to have a greater impact than curriculum content on students:
George: Kids who come back to school, now its 10 years since that first crop of kids I had, and say, “Sir, do you still do such and such?”, and I’ll say, “Yes”, and “Do you still tell that story when?”, “Oh yes, every year I tell that special hug story”. Its great stuff... they remember those moments more than they remember the abcs [sic] that we taught them.(audio-recorded meeting, December 4, 2008)

Story becomes a way for teachers to connect to their students. Tess described her efforts with her very difficult class of boys:

RF: Do they tell you stories? Your class, do they tell you stories?
Tess: Oh my gosh, yes, they tell me so many stories!
RF: Do you listen to them?...
Tess: A lot of them are about the weekend and I don’t need to hear about that, but sometimes they tell me stories about buying a snowmobile and of course I listen to that.
RF: Why?
Tess: Because it’s important to listen and to make that connection and have that rapport because then its only going to help me down the line when I’m trying to talk. You know I listened to your story, now you have to listen to my lesson. (audio-recorded meeting, December 4, 2008)

Story can touch emotionality and spirituality in ways that ordinary lessons cannot. An extraordinary example of this, which I was able to observe, came from George’s Shh! Environmental Day lesson. Not only did George want to embed environmental expectations in his lesson, he also wanted to meet the Ontario Catholic School Graduate Expectations (Institute for Catholic Education, 1998). To achieve this he invited his colleague Marc, the school
chaplain, to team-teach his grade 11 biology class. The class met in the school chapel, a very small, intimate space. The lesson began with Marc re-telling the story of the three little pigs, with a decidedly environmental twist:

George: Big M took over at that point, he’s a famous storyteller. So he was telling a story of the three little pigs, he always has a children’s story and he turns it into something... so he told the story of the three little pigs… Steve, Paul and Kathy, they all love the environment. One of them however, because of business, because of making money, has turned his back on the environment. His company pollutes and pollutes. The second person still sends money to groups, but drives a big fancy SUV, so is living his life pretty traditionally, pretty standard consumption, pollution. The third person, the mom, Kathy is still having a love of the environment, passing it on to her children, through storytelling, through example, through her day to day life, modeling how they run their family household... so that was the house, that was the strong house, the brick house. Marc didn’t say that, but that was like the last house that withstood all the troubles in the world. And so we discussed that a little bit, the three people how they were different and the kids… the kids could almost see themselves in the three little pigs. In these three people, in Steve, Paul and Kathy, and they said, “We know that Kathy’s the best but, can we get ourselves there?” And one guy said, “I don’t know if I want to, I don’t know, because I kind of like the pursuit of that guy’s Hummer and this other guy’s fancy business with all kind of millions of dollars coming in”. So that was a good discussion. (audio-recorded meeting, December 4, 2008)
Marc then led the discussion to embrace Catholic teachings about environment and George described this further:

George: The way Christ and the Catholic church is calling these kids to live would be to not just think, “Well you know I should put that can in the recycling bin because I’m supposed to,” but it should come out of love…

RF: It made me wonder about how much those of us in the public system have any kind of spirituality or emotional, or even help kids make emotional connections…

Harvey: It’s almost like you’re not allowed. You feel like anytime you bring in a spiritual idea, or a personal feeling or a personal belief that you’re imposing your beliefs. (audio-recorded meeting, December 4, 2008)

The participants agreed that stories are a powerful tool to support student learning, and that their potency and influence extend well beyond the years of youth. Indeed, stories can be effective tools for reflection and learning for teachers as well, as discussed in the following topic.

*Two Narratives*

Teachers frequently tell each other stories about their work as a means of processing school events, and improving their practice (Hart, 2003). In a similar fashion, participants in our group shared stories that were both knowledge-based, for example how porpoises hear sound or how whales beach near wind turbines in the North Sea, as well as stories pertaining to their daily practice involving student and colleague interaction. Their stories served as points of connection, allowing every participant access to each others’ knowledge and experience. I have included descriptions of the origin of two teacher narratives in the a priori topics, as I had hoped
that several of these would be generated by the participants. Indeed, the writing of a narrative is listed on the Information and Consent Form (Appendix B) as one of the expectations of participation in the project, and I alluded to the writing of narratives several times during the course of the project.

During the fifth meeting, after talking about the impact of story in our lives, I asked all of the participants if they would consider writing a story or narrative, focused on addressing some aspect of how the project had influenced them. I explained that their stories, with their permission, might be re-worked into case studies that other teachers could use as starting points for their own journeys into environmental education. As participants as well as teachers, they would have a practitioner’s eye for the sort of detail necessary for other teachers to connect to the issues of EE contained within their narratives, and they were in a unique position to identify problems specific to secondary science teachers.

Both Tess and Jane prepared stories that were reflections of some aspect of the AR project in which they had participated. Their first drafts were presented to the group, who discussed them and made suggestions regarding their relevance and accessibility for other educators. The final drafts are included in the Appendices H and I. They offer two very different perspectives on the work of the teachers during the course of the project.

Tess was the youngest and least experienced of the participants, and her story is a direct reflection of her efforts to come to understand and improve her classroom management practices. Her recent studies at a faculty of education had introduced her to the use of case studies as learning tools, and she wrote her story in the form of a case, including discussion questions. Jane, the oldest and most experienced teacher in the group wrote about her inability to
make a personal connection to ecology studies; yet, after so many years, she was able to find a conduit to convey to her students her concerns for the environment, and for the future. I very much appreciated the candour and honesty that Tess and Jane brought to their writing, recognizing that such public and permanent admissions of struggle, which others might interpret as incompetence, were exactly the ingredients of compelling stories with which colleagues might identify. After reading her first draft to us, Jane commented:

I’m not sure if that’s what you wanted because there’s too much of me in there but that’s how I feel. And I thought if that’s what you wanted, about my fear of teaching this, this is why.

RF: I think you described how many, many people feel. (audio-recorded meeting, January 13, 2009)

I believe that both stories, while very different in their style and content, are both rich sources for connection and understanding of the position in which many secondary science teachers in Ontario may find themselves. While I had expected a strong showing of the importance of story for both student and teacher development, I had not expected the power of story to open the door to emotional and spiritual learning to the extent that I experienced with George’s class, nor did I expect the humour and candour of Jane’s narrative, nor the struggle and frustration evident in Tess’ case.

In summary, this chapter examines the topics and ideas for which I expected to, and did indeed, find evidence in the data. In brief they comprised: my concerns of concurrent research and facilitation, science content, and pedagogy; the interpretation and integration of EE in secondary science; the enactment of action research; and the role of story in teacher
development. However, the a priori topics and ideas represent only a portion of what the data revealed. Further consideration of the data revealed ideas and concerns that I had not expected to find, and in a sense they lay hidden in the data. These began to surface as the project shifted through time and intent, and as I began to look beyond the topics suggested by my review of relevant literature. The next chapter, aptly titled *Data Analysis: A Posteriori Topics*, examines these unexpected topics in detail.
Data Exploration: A Posteriori Topics

A Posteriori Topics Uncovered

While it was personally validating to find evidence in the project data that supported, and was supported by, the review of literature addressing science and environment teaching and learning, I hoped that this project would result in more than a corroboration of what is so far understood about those topics. Fortunately, some themes and ideas that had not been demonstrated during my investigation of relevant literature did emerge. They are herein referred to as a posteriori topics and are dealt with in this somewhat lengthy chapter. (My deliberations regarding the process of categorizing topics as a priori and a posteriori are addressed in detail in the last section of chapter six, Project Overview, and the first section of chapter seven, Data Exploration: A Priori Topics)

Because they seemed at first scattered and disconnected, in this chapter I will examine the a posteriori topics using a framework suggested by Joseph Schwab (1973), in his treatment of curriculum revision and development. Using his work as a foundation, the embedding of EE in secondary science curriculum can be viewed as a re-construction of curriculum, and as such, finds common ground with Schwab’s considerations of both the process and the requisite pieces or commonplaces.

Schwab’s Four Commonplaces

Schwab (1973) proposed that in order for curriculum to be most effectively created or revised, the curriculum writing team must be cognizant of four necessary components or ‘commonplaces’ which all hold equal importance for the process. He labelled these subject
matter, learners, milieu and teachers. Subject matter refers to the topic content, and the discipline from which it stems; in the specific case of this project’s data it would encompass themes around secondary science and EE content and pedagogy. Learners is the commonplace dealing with the particulars of the students who, through their teachers, were also participants in the project. The milieu is the commonplace that recognizes the many inter-related communities in which the educative and research process occurred; including the classroom, the community, students and various other groupings. The milieu is conscious of the relationships that exist amongst and between the educators, students, administrators, researchers, and others having various involvements in the project. Lastly, the teachers in the group form a commonplace inasmuch as they bring their individual personalities, knowledge, ideas, backgrounds, experiences and skills to the project. It is necessary to mention that the fifth element, considered by Schwab (1973) to be imperative in the curriculum revision process, is that of curriculum making, requiring the facilitation of the curriculum specialist who would act as chair in the gathering of the representatives of the commonplaces. He describes the duties of the curriculum specialist:

It is he who reminds all others of the importance of the experience of each representative to the (curriculum-making) enterprise as a whole. It is he, as chairman, who monitors the proceedings, pointing out to the group what has happened in the course of their deliberations, what is currently taking place, what has not yet been considered, what sub-ordinations and super-ordinations may have occurred which affect the process in which all are engaged. (Schwab, 1973, p. 505)
Schwab’s description of the curriculum specialist sounds remarkably like the researcher/facilitator in the AR process, and as such re-assigns my role in the project as that of a chair and gate-keeper, not only of the teachers, but of the three other commonplaces, subject matter, milieu and learners as well.

As described, Schwab’s (1973) four commonplaces will provide a framework for the description and analysis of topics and ideas that arose unexpectedly from the research data of the project. By beginning with an analysis of the teacher, Schwab’s fourth commonplace, an initial understanding of the views of the individual teacher/participants will serve to elucidate the further analysis of the a posteriori topics as viewed through the lens of Schwab’s (1973) work. In addition, the analysis of the teachers will include a brief description of each of their individual lessons on *Shh! Environment Day*, inasmuch as the lessons reflect the perspectives and the project work of each of the participants.

*The Teachers*

Schwab’s (1973) fourth commonplace addressed the role of teachers in curriculum making. However, the teachers as participants in this AR project were such a significant and far-reaching component of the project, with a wealth and breadth of rich data, that an additional framework for discussion and analysis was required. For this requirement I turned to the work of Lee Shulman.

In his earlier research and theorizing on teacher learning, Lee Shulman (1986) posited forms of teacher knowledge, such as content and curricular knowledge, pedagogical and propositional knowledge, and case and strategic knowledge, as ways of understanding and describing the work and professional growth of teachers. At the heart of his work was the
question of how teachers transform their knowledge into student knowledge; he further proposed that the content or subject matter of a discipline has significant impact on how that knowledge transformation or teaching could occur. (Most notably, in my view, Shulman turned Bernard Shaw’s adage, “Those who can, do. Those who can’t, teach”, on its ear; and rightly valorized the work of teachers when he penned, “Those who can, do. Those who understand, teach.” [p. 14, 1986])

In Shulman’s more recent work on teacher development (Shulman & Shulman, 2004), he and co-author Judith Shulman proposed five components of teacher learning and development: reflection, vision, motivation, understanding, and practice. In contemplating the profiles of each of the teacher’s participation in the project, I was attracted to the five categories listed above, and decided to use them as leitmotifs to organize my thinking and writing about these teachers’ work.

**Harvey**

With a background in natural science research, Harvey came to the project with significant knowledge and understanding of the scientific and environmental education issues that we tackled in the project. He had international teaching experience, a personal love of the outdoors, and an admitted desire to develop and improve his practice. Thus, for multiple reasons, he showed a very strong motivation to participate. Harvey often modeled a thoughtful and reflective attitude, through his careful listening and consideration of others’ comments, and his deliberate articulation of ideas. In addition, he was a supportive and helpful member of the learning community, with timely suggestions for interesting and creative lesson activities.
It was in the vision for his practice that Harvey felt most challenged by the project, being particularly caught up in the tension between students’ acquisition of content versus an STSE issues-based pedagogy. Following, are a number of transcript excerpts in which Harvey linked content knowledge to university bound students, and voiced his fear that a holistic or issues-based approach to EE would result in the loss of knowledge acquisition:

But if there was a shift though [away from a heavy focus on content-based testing], are we doing student a disservice if we know their endpoint or their potential endpoint? We know they’re going to university and they’re going to have to write a test...

...I think knowledge is important. I don’t think it’s the only thing.

...There’s the idea that we want to take a more holistic approach and get the kids more involved. It seems to diversify your teaching strategy but ...what’s being lost? So maybe knowledge is being lost? (audio-recorded meeting, November 19, 2008)

Yet Harvey also commented on the value of issues-based teaching, as opposed to traditional pedantic lessons, as the basis for changes in behaviour. During the course of the project, Harvey was continually trying to find a balance between the two while teaching senior science courses in chemistry:

I think if they can develop their own views on any issue and support it then that’s what’s going to effect change in anything they’re involved in. If they’re just going to sit there and take in information and do what they’re told then that’s what you’re going to get.

You’re going to get a kid working in a supermarket that won’t do anything, if stuff falls on the ground he’ll just look at it until the manager says, “Can you clean that up
please?” because there’re just no problem solving skills. (audio-recorded meeting, November 19, 2008)

Harvey continued to struggle with the balancing of content and issues in his senior chemistry class throughout the project. However, during a visit to that class I found students engaged in a meaningful lesson that blended a chemistry lab investigating water from different sources with an ongoing discussion of the environmental implications of water pollution. The students had been required to bring water to class from a variety of sources, such as their faucets, and wells; and then use procedures found in a senior chemistry textbook to determine water quality and mineral content. As they worked, Harvey challenged each lab group to connect their findings to local public water issues. It became apparent that what might be for Harvey an intellectual struggle between knowledge acquisition and issues-based learning, parlayed for his students into a rich experience that blended both content material and related environmental issues.

George

George’s strength was in his ability for reflection, not only for his own practice, but also for the conversations that occurred during project meetings. He frequently paraphrased dialogue amongst group members, elaborated definitions or summarized points being made. George was predisposed to systems thinking by his own account, preferring the big picture over the minutiae of reductionism. It was his stated reason for pursuing science studies in ecology rather than pure biology:

The reason I got out in second year, moving into third year, I went to the environmental science side of biology, to the ecology side because I didn’t want to go any further in.
liked knowing an organism’s place in the world as opposed to knowing about its left toenail and how it grows... Why did I change programs? I just enjoyed that more, knowing where we fit into the big picture instead of getting to the super small picture… When I got more into environmental studies and environmental science, I found I like the fuzziness. I like that for once you could have an answer and debate and not agree and move on. (audio-recorded meeting, October 16, 2008)

With his ability to reflect, and his inclination towards keeping the big picture in mind during most discussions, it was George who, after lengthy and convoluted group discussion was able to summarize the conversation and then articulate the research question for the group:

George: We could have set environmental days in our own classes and then meet again and then, “Hey, on our first environmental day this worked and then this didn’t work.”

Harvey: Sure, it’s a good idea.

George: So we could hit our three classes a day. On that day, whatever that is, in each of our classes, no matter what the topic was that day, which means you have to embed...

Harvey: As a group we can kind of figure out, depending which class you are teaching, give people ideas for on that day.

[indistinct]

George: Maybe our question is: Can we model a small group approach to integrating, environmental studies into curriculum?

[ooohhsss from the group]

Jane: Wow that’s…

Bart: That was great! (audio-recorded meeting, November 19, 2008)
George’s vision for his science classes was for open-ended, student driven learning. However, this vision was stymied by two influences: his propensity for storytelling, and the ultimatum of his Head of Department who had told him that if he did not complete the grade 11 curriculum he would not be given the opportunity to teach grade 12.

George: I mean that would be great, learner centered teaching... it’s just so hard to do that, because I prefer to know where my lesson’s going, because I need to get done, because I want to teach grade 12 again and I better finish grade 11 curriculum if I’m ever going to teach grade 12 again. So that’s what I mean, you’ve got to finish. It’s teacher centered too much...why I never finish ecology, tons of stories, tons about the kids. Like reproduction. I get right back into when I remember when we just found out about Alysha (his daughter) and about pregnancy. So grade 9 reproduction (unit) is crazy because I tell way too many stories. (audio-recorded meeting, December 4, 2008)

George was evidently not tied to content in the same way that many science teachers are since he rarely covered the prescribed curriculum in its entirety, being intent on fostering student relevancy and engagement in the topics that he did choose to cover. This was quite apparent during my visit to his Shh! Environment Day lesson with the grade 11 biology class. The lesson was intended to address not only issues of EE, but also the Ontario Catholic School Graduate Expectations (Institute for Catholic Education, 1998) and the grade 11 biology (Ontario Ministry of Education, 2000) STSE requirements. The lesson mirrored George’s professional strengths, in that it was very reflective, and based in large part on storytelling that aimed at having students consider the impact of the First World on Third World inhabitants. George had invited the school chaplain to team teach with him; the chaplain used the story of the Three Little Pigs as a
metaphor detailing the manner in which three different people lived their lives in relation to their environments. The students were encouraged to identify with one of the pigs, whereupon a lively discussion ensued as to how the students might balance their lifestyle choices with their footprint on the environment. Finally, since the lesson took place at the beginning of the advent season prior to Christmas, the students were encouraged to commit to one significant act of environmental stewardship over the Christmas holidays.

Certainly, George’s understandings of the principles of EE and STSE strategies seemed clear, as manifested by his many suggestions for EE embedded lessons, and his uncomplicated paraphrasing of discussions during the project. However, rather than confront his disinclination for detail and content (disciplinary knowledge), George remained within his comfort zone, and chose to pursue a big picture biology lesson for the *Shh! Environment Day*.

This choice likely speaks to his practice from a number of perspectives. On the one hand George offers students of biology an issues or story-based approach that is probably refreshing and engaging for many students, but on the other hand, students planning further studies in the sciences may find themselves lacking in required content knowledge. Within Shulman and Shulman’s (2004) model, George’s capacity for adaptation of curriculum was laudable, yet his adaptations often precluded the completion of curriculum, possibly preventing full knowledge, and competence acquisition for his students. Nonetheless, George’s practice would possibly offer students of science a refreshing, and important issues-based alternative to traditional science classes.
Bart

Bart presented an enigma for me as the researcher and analyzer of data. The following description of his ‘teacher learning’ during the project is, in my opinion, incomplete as I feel that I did not elicit fully the data that would allow a more thorough representation of his practice.

Although he made a solid contribution to the work of the group, Bart did not show evidence of personal reflection in familiar forms such as the keeping of a journal, preparing a written narrative, or speaking in a reflective manner about his practice during discussions. While Bart brought both disciplinary and pedagogical knowledge to the conversations of the group, the AR project did not seem to provide him with the occasion to improve or challenge his work as a teacher, and yet the project obviously had some impact for him since toward the end of it he commented:

I’m actually looking forward to teaching the 3E (science course) next semester. Never taught it before, I don’t know anyone who’s every taught it before. I have nothing in terms of resources, so it’s going to be interesting after doing this. It’s going to kind of change my philosophy going into the course, you know, integrating stuff into it. Part of the curriculum for it is environmental, but just the idea of every day how I can make them think about the impact of environment. I’m looking forward to seeing how it works out. (audio-recorded meeting, January 13, 2009)

Bart’s motivation for tackling an AR project based on EE and science likely stemmed in part from his experiences as a youngster; travelling and camping with his family in a pop-up trailer. In addition, his professional motivation also had its roots in connecting with what he described as “an awesome outdoor club” (audio-recorded meeting, October 2, 2008) at the
school at which he was teaching. Both experiences speak to his internal motivation based on a combination of his personal and professional experiences.

At no point did Bart clearly articulate a vision for what teaching and learning should, or could, look like, though some of his comments were indicative of his perspective. Bart spoke with confidence, in realistic, pragmatic terms, based on practical rather than theoretical considerations. He seemed to live and work in the moment preferring a practical, hands-on approach with students regardless of their position in the school:

Bart: I don’t understand why hands-on doesn’t apply to academic students.

Sharon: Academic is more theory laden and applied is more hands on.

George: Because you’re right Bart, academic kids learn better too when they...

Bart: Why do just applied kids need hands-on? Ridiculous! (audio-recorded meeting, January 13, 2009)

In another discussion Bart described his training for the revised curriculum for computer studies; the revised curriculum consisted of close to 50 pages of front matter, and these normally consist of statements addressing the theoretical framework of the curriculum content. It is obvious that he could barely tolerate the foray into theory, longing instead for a discussion of the more tangible elements of content and teaching strategies:

It was painful. Because six to seven hours of looking at that. It was horrible. It was just so overdone. And then two hours of actually looking at the new curriculum which had been completely redone. So I was there for two days and most of it was wasted because I was hoping the focus would be on, at least in some detail, the content. (audio-recorded meeting, January 13, 2009)
Bart’s understanding of teaching and learning was readily apparent, and could be considered one of his strengths. His disciplinary knowledge was quite broad, and often became a source of interesting information for the group. He frequently was able to pinpoint topics and lessons in the different science courses, and within various textbooks. For example he easily identified the widely ranging sources for acid rain lessons; and cost-benefit analysis of fuel consumption, and migration routes. Indeed, disciplinary and pedagogical knowledge were the areas that he identified as important, and as possibly presenting the most difficulty for the work of teaching EE embedded science.

I think the biggest difficulty anyone has had with this, particularly anyone who has just less experience with the environment, is finding resources for it. You could say, “I want to do this in this unit. I want to do this... how?”, and particularly if you don’t have any environmental training or whatever, its going to be really hard. (audio-recorded meeting, November 5, 2008)

Bart also demonstrated substantial knowledge of learners, and issues of classroom management. He was able to give Tess, who struggled with student behaviour problem, some useful feedback and information on difficult students:

They don’t necessarily see that (doing well in school) as being a great thing. There are kids who intentionally withhold their knowledge.

...How many kids do you know that you’ve taught that will intentionally not do work, not hand in stuff, not perform well simply because they don’t want to look like that?

...They intentionally underperform [sic] on everything because they don’t want to be that kid who gets a 95. (audio-recorded meeting, November 19, 2008)
Yet while Bart’s pedagogical knowledge appeared strong in some respects, in the discussion about action-oriented teaching versus activities, it seemed that he was unable to transfer his pedagogical knowledge to grade levels with which he was not familiar. In this excerpt he argued that an action-oriented approach is not appropriate for students at the primary level.

How do you expect a grade one student to do action based problem solving? ... It’s insane, it’s too much...By the time they’re getting up to the end of their high school careers, not only do they have the background knowledge now to do some more action, they can actually think about a problem and think about what possible solutions are. But their brains are working better for it as well. Just in terms of biologically they are able to handle that kind of thinking. (audio-recorded meeting, November 19, 2008)

Bart’s capacity for adaptation of curriculum, as part of his practice, seemed to be another of his strengths. A lesson that he presented to the group, before any lengthy discussion regarding embedding EE in science curriculum, pointed to his intuitive capacity for adaptive actions, and spoke to his years of experience.

I kind of borrowed off a project that a previous teacher had done where they had to do something on energy sources, but I kind of augmented it into looking at renewable versus non-renewable. So they not only had to figure out all the energy sources and how it’s converted into electricity for use, then they also had to do a comparison of: Is it renewable? Is it feasible? Is it a viable energy source? Things like that. All of them presenting it into a big grant proposal type thing where all the teams are trying to beat out the other one. So where one team comes with their energy source the other team
beats up on them for why it’s wrong and a lot of the discussion was focussing on environmental impact. (audio-recorded meeting, November 5, 2008)

By his account, the lesson was very engaging for the students, who spent a great deal of energy attacking other teams’ proposals whilst defending their own. During the *Shh! Environment Day*, Bart again demonstrated his mastery of encompassing and engrossing lessons, with a Physics lesson on sound in which students explored the nature of sound by experimenting with tuning forks, and then applying that knowledge to communication strategies among porpoises. As the third step to their lesson, Bart had the students use the internet to research the ban on leaf-blowers as sources of noise pollution in urban areas. Remarkably, Bart was surprised that the lesson went as well as it did, particularly in the computer lab. However, his success surely highlights his strengths in practice:

> So the first half of the period was the tuning fork and talking about the porpoises and then we went down to the computer lab and they were doing research on that. And they had to come up with basically an argument, for or against... I was actually impressed because when they got into the computer labs...90% of them were actually reading up. And there was a ton of stuff on the internet about why they should be banned, and they were all doing it. Wow, kind of shocking. I’m so used to kids going into a computer lab doing research and having to tell two thirds of them to get off game sites...I was really kind of impressed. So that went pretty well for me. (audio-recorded meeting, December 4, 2008)

However, by Bart’s own telling not all of his practice is an exemplary display of pedagogy; he struggles with certain hands-on activities, particularly in chemistry and physics
classes. For undetermined reasons, labs and demonstrations are rarely successful in his classroom, and he takes a very mystified attitude towards this phenomenon.

Bart: My classroom defies the laws of chemistry and physics. I swear nothing grows. No chemistry experiment ever works. Acid base testing I did on the tap water and I come up with five using universal strips...I can’t do anything in this classroom!

RF: So how do your students react to that?

Bart: They laugh at me, of course they do. Honestly I think by the time I get them in the grade 11 or 12 they already know that experiments don’t work in my room.

RF: Does it make them less interested in science or less knowledgeable?

Bart: I don’t think it affects either their knowledge or interest. Well it probably does affect their knowledge to a certain extent because they never actually see it in action. They don’t get any practical examples. Like I teach them some sort of chemical reaction or whatever and I do it and it doesn’t work then they don’t see it. They don’t know what that looks like.

George: They learn persistence. He keeps trying.

Bart: I do, I keep trying. (audio-recorded meeting, November 19, 2008)

As a member of the AR project community, Bart enjoyed discussion, and was not reluctant to voice a contrary opinion. This made for often lively conversations once the group of participants had come to trust and respect each other. In this excerpt he suggests that the group’s research project has missed the point of embedding EE across the curriculum, by working towards a one-day event; in a sense his words shed light on the vision that he has for EE in his class:
I’d kind of felt like we’d missed the point. Just because we’d spent a couple of weeks focussing on how can we come up with this day that we could have this environmental focus on... but I think it completely misses what we really need to do. It’s the whole idea of ...working it in all the time. Like coming up with, not necessarily dramatic ways, it doesn’t have to be a massive lesson on the environment for this topic, but just always coming up with these relationships ... How does it work into the environment? What is the impact? What can be done? Particularly in science classes,... You could probably have some sort of environmental connection to 90% of your lessons...It doesn’t have to be a huge thing, and even if its just a comment, or just a question, it doesn’t have to be anything significant. But I think in order for the whole idea of more environmental awareness to actually have an impact, one day doesn’t do it. Its just not enough...There’s no way one class is going to have an impact, no matter how good that lesson... There’s no way those kids are ever going to get something out of it. But if its something that keeps coming back at them, day after day, at least its something that they may eventually start thinking about, right? (audio-recorded meeting, December 4, 2008)

His penchant for the practical was perhaps the most beneficial, and the most detrimental, attribute that he brought to the project.

_Tess_

Tess was a young woman in her second year of teaching when she participated in the AR project. I had actually approached her to consider joining the project because I felt that she would bring a unique perspective to the group whose members where all seasoned and experienced teachers. While I believed that her studies at her faculty of education would give her
a fresh, possibly more modern approach to her practice, as it turned out, her experience in the project drew on the expertise of the other participants to a much greater degree than I had anticipated.

Tess, through her recent studies in education, had a theoretical vision of embedding EE in science curricula, and a theoretical understanding of disciplinary and pedagogical knowledge, but lacked the classroom experience that could translate and adjust her vision to the reality of high school science classes. Tess’ theory-based vision is discernible in the following excerpt in which she uses phrases reminiscent of her studies at the faculty of education:

I think it’s more like cooperative ed learning. That kind of thing, flexible and adaptable, learner centered. It’s not the sage on a stage. It’s the student that’s doing. Even learning centers. You don’t do it so much in high school but in elementary… (audio-recorded meeting, November 19, 2008)

It was the practical work of teaching that was her overriding concern during the semester in which the AR project took place. She was still developing competency in managing a classroom; becoming acquainted with issues of behaviour and motivation; and establishing herself as a member of the school community. Her unsure footing as a practicing teacher was evidenced in my notes during our first interview, “Tess seemed harried and stressed but pleasant. She never completely relaxed enough to think clearly through much of the conversation”. (audio-recorded interview, October 29, 2008)

In our interview I addressed the fact that she was the youngest in the group:

RF: Do you feel like you are the youngest there, or not?

Tess: Yes.
RF: In what way?

Tess: Just in terms of experience.

RF: But you sense it. Do you think other people sense that you are younger?

Tess: Maybe, but I don’t think that alters how they take what I’m saying. (audio-recorded interview, October 29, 2008)

On several occasions I suggested that if the project was becoming too burdensome for her as a new teacher, she could consider dropping out, with no ill will or consequences, however, she was adamant that she continue as a participant. Indeed throughout the project, despite her standing as youngest and least experienced, Tess maintained a confident and professional attitude; she initially did not speak up often, but when she did it was timely and constructive.

The participants of the AR project became, for Tess, an important community that willingly provided advice and support for a number of issues that many new teachers must overcome. These included, but were certainly not limited to, an experience with an irate parent, and an irate colleague; defiant students; school policies and procedures; and one of her particularly difficult classes. Tess’s response to the ongoing mentoring was, “It’s nice to know that some of the people have gone through the same thing, I probably see this as my first experience with _____, right?” (audio-recorded meeting, December 4, 2008)

Elements of her practice, the capacity for design and adaptation of curriculum proved very difficult for Tess, who recognized that a poorly managed classroom was not conducive to basic student learning, let alone experimenting with new teaching strategies. Of her three science classes, it was a group of 18, grade 10, applied students, only three of whom were girls, who presented the most difficulty. Although classroom management was not within the immediate
scope of the AR project, Tess’ work with this class became a topic of discussion for the group on several occasions. Tess described this group in more detail in her narrative *The Lesson That Went Awry (Appendix H)*. It is essentially the story of a group of unruly boys who ran amok frequently. The disconnection between best practices taught at the faculty, and the reality of a poorly behaved class are evident in her description of her practice with them:

It’s just when things aren’t focussed, teacher-centered. I mean obviously I try not to do that all the time, but I mean its chaos... It would be easier for me just to do notes all the time but that’s obviously not the best thing to do and I don’t think they’re going to get the most out of that. I just kind of break it up. I try to alternate, you know? (audio-recorded interview, October 29, 2008)

Far from undermining or distracting the work of the group, Tess’s situation provided the other participants with fertile ground for creative thinking; drawing on their experiences with difficult students they engaged with her in lengthy discussions, offering suggestions for her class for the *Shh! Environment Day*. Throughout this excerpt Tess’s voice is negative and frustrated; she is reluctant to embrace any of the ideas because she cannot imagine them as successful:

Tess: They don’t even want to fill in the blanks, “Why do you make us write so much? Can’t you just photocopy it? Well, you read it to us”, while they throw stuff around the room. Oh god...

Sharon: What if they did a commercial? Like a public announcement?

George: Or radio. That’s easy, they could speak it...

Tess: They won’t even do something like that because I know they can’t. My 2P’s, they’re just, “This is retarded.” And they don’t care.
RF: Would they do a poster?

Tess: They might do a poster. Some of them might complain about having to colour, because I’ve done colouring and they hated it. I have a lot of boys.

RF: What do boys like to do?

Tess: I don’t know ...

Bart: Video, they like playing video games.

Tess: Even the radio announcement, that would be too much effort involved to work on it. I have one 2P class that would probably... it would be ok. But the other one, absolutely not.

George: It could be if they’re just taping on a traditional tape or a digital recorder you could challenge them to choose one of their favourite pieces of music. Have it playing in the background, as the music underlying the public service, because there’s going to be music.

Tess: Yes.

George: So in other words, they might like it if they’re choosing something they like. There’d be a lot of bleeps on it.

Tess: Oh that’s what I’m saying.

Bart: It has to be low enough that you can’t actually hear the words.

Tess; Even when they’re speaking, I let it slide. There are kids who say the f word maybe once a sentence, and I don’t do anything because they don’t even realize it.

Bart: So if you keep sending them down to the office, they keep getting suspended.

Tess: So I choose my battles. ...
Sharon: Could do a video and they get a camera.

George: Their response could be differentiated too. You could set up all kinds of options and then choose. Two people doing a commercial, one person doing a comic strip.

RF: Could you ask them?

Tess: Yes, I can.

Bart: Just flat out ask them, “I need to know what you know. how do you want to show me?”

RF: Or “How do you feel about this topic? What do you understand about it?

George: “You need to demonstrate your understanding somehow, how are you going to do it?”

Harvey: Give them a list of ideas.

Bart: Yes, give them a list of ideas and say, “Choose anything.”

Tess: No, I know. I just find in class if I give too many options, they don’t know which ones to take. Which direction to take. They haven’t had the experience of making the decision of how they want to show what they know...

RF: So you can’t give them all thirty things.

George: Three, four, five options.

Bart: They’re not doing an article, they’re not doing a pamphlet, computer might…

Sharon: Computer … make a little poster.

Tess: I’ve already done that. Two days in the computer lab and the first two weeks of school doing a pamphlet on endangered species and I think I got maybe six from that class. Two days of goofing off on the internet and...
RF: ... I think that’s a challenge for all educators. We can collaborate maybe a little more with you about that. (audio-recorded meeting, November 5, 2008)

Eventually, Tess did adapt an existing lesson for the difficult class. It is described fully in her narrative in Appendix H. Briefly, the beginning of the lesson, which took place in the classroom, consisted of an introduction to the topic of fuel efficiency for different types of vehicles. Next, Tess explained that the class would go out-of-classroom to survey the number and types of vehicles that were used in the city. The students were told they would have to walk out to the city road that passes the school, and for 15 minutes, from their positions on the sidewalk, the students were expected to record types of vehicles that passed by. (Vehicle descriptors included: sport-utility-vehicle, van, half-ton, sedan, hybrid, etc.) Tess explained her expectations for their out-of-classroom behaviour to the students, prior to departing the classroom. The end of the lesson took place back in the classroom, where the observations were compiled, and the students were asked to create a poster related to the use of fuel-efficient vehicles in the city.

As expected, both disciplinary and pedagogical difficulties were encountered, some verging on the humorous as several of the boys in the class commenced with a series of predictable antics. I had offered to accompany the class on their outing, and so, was able to act as a secondary supervisor. They were indeed a recalcitrant bunch! Upon debriefing and discussion of the Shh! Environmental Day experience, Tess did not withhold in her description of what occurred, and was very open to discussing how she could improve the details of such a lesson:

I think that one thing I could have done differently is that they were all so excited to go outside they wouldn’t listen to me when I was trying to give them instructions ...but then
one kid said to me,” Miss, how does counting cars have anything to do with drawing a poster”, so maybe I guess I didn’t really make that connection too well, I don’t know... I did that carbon dioxide emission calculation on the board with them but I think they were just so gung-ho on going outside that half of them didn’t pay attention. I asked them to do it but I don’t think a lot of them did it. They were just so excited… (audio-recorded meeting, December 4, 2008)

Tess’s self-evaluation of her practice was unassuming and candid; she modeled self-reflection commendably for her counterparts in the project. As the project progressed, and her comfort level increased, she made more significant contributions, particularly in the area of narrative as a way of strengthening practice. Tess was one of two participants who prepared a narrative, accompanied by reflective questions, about her experience in the project.

Sharon

Sharon had been teaching for several years, and particularly enjoyed studies in the health sciences. Her demeanour was genuine and enthusiastic and she described herself as a “take charge kind of teacher” (audio-recorded meeting, October 2, 2008) who strove to help her students make connections between science and their personal lives. Her motivation to join and work in the project stemmed from this keen approach to learning, and was almost palpable at times. The project therefore became yet another avenue for learning which she could explore. Sharon did not, however, profess any great love of the outdoors.

Sharon: I don’t mind looking at stars but, we are at our cottage out on the deck and it was fine but its sooo …! “Ok you’ve seen clouds!” And I don’t even know what I’m looking at. “Ok, can we go in now. There’s mosquitoes.”
Sharon: You can hear my pain! (audio-recorded meeting, January 13, 2009)

Despite her personal views of being in nature, Sharon acknowledged that environmental issues were extremely important elements in a science curriculum, and for student’s daily lives. It was her strategy to often think aloud during discussions as she endeavoured to make sense of new concepts. (It was a practice that I found disconcerting at times as it was difficult to follow her thoughts; consequently I have made an effort to edit her voice, but only as much as is required to follow her deliberations.)

Sharon’s vision for embedding EE in her science teaching first required establishing a visual model of how EE related to science. I described my view of EE as an umbrella under which studies of ecology and environmental science; issues of society, economy, politics and justice; outdoor and experiential education, adventure education and so on were found. Sharon’s response led to musings of what students should learn:

I was surprised with your definition because it made me think of it in a different way. I would have thought of it as a branch of ecology. And the ecology is the umbrella, that’s the system. And the environmental study of that is the impact of the humans on the environment. So I thought of it differently. ... I guess a lot has been said about the human impact. But hopefully teach a little bit about appreciation, along with how to minimize our impact. The ecological footprint and stuff. Even allowing them to appreciate it so that they do care. Maybe we can teach them some chemistry and how it works and throw away the plastic bag. Don’t just do it, but the ‘why’ behind it. (audio-recorded meeting, October 16, 2008)
Sharon’s vision for EE was best described as she recounted an outdoor lesson near her school with a group of students. During their field trip they chanced upon personnel from the Ministry of Natural Resources (MNR) conducting field studies. The ensuing interaction was, in her view, a perfect science lesson embedded with EE; an authentic and synergistic encounter:

So we went (to a little creek) and did a little field study there and we found some bugs and all sorts of things. And then the MNR was doing a little training session for fish counting, so they were there and I said “Hi. What are you doing? I have some kids here that are in biology.” We sat around and they showed us how they count fish and how they send an electric current that temporarily electrifies the fish and they come up and they count them. Ok, this is the perfect lesson right? (audio-recorded meeting, October 16, 2008)

Sharon was always very conscious of helping to create those connections between science, environmental studies, and the lives of students and their teachers. It was she who suggested the date for *Shh! Environmental Day*, based on the time of year:

It would be neat to do it maybe on the first couple of days of December, with December being such a wasteful month, with electricity and packaging and presents. It would be neat to start your month off instead with an environmental consciousness... You know what I mean, December… you spend too much, eat too much, waste too much. It’s just an excessive month. (audio-recorded meeting, November 5, 2008)

Sharon’s real strengths as a participant in the AR project were her consistent commitment to a reflective practice, and continual rethinking of her disciplinary and pedagogical understandings as they related to embedding EE within science curriculum. Her initial self-
professed preference was for the role of teacher-in-charge, taking a content oriented position, and teaching as if every student was to enter the field of biology, yet she recognized that this was not the case. She spoke of her role as being one of imparting and sharing knowledge, and showing students “ways to discover more about knowledge” (audio-recorded meeting, January 13, 2009). Sharon’s dilemma with the pedagogical differences between EE and traditional science teaching was most noticeable in her considerations of her role as a teacher of subject matter and strategies (in particular those associated with EE/STSE), in which she felt that she was not knowledgeable. In the following excerpt, Sharon comments on how vulnerable it would make her feel to have students studying environmental issues with which she herself might not be entirely familiar:

How do you teach something that you don’t know much about?... We’re not necessarily activists so are we always able to identify problems? And is that why I’m not always comfortable with all sorts of issues sometimes?... I guess maybe not knowing the solution, ...They’re [the students] going to enlighten you… I don’t know, maybe you’re not the resource person that you often are with academic knowledge...Well there’s this insecurity (in talking) about environmental issues. I’m learning as they’re learning. And often you’re more the expert in the field so to do this stuff with environmental. I don’t have that comfort level. That’s scary. I don’t know…Would students lose, not necessarily respect, but confidence in a teacher? And if students don’t have confidence in you I think I’d feel a little more vulnerable. (audio-recorded meeting, November 19, 2008)
But Sharon’s engagement in the project was not static, and she readily undertook classroom activities that might include more EE content and pedagogy; she shared these on an ongoing basis with the group:

I struggle, I struggle with this… You want it to be relevant ... We did (research) for micro-organisms that cause disease, and that’s usually where I’d focus and leave it at that right? That’s my comfort zone. But then part two is that Mother Nature put out a want ad. She was looking for organisms to recycle matter and so they had to submit their resume with their qualifications... So its there, I guess it’s in my mind. That’s what’s neat about this (AR project), it’s always in my mind now... I find that since we’ve started doing this I feel like bringing more live things into the classroom. I’d love a fish tank, it’s just all the maintenance scares me. Last week I brought plants, ... I’ve never had plants in the classroom for very long. “You know what? Everybody bring some clippings from home and bring some in.” And I bought three, four plants and, “Let’s live it. Let’s not just learn about it.” ... Since we’ve started this whole project there’s been an awareness and everything. You start everything thinking about it differently. And I did my plant unit and it used to be anatomy, physiology and uses and go and done...(This time) they picked a plant that has a lot of products and something that had a social issue. And they had to bring that up in their project. Before I didn’t always do this because its like, “Time (claps hands) Time.” And the projects are great. (audio-recorded meeting, November 5, 2008)

The unit on plants was of specific concern to Sharon since in the past she would spend as little time as possible on the topic. However, once she was able to incorporate social issues, and
bring live plants into her classroom, her attitude towards the unit changed entirely. She recognized that an EE/STSE approach to content matter that she ordinarily found uninteresting, might have the capacity to change the experience both for herself and her students.

One of Sharon’s most memorable moments, in my view, came during a discussion of the nature of EE, and the types of teaching approaches that would best suit it. The descriptors of EE included words and phrases such as: lifelong, interdisciplinary, holistic, locally relevant, systemic, flexible, adaptable, issues-based, field-based, interpretive, and action-oriented (Smyth, 2006). Bart begins the excerpt with the comment that none of the descriptors of EE specifically mention the environment.

Bart: I’m just looking at the list right now, I don’t know if I’m missing it but...this list of environmental education doesn’t seem to have anything about how you can impact the environment.

Sharon: It’s more like its not EE about the environment. It’s EE as a way of thinking about teaching. Teaching style.

Tess: I think so too.

Rf: I think its a cool interpretation.

Sharon: It can be a different way of thinking. It’s not necessarily about the environment.

(audio-recorded meeting, November 19, 2008)

This was a eureka moment for Sharon. She came back many times during ensuing discussions, to her realization that EE offers a different pedagogy from that of the traditional science that she felt she was teaching. This turning point became evident in her discussion and
understanding of science curriculum; and in her capacity to envisage a different practice for herself:

Is it also important because of the tool of science? It’s also important in the function of the world. I mean, technology, discovery, all of those do advance human kind. So [science] is a powerful tool. Not only do you want to be able to create it, you want to be able to think about its implications … It’s much more than just creating it, right?...

Science can cure disease. It can get us to the moon and beyond. That’s powerful information. So you don’t just want to inform [the students], you want them to know what to do with it… It’s not just today’s lesson but to think about it. To have an application outside of school, and again not necessarily environmental but socially, or within the community. (audio-recorded meeting, November 19, 2008)

On Shh! Environment Day, during my classroom visit in Sharon’s 3C biology class, the students were discussing the organic offerings of the local grocery store, based on their field trip to its produce department earlier that morning. The students were recording and commenting on, not only the availability of items, but also their relative nutritive and health values. Afterwards, Sharon planned for each group of students to prepare a letter to the grocery story outlining their findings. Sharon seemed at ease with the content and pace of the lesson; clearly she was finding professionally acceptable ways to embed EE in her practice.

Sharon’s experiences with embedding EE included one other episode that deserves mention, as it points to an area of practice that requires adaptation if EE in the outdoors is to be included in curriculum. Taking students out of the classroom requires an adjustment of
behavioural expectations, since the space occupied by the class changes considerably. There is an added element of risk and behaviour management that must be recognized:

I took my kids outside when it was really nice. It was the day after we were together and it was really nice. I said, “Too bad, it’s really nice and I’m going outside. We’re doing plants, we’ll go pick some plants and draw pictures.” And it was in the environment and I thought they couldn’t concentrate so we went outside. It was the last period of the day. I had kids climbing the trees and I ended up giving them heck. “Do you know how much trouble I’d be in if you fell? I don’t care if you get hurt! I would be in so much trouble! So then the next week we did our formal field study so I knew what to say to them.

(audio-recorded meeting, November 19, 2008)

Thus Sharon expanded both her practice of pedagogy, and her understanding of teaching a form of science such that it could accommodate EE strategies and concepts.

Jane

I chose to write about Jane last in this analysis of individual participants since the AR project became, for her, a most remarkable experience. Jane had been a secondary science/chemistry teacher for over twenty years, teaching in every grade level, with a firm grasp of the curriculum, a position that left her knowledgeable but increasingly bored:

I’ve been teaching for a long time and, you know I think I’ve taught every grade nine science course over and over and over. And I can just say, “Ok, where am I at?” and I can just go, right? And it’s boring. (audio-recorded meeting, December 4, 2008)

Jane felt that although she disliked outdoor activities, and had a very poor grasp of environmental studies, the AR project offered her an opportunity to converse and collaborate
with colleagues from other schools, and perhaps refresh her practice. She certainly came to the
project with a vision of what a science program should offer students: a scientific literacy that
would serve them as consumers and citizens:

I think that I’d want students to leave school with the ability to make good choices and
not be influenced by media or scare tactics. I have this friend who is always sending me
emails about what shampoos not to use because she read somewhere that they were
toxic. I mean I don’t want my kids to not be able to figure out what is true or not. (audio-
recorded interview, October 29, 2008)

Her twenty years of teaching experience also afforded Jane a level of confidence, and
understanding of disciplinary and pedagogical matters, that can only be developed over many
years as an educator. Jane did not, however, portray confidence as a participant in the project,
and thus seemed, initially, to have no avenue through which to change her practice. Rather, she
made it abundantly clear that she was very uncomfortable in the outdoors, both personally and as
an educator, and therefore had a very low opinion of her abilities to teach any facet of
environmental studies. The following is an excerpt from her narrative *I Hate Nature but I Love
Teaching Environmental Issues*, which is included in Appendix I:

When I teach a subject, I am only comfortable if I have a deep understanding of the
material. I can think up great lessons and activities. My enthusiasm is contagious
(usually). The exact opposite is true with environmental science. I have always avoided
stream and field studies as I felt I did not know enough about the types of plants or
creatures we would find. I hate saying, "I don't know". I had students who knew far more than I did about what fish were in our lakes, etc. I didn't know how to engage the students.

Indeed, throughout the project, Jane continued to profess an intense dislike for any outdoor activity that involved close contact with nature, including activities like camping, hiking, fishing, or any of the myriad undertakings which outdoor enthusiasts pursue. Understandably, her aversion precluded any out-of-classroom activities for her science students; a state of affairs over which she was rueful, recognizing the value of learning a topic like ecology in an outdoor setting, yet feeling entirely unqualified to tackle such an outing.

RF: Jane, why do you not take students outside?

Jane: Because if they ask me, “What is this plant?” I won’t know the answer. I’m not comfortable.

RF: So you are missing a knowledge base. Are you uncomfortable with having these students outside the classroom?

Jane: Depending on the class, sure. But, it’s more that I don’t know when they ask.

That’s what I’m uncomfortable with. It’s not that I don’t know a couple, I wouldn’t know most.

RF: Well you knew more trees than anybody else.

Jane: Yes! Maybe I’m just hard on myself.

George: I think you are hard on yourself. (audio-recorded meeting, October 16, 2008)

Indeed, throughout the project Jane demonstrated a very good understanding of many outdoor and environmental issues, and she actually confessed that as a pre-service teacher she
had completed a placement at an outdoor education centre. Surprisingly this placement remained an isolated incident for her, and did not apparently impact her practice:

But you know I did a placement, I actually took environmental science as a teachable and I was at an outdoor ed. [sic] centre for a whole week...It was honestly the best two weeks. I went back home on the weekend and I spent the whole week out there, I stayed there, slept there…. classes would come out and stay a week and we had a blast! That was the first time I was ever in a canoe. I was terrified! I said, “Oh god why didn’t I take math as a teachable instead?” but it was so much fun. (audio-recorded meeting, October 16, 2008)

Initially, given her distaste for nature both she and I were unsure how she would approach the intent of the project, which was to find ways to embed EE in science curriculum. She seemed unconvinced that she could teach EE without the knowledge to identify plants and birds, and I continued to encourage a larger, issues-based perspective. Jane’s impasse was finally surmounted by the obvious: a desire to connect students to the science they had to learn, and a common concern for the health and well-being others. From her narrative:

These past few years I have become very aware and concerned with the myriad of environmental problems affecting the earth. I’ve got children and I want them to live in a healthy world. I began to be disturbed by pollution for one thing. And how the climate is changing. But my teaching of ecology did not change. I didn’t make a connection with my personal concerns and teaching about the environment. Then I believe things started to slowly change for me when "An Inconvenient Truth" came out. I first showed it to my university chemistry class when we finished up the gases unit. They were riveted and we
had some great class discussions about it. I then showed it to my grade 10 students. Same effect. I started to realize that environmental issues are just as important to most students as they are to me. Even so I was still stuck on the idea that I did not have enough knowledge of nature to teach environmental science.

Jane did not contribute often to group discussion early in the project. She did however listen intently, and she kept a journal; the hallmarks of a reflective educator. Our discussions ranged far and wide, touching on many environmental issues such as the power of story, the move in EE towards socio-political-economic issues, as examples. These elements, as well as her broad understanding of curriculum, her experienced approach to practice, and her sincere desire to breathe new life into her treatment of the ecology unit, came together for her.

Jane: At first I thought that embedding EE in the courses would be really hard because I don’t feel very comfortable with it...But, for example today it was a really good lesson with the applied (class). We’re just finishing up with ecology and they started telling stories about fishing and hunting and how that connected to the ecology we were learning.

RF: Were you uncomfortable with that?

Jane: No, I’ve told them that I’m not an expert in the field but they really liked telling their stories, and I thought, “Hey, this is embedding EE in the curriculum”. But they thought that they had tricked me into wasting part of the class with stories... Being in this group, it’s just refreshing me. Now I’m thinking from an environmental point of view and it’s just making things more interesting for me and I think for the students as well...Because environmental issues are everywhere … They are pervasive in our
lessons, and now that I am more tuned in and thinking about embedding EE the opportunities keep coming. (audio-recorded meeting, November 5, 2008)

In preparing her lessons for *Shh! Environment Day*, Jane took an entirely different approach to teaching about hormones. Rather than her traditional lecture and note format, with a possible recipe-lab, she decided to look at the issues involved with environmental estrogens. Following, is her description of her preparation. Her years of experience are evident as she addresses the details required for successful lessons.

Jane: When I left here last time I think Sharon mentioned environmental estrogens. I thought: grade 9, reproduction, we’re talking about hormones. We’re just going to do that… So I started to look up articles and a wide variety, human health as well as animal and plant health. It’s everywhere.

[agreement]

Jane: So I think I’m just going to select articles, put them (students) in groups, give them chart paper, each with a different article, focusing more on human health. But I wanted to find some articles with bias because there’s some that say its fine, they’re not hurting. I wanted to find a variety. I’m still digging around for articles, so I hope I can do this in a period. And if not it can carry over, but my focus was to find a one period lesson but after they can present to the group what they found and at the end I’m thinking the action thing… So for the 10’s I might focus more on the animals and effects on animals. And trying to find a variety of stuff in academic and applied.

RF: Where are you finding articles?
Jane: I’m googling, there’s lots, so I think I’ve got about eight or nine right now that I’ve printed out. (audio-recorded meeting, November 19, 2008)

I visited Jane’s class on *Shh! Environmental Day* to find the students very caught up in their various articles, summarizing the main points on chart paper, and making personal connections to the information on environmental estrogens. I also had the opportunity to observe Jane’s interaction with her students; her manner was calm, thoughtful, sometimes humorous and very confident. I commented on my observations in the next meeting.

RF: The other comment I want to make about Jane which I noticed is that there was one point they were asking you something about DDT in the environment. And they said, “Well what did it do? And why was it bad?” And you came right up with the fact that the gulls’ eggs were soft. And I thought, you know, here’s the person who says she doesn’t know a whole lot about environmental stuff and you were just really on. You know tons of stuff. There was no gap.

Jane: Yeah, but show me a plant outside and I don’t know what it is. (audio-recorded meeting, December 4, 2008)

Our discussion moved on to explore the effectiveness of using an environmental issues-based approach to teaching science and covering required expectations. As had been mentioned on several other occasions, environmental issues were most often covered towards the end of a science unit if time permitted, and the textbook offered an appropriate study. Jane voiced her sense of haste in science teaching, driven by a desire to cover as much content material as possible. Jane felt that urgency during the *Shhh! Environment Day* until she noticed some
unexpected developments: students who generally had poor grades were staying after class to complete their assignment, and students were learning facts and concepts without taking notes.

Jane: All I got done that period was the research. At first I had it in my head, “You gotta finish! You gotta finish!” but I didn’t care because, with my grade 10’s, two were left at lunch. And these were not my two good students. One of them is failing the course and they would not leave!… [For the grade 9’s] I thought I’m going to teach the hormones this way (issues-based) instead. It was good because in the articles the kids learned what estrogen does because the articles actually said it does this and this and testosterone does this and this. So they learned it that way instead of us doing it [as a note], so I thought, “This is great”, because we can teach, it opened my eyes, we can teach things in completely different ways, I can teach it through an environmental (perspective).

RF: I like your comment that you don’t have to do the note… They can learn things in other ways and they still learn them.

Jane: Yes, you don’t have to teach about it and then look at the environmental effects.

Harvey: It doesn’t have to be separate. (audio-recorded meeting, December 4, 2008)

The experience of the AR project was a very positive one for Jane; her understanding of disciplinary and pedagogical issues was significantly broadened with her work to embed EE in the curriculum, her practice in the topics of ecology and environment was notably enhanced through an issues-based approach, and she was genuinely delighted in how enthusiastic she felt about teaching EE. Jane was particularly pleased that her students noticed her change in attitude, and commented on it to her. What was the secret ingredient of her success? Was it her ability to quietly reflect? Was it her experienced practice? Perhaps it was the motivation to do something
new because the old wasn’t working for her, or the effect of a supportive community. Quite likely it was a synergistic combination of all of these. The title of her narrative serves well as her closing statement: I hate nature, but I love teaching environmental issues.

Subject Matter

While somewhat lengthy, the detailed description of the teachers, as the first of Schwab’s (1973) four commonplaces, sets the stage for a further description of a posteriori topics that emerged from the AR project data. As I perused the data, I was struck by the recurrence of a number of topics found in the conversations and opinions of the participants which pointed to potentially meaningful (but unidentified in the literature) ideas that influenced the subject matter of the project, namely the embedding of EE in science lessons. For example, on several occasions textbooks were mentioned as powerful determinants of unit and lesson content.

While working with the data, I relied on my experiences both as an educator and as a researcher; I compiled both the ideas, and the texts in which they were embedded, into one large file titled other issues, and subsequently grouped together the comments and ideas that showed similarities. These new groups showed a strong resonance with Schwab’s commonplaces: subject matter, milieu and learners, although in some instances, the topics overlap into more than one commonplace. For example, the use of textbooks is a topic that has connections to both the milieu in which teachers work, as well as the subject matter with which they work. I chose to place the overlapping topics where they appeared to have the most impact within Schwab’s commonplaces. Thus, the use of textbooks is discussed in terms of its impact on the subject matter found in science lessons.
Thus, as a continuation of the description and exploration of the data, Schwab’s commonplace titled *Subject Matter* addresses: the power of textbooks in the construction of curriculum by individual teachers, an exploration of the participants’ varied understandings of what is meant by embedding environmental education, and the future influence of the revised *Ontario Science Curriculum* (Ontario Ministry of Education, 2008) on secondary science lessons.

**Textbooks as curriculum makers**

As described by the participants in this study, there are circumstances in which the textbook alone is used for planning and implementing lessons in their classrooms; most notably when they lack specific science knowledge, when they are short on planning time, or when the textbook contains useful activities or seat work. The use of the textbook was studied by Ogan-Bekikroglu (2007) and Tarr, Chlvez, Reys and Reys (2006) whose research showed that, because the science teachers in their study used their textbooks almost all of the time, the textbook became the curriculum. However, textbooks tend to be neither reliable sources of content knowledge (Kirk, Matthews & Kurtts, 2001) nor grounded in any meaningful historical or social context (Winchester, 2006); thus, they may perpetuate a study of science that is both traditional and neutral.

For the participants, the exclusive use of the textbook was a commonplace, but also undesirable, route to curriculum. Both Jane and Sharon spoke to this experience when they were faced with teaching ecology at the grade 10 level. Jane further expressed her dissatisfaction with, what felt to her, to be a stunted form of teaching because her lack of environmental knowledge left her feeling incompetent, and therefore unable to make the lessons interesting.
Jane: But then it’s when we get to the ecology unit and I don’t have the comfort level there, you know the knowledge, so it’s, “Let’s open the textbook to page,” and I really don’t like that. It’s not interesting. I don’t know how to make it interesting. (audio-recorded meeting, January 13, 2009)

Sharon voiced the assumption that if material appears in the textbook, then it must be the right thing to cover in the topic area, and later alluded to her dependence on the textbook for teaching purposes:

Sharon: I think the 3c, 2p [grade 11 college, grade 10 applied science] courses are better designed curriculums [sic] in the textbooks because they’re designed where there’s an activity every second day. Or introduce a topic with this activity. The 3U [grade 11 university science] textbook is laid out: narrative, lesson, questions.

RF: Hm. It’s more text-based, very text-based.

Sharon: And there’s sometimes one lab in a whole chapter.(audio-recorded meeting, January 13, 2009)

Later in the conversation Sharon explained that her understanding of how EE fits into the curriculum was also based on the structure of the textbook.

Sharon: It’s a totally different way of thinking of it, that ecology is a branch of EE, not EE is a branch of ecology. And maybe is that because of our textbooks, the way they are set up? Because this is the ecology unit in the grade 10 and then towards the end you do a couple of lessons within that unit about human interactions. (audio-recorded meeting, January 13, 2009)
Bart added to Sharon and Jane’s comments with his own observations on how science textbooks were designed to focus on content, and science issues deemed as secondary add-ons:

Bart: STSE was last and got done the way the textbook set it up, which was the issues stuff was at the end and you did it if you had time, but you did content first. (audio-recorded meeting, January 13, 2009)

Thus, for Bart, Sharon and Jane, the textbook can become the framework that determines portions of curriculum; it can set the tone, establish content requirements, and direct activities. Indeed, George suggested that there are teachers for whom the textbook is their only form of lesson planning, “…some people just go left to right [motions turning pages in a book] day by day”. In the cases described above the textbook had become the curriculum maker.

Embedding environmental education

While EE and STSE are closely aligned in their approaches and goals within the science curricula, the participants in this project used as their focus the statement from *The Bondar Report*, Recommendation 11 (p. 14, 2007), “embedding environmental education in all topics and all grades’. The participants’ varied understanding of this statement is reflected in some of their commentaries as they embarked on the project; Jane and Sharon found themselves very mindful of the multiple opportunities to address environmental concerns during their daily science lessons.

Jane: After our last meeting I thought, well I’m teaching (grade) 9’s and 10’s this semester only and I thought well I’m going to do the physics unit in 10 because that’s pretty hard to think of something you know. And when I started to think
about it it’s not difficult at all. If you have it in your mindset, this is what your

going to do, incorporating environmental studies, you know, its just everywhere.

Sharon: Especially with the cars right?

Jane: Yes, so we’re doing Motion and we started with something about smart

highways, the MTR, the automated one in San Diego. And we started talking about

that and ... from there we just went into everything, everything. And I think when

the kids left they were kind of giggly. They didn’t have to do any work, because

they hate it, the formulas and everything, but we had a great class. It was really

good and it just went into everything, climate change, pollution, recycling... just in

the cell, introducing the cell. I mean talking about organelles and chloroplasts came

up and we started talking about photosynthesis. We started talking about that and I

purposely went on a bit more about that. And talking about trees taking in CO₂, and

deforestation, and you know that stuff came up.

RF: What was the student response?

Jane: Oh they were really engaged in it.

RF: How do you judge engagement?

Jane: A lot of hands up, excited, everyone wanted to say something. Some wanted

to tell who does this and who does that. I found out a lot of people have their own

wind turbines at their cottages and...I thought it was amazing. (audio-recorded

meeting, November 5, 2008)

As Jane told this story, it was evident that by giving students her tacit permission to

connect to their environments, and by lending her expert knowledge to students’ discussion of
EE/science issues, she breathed new life into a topic area that was, for her, stale and disconnected from reality. However, the two lessons described above were not so much planned as they were happenstances of teachable moments. Such an approach to EE would be in direct contrast to Pedretti’s assertion that “the practice of STSE education must be explicit and considered. Casual infusion, or the occasional reference to science and its application to society is not adequate to achieve STSE education goals” (Alsop, Bencze & Pedretti, p. 125). Taken at face value, Pedretti’s statement might indicate that there is a difference between STSE education, and the embedding of EE in science curriculum. Should science teachers strive to deliberately embed EE in curriculum or is it sufficient to make reference to EE at appropriate times? Certainly there should be a sense of deliberation, mindfulness, and planning attached to any science lesson. However, the teachable moment should not be discounted as insufficient. In a discussion following the implementation of *Shh! Environmental Day*, Harvey makes the point that embedding EE in science should be seen as further development of existent lessons, rather than a departure from them.

Harvey: I thought that maybe that was the purpose of this, to see that we didn’t need to do something really elaborate... I didn’t think that it was that hard to do. You know I think that’s kind of what I got out of it: you know this really wasn’t that hard. Maybe I had to change things a little bit but for the most part I didn’t have to put tons and tons of time into this. If that’s the case then I can probably do it on a regular basis.

George: Because you said you made a specific point of embedding it in whatever you were doing right then at that time

RF: That was your goal.
Harvey: I think for the most part from what I’ve heard of our activities, they were great, but I don’t think they were something like, “What am I going to do? Am I making it really elaborate and changing everything around?”, and then the next day you go on back to your normal class. It seemed more like people just worked in the context of the curriculum or unit that they were in and then put a little twist on it. (audio-recorded meeting, December 4, 2008)

Evidently there appears to be a difference in perspectives on STSE implementation and the embedding of EE in science curriculum between Alsop, Bencze and Pedretti (2005) and the participants of this research project.

*Participant response to the revised science document*

Towards the end of the AR project, the group had the opportunity to briefly review the revised science documents (Ontario Ministry of Education, 2008) which were released in January 2009. The participants spoke at length about the front matter of the documents which focused on, amongst other things, the components of pedagogy, STSE, and EE. The release of the documents was opportune, as it came at a time when the participants could speak with some knowledge and expertise on issues-based approaches to science and the relinquishing of content as the impetus for curriculum development. Re-visiting one of Bart’s comments provides evidence of the shift in focus.

Bart: STSE was last and got done the way the textbook set it up, which was the issues stuff was at the end and you did it if you had time, but you did content first. They’re trying to frame the new curriculum as issues first and you know the basic concepts are
necessary but they shouldn’t drive the curriculum. (audio-recorded meeting, January 13, 2009)

Further, within the documents the specific expectations could be found for each course. These elicited a range of responses, as the teachers attempted to understand the revised scope and sequence of the modified arrangement of topics in the four grade levels. The expectations for each unit of science are organized such that the first set of expectations address STSE goals, the second set address the development of skills of investigation and communication, and the last set of expectations deal with basic concepts and facts. The organization of the revised science documents brings issues-based problem solving to the forefront; whereas content knowledge held that position in the previous curriculum document (Ontario Ministry of Education, 1999) which had been in use for a decade. George expressed his concern that the vague nature of the new STSE expectations, coupled with inadequate training for teachers, would lead to a continuation of current practice rather than pedagogical reflection and change.

George: My fear with this document and going back to the 1999 document… I never read them.

RF: You never read them? Oh

George: I read them enough to know where we were at. My fear is that people will turn to where we are right now [STSE expectations] and they’ll say, “Well this doesn’t tell me what to teach,” and they’ll go to that third section [Basic Concepts]. (audio-recorded meeting, January 13, 2009)
In fact, George went so far as to comment that teachers would simply move their chemistry notes out of their grade 10 binder into their grade 9 binder, and consider that, a satisfactory method of meeting the requirements and expectations of the revised document.

In addition, the group commented on the southern Ontario flavour of the document in terms of providing background information and ideas for teachers. Regardless of where one might believe that northern Ontario begins (there is some controversy over this, with true northerners insisting that North Bay lies in the south); by far, the great bulk of Ontario’s population lies within the watershed of the Lakes Huron, Erie and Ontario, and the St. Lawrence and Ottawa Rivers (Statistics Canada, 2006). Therefore, it is understandable, and indeed expected that a provincially centralized curriculum development initiative would focus primarily on the issues and examples that exist in those regions. This situation requires that teachers in Northern Ontario communities must navigate an added layer of curriculum interpretation and issue-replacement. In the following excerpt the project’s group is discussing which local factors or environmental concerns relating to human activities might be substituted for those suggested in the revised document.

George: They don’t tell you what factors.

RF: Well, they give you two sample issues but the Great Lakes don’t have much to do with our town, and neither does the Niagara Escarpment or the Oak Ridges moraine. So what would be a local factor related to human activity?

George: Over-hunting, over-fishing.

Bart: Well urban sprawl, not necessarily urban sprawl, but mining sprawl. (audio-recorded meeting, January 13, 2009)
A closer look at the examples offered for various topics in the document reveals that the authors made substantial efforts to include items and issues applicable to Northern Ontario. However, the general perception by the participants, in particular Bart and George, is that the documented curriculum is a document written primarily for students and teachers in the south.

*Milieu*

Schwab’s third commonplace, the milieu associated with curriculum change, addresses the various communities and relationships that constituted the environs of the project participants. Most notable were the distanced and disconnected relationship they had with their respective school administrations, and their perception that the teacher community, of which they were members, was confronted with more work than could be reasonably accomplished.

*The EE / administrative disconnect*

A number of the participants expressed a frustration several times with the apparently disconnected curricular demands made on them by the various levels of administration that govern their work. The two most notable disconnections which they identified were those addressing the issues of curriculum design and the use of professional learning community (PLC) time.

Generally, all of the participants understood the revised science documents (produced by administrators at the provincial level) as advocates of an issues-based approach to science. Also, coupled with their understanding of EE, they recognized that this approach would lend itself to a more student-focused approach to their teaching. However, three of the participants voiced their concern about a strong contradiction between student-focused teaching, and the administrative
requirements (both local and provincial) for content-based, quantitative data measuring student success.

Sharon:... our curriculum is so prescriptive and yet they want to have all these things embedded in it. So a holistic way to teach protein synthesis…. there’s conflict there in those ways of thinking.

Harvey: I think they’re contradicting in a way that we are really, really focused on student success.

Sharon: Measurement of student success.

Harvey: Measurement.

RF: You’re right, that does introduce a lot of conflict.

…

Jane: Our school board is pushing backward design though, so you couldn’t do that (open-ended issues-based activity or action) at all. You’re supposed to have an endpoint and then work backwards...You don’t know where you’re going to end, you know? “Where’s my rubric? What am I going to be collecting?” (audio-recorded meeting, November 19, 2008)

To some extent the conversation above focuses attention on the perceived difference between methods of teaching EE, and methods of teaching traditional science; such that assessment and evaluation strategies associated with the first are largely qualitative, and those associated with the second are quantitative. For Sharon and Harvey this emerged as a contradiction; they had not, at that point, found an adequate strategy to harmonize the two.
The second issue regarding milieu, brought forward by Harvey, was the misuse of (professional learning community) PLC\(^2\) time. He felt strongly that time for PLC should not be rushed, nor should the work of the PLC be designated by local administrators; rather, it should be a time that teachers themselves use to create a useful collegial forum for learning. Harvey was particularly adamant about the misuse of PLC by administrators, and the resultant loss of valuable discussion and planning time for colleagues.

Bart: Our PLC’s are pretty stringently designated…

Jane: If we had access to real PLC time, with people we could really relate with, like you guys, and not lunchtime meetings.

Harvey: We have PLC’s. We have one tomorrow… It’s a professional learning community, right? That’s what it’s supposed to be. But I don’t know how many times you guys have worked on school goals and things of that nature... basically I would frame them as administrative tasks pawned onto staff...We’ve used part of a PLC to mark the mock literacy test. That’s not a professional community at all, that’s not even our marking time, its marking a mock literacy test. Is it valuable? ...Even the value of coming here, saying, “This is what I’m thinking of doing with my environment day class,” getting feedback, suggestions, sharing the outcome and getting feedback. Imagine if you could do that on a weekly basis, with a new activity you wanted to do with your class! or a new project. Just being able to talk to another teacher is just... how often does that happen? I’m teaching courses with other people but we never get a chance to talk.

\(^2\)At the time of the research, schools in Ontario were encouraged by the Ontario Ministry of Education to engage in a form of professional development called professional learning communities (PLC). The intention of PLC’s is strongly mirrored in the action research cycle of identifying an issue in education, the research, design and implementation of a response to that issue and the subsequent discussion that continues to refine the response.
It’s not like we don’t want to, we just never get the chance.

Bart: You’re never given the time where you’d have the opportunity to do it.

Harvey: That’s what I think PLC’s should be about. (audio-recorded meeting, January 13, 2009)

Apparently, the initiative to provide time for teachers to meet on a professional basis for the purpose of further learning and curriculum development was viewed by Harvey and Bart as time that was being sabotaged by administrators with their own agendas.

Multiple curriculum responsibilities

Harvey’s comments regarding wasted time led the research group to a discussion of the multiple expectations on teachers to embrace ever increasing numbers of extra initiatives in their work with students. Literacy, numeracy, career education and student success strategies are all initiatives of the ministry of education of Ontario. Secondary teachers are expected to include, in their lessons, elements that would improve the literacy and numeracy skills of their students, build character, introduce careers options and improve student retention (see Ontario Ministry of Education, 2008, p. 29-44). All of the participants very cognizant of the perception that embedding EE in all grade levels and topic areas would be viewed as yet another burden on an already over-extended curriculum. Jane and George discuss their specific situation below:

Jane: I mentioned EE and the Bondar document to our principal and he rolled his eyes!

George: Well I think I know where he’s coming from. You know first there’s literacy and then numeracy and now EE.

Jane: That’s true, and at this school we have religious studies that we are supposed to embed in all of our courses. (audio-recorded interview, October 29, 2008)
Despite their excitement about, and their commitment to EE, the participants realized that their work was indeed multi-faceted. This meant that it was very possible, indeed very likely, that some portions of it would take precedence over others, as dictated by their administrators, the immediate needs of their students, and the element of time. In their reality, EE would become only one more of an array of initiatives that crowd into the science curriculum.

Learners

The fourth, and last, of Schwab’s four commonplaces to be examined within the parameters of the data concerns the role of the learner, in this case the student, in the process of curriculum change and development. Capturing the interest of the students and cultivating the desire to learn were common threads running through the many conversations that the participants had regarding their students’ response to secondary science curriculum.

Student engagement

Schwab’s (1973) four commonplaces identify the learner, as an integral part of the curriculum development process. Indeed, the directions that individual participants took during the project were based to a large degree on the attitudes, interests, and abilities of their students. As an example, in the excerpt below Sharon discusses her goal of having the grade 11 biology students attending her class, “get a bit of learning done”, have fun, and find relevance in the lessons:

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Student engagement

Schwab’s (1973) four commonplaces identify the learner, as an integral part of the curriculum development process. Indeed, the directions that individual participants took during the project were based to a large degree on the attitudes, interests, and abilities of their students. As an example, in the excerpt below Sharon discusses her goal of having the grade 11 biology students attending her class, “get a bit of learning done”, have fun, and find relevance in the lessons:

Whatever your goal is, your ultimate goal has to be to have them there. They have fun and you hope that maybe they got a bit of learning done. If they’re there then that’s one goal...It’s me looking at them and observing them, and, “What are they getting out of
this?” and keeping that relevant...They need to have that connection and that engagement and I think it’s (EE strategies) just more in the front of my mind. I’m trying to let go of, ok so there’s twenty expectations, if we get ten really well, and even if we get some that aren’t on this list, is that not a better outcome?...Because it’s a constant struggle, for that class in particular, to always keep it interesting and relevant...The topic is one thing and then that connection, that’s neat, because you strive for that in every class. (audio-recorded interview, October 17, 2008)

The participants discussed the attitudes of their students at some length, particularly those who most often took science courses in the applied or college streams, and felt that as a group, the students working at the applied or college levels seemed to share a lackluster attitude towards their academic studies. For this reason, they often became the focus of project conversations that pondered student motivation and engagement. In particular, Sharon noted that student motivation seemed dependent on the potential for short term personal gain:

Sharon: Well its very narrow minded, like it’s all about them. I find its all about immediate fun, so its short term thought. Like environment is so long term...like they think of the immediate moment and not about consequences, not about anything.
RF: And it’s your struggle, not theirs.
Sharon: No they don’t mind. They’ll just sit back and do their time...Do their time and do the minimal work. (audio-recorded meeting, December 4, 2008)

Harvey recounted a particular conversation with a student, in which he was taken aback by the honest admission of selfishness and self-involvement:
Harvey:...I actually had a conversation one time in a 2P [grade 10 applied] class and we were talking something about the environment and it came down to asking them why they don’t care. And a person actually said, “I’ll just be completely honest sir. Unless its about me, I absolutely don’t give a crap. I’m just really selfish; I just care about what happens to me”. The person actually said this! (audio-recorded meeting, December 4, 2008)

The comment deserved mention as the participants felt that it seemed to represent a general attitude amongst their students; a high degree of opportunism and selfishness.

Tess’ teaching assignment included a particularly noteworthy group of applied students; their attitudes and behaviours became a frequent topic of our conversation, inasmuch as the participants felt that Tess’ students were representative of many of their peers. Tess went to great lengths to build meaningful teacher/student relationships with her difficult students, and in so doing she began to understand the roots of some of their attitudes.

RF: Why do you think that is? You said that the 2P’s [grade 10 applied students] didn’t care.

Tess:...It might be because some of them have bigger things to worry about. Or maybe they’re just being ignorant. I don’t know, or it could be a combination of both. I mean they tend to have, and I know this is stereotyping, but they tend to have difficult home lives, so school and conserving the environment aren’t at the top of their priority list. (audio-recorded interview, October 29, 2008)

Tess’ comments reveal her growing understanding of students as complex young people, whose lives extend well beyond the confines of a classroom, and for a number of whom forms of
academic study are secondary to other concerns. Harvey expressed his view that disengaged students are very aware of the roles that they play in the context of the school environment, and that they endeavour to maintain those perceptions:

Harvey: The other thing is that they really feel, this is what I felt when I was with them, that they fit into the sort of role of being a bad group of students so they almost have to live up to that. “What can we do that’s gonna [sic], you know, keep our reputation intact? We have to cause problems, right?” So I always felt they were trying to live up to that bad person role, that bad student role. They’re almost afraid to show that they know anything. (audio-recorded meeting, December 4, 2008)

The project participants, who had described themselves as highly motivated students, intent on achieving their personal goals, felt a sense of separation from students who are disconnected from academic studies. The project participants felt that they had so little in common with disconnected students within the school environment that they were struggling to find a common ground on which to base a teaching/learning relationship. As one of Schwab’s (1973) four commonplaces of curriculum development, the learners, in this instance, might be viewed as both a barrier to the embedding of EE in their curriculum, and as a further justification to find ways to do so\(^3\). However, despite the rich opportunities for research and discourse that such a topic would provide, it lies outside the intentions of this dissertation and as such will not be dealt with.

\(^3\) The matter of student motivation for special groups of students is, I believe, one that is extremely important and which may be moved in a positive direction through forms of EE; already there is strong evidence that some forms of EE are powerful motivators for disenfranchised students (Davidson, 2001; Hattie, Marsh, Neill & Richards, 1997; Louv, 2005).
In summary, this chapter explores the a posteriori topics and ideas through the lens of Schwab’s (1973) four commonplaces: teachers, subject matter, milieu and learners, all of which, according to Schwab, have significant impact on the process of curriculum change. Using a model proposed by Shulman and Shulman (2004), the position and contribution of each of the individual teacher/participants is explored through her/his contributions in terms of their vision, motivation, understanding, practice, and reflection during the project; and their relationship to the project community. Continuing with Schwab’s commonplaces, the subject matter addressed by the project offered insight into the role of textbooks as curriculum makers, the various perceptions of environmental education as an embedded component of secondary science curriculum, and the future importance of the revised science curriculum in Ontario.

The commonplace titled milieu attends to the perceived disconnection between teachers and their school administrations, as well as the multiplicity of responsibilities assigned to teachers. Lastly, the learner commonplace considers the relevance of student engagement in the process of curriculum change.

The following chapter will further analyze the data by proposing and explicating a number of propositions and implications that might be derived from a reading of the previous two chapters.
Chapter Nine

Propositions and Implications

Back to the Beginning

At this point in the dissertation, having described the intent of my research and the literature and theory which were its foundation, and having detailed the project and completed a preliminary exploration of the data, I will, in this chapter, revisit the seminal questions underlying the study. The questions arose from two headwaters: my personal passion for environmental education, and my career in secondary science teaching; the blending of institutional science teaching and contemporary environmental education are envisioned in the metaphor of this confluence of two significant traditions. The theoretical bases for the project resided in two positions: eco-feminism as a framework both for the methodology of the research and as a foundation for environmental education, and the realist/constructivist paradigm as foundation for the multiple knowledge constructions inherent in the project.

In returning to the questions in the final pages of the dissertation, a cyclical epistemology is enacted; a fitting approach to knowledge acquisition in this project, inasmuch as it is echoed in three major elements of the project: the action research process, the scientific method, and the workings of nature itself.

As a means of speaking to the research questions, I will consider a series of propositions, each to be accompanied by further interpretation and discussion. These propositions, which are tentative assertions based on the data that resulted from the project, will take the place of definitive conclusions. I will then discuss the implications that the project-based propositions might have for the future of environmental education, and for teachers of secondary science who
may be required, as is the case in Ontario, to embed or integrate environmental studies into their curriculum. I will end the chapter, and the dissertation, with my closing thoughts regarding the confluence of secondary science and environmental education.

However, before embarking on a reappraisal of the data, in preparation for a discussion of the propositions proffered by the research questions, and as a basis for a consideration of the implications of the project, it will be necessary to briefly review the earlier discourse on the generalizability of qualitative work. To what extent can conclusions that might be considered truth statements be drawn from this qualitative/narrative data?

**Generalizability Revisited**

In the shift toward a post-modern perspective in humanities and education research, qualitative methodologies have become common and valued. However, the impact of the positivist quantitative tradition lingers in a continued demand for reliability and validity in data. For this reason, and to frame the limitations of the implications to be drawn from the data generated by this project, the ideas expressed by Larson (2009) and Wallace and Louden (2000) are revisited. First and foremost, is the tacit acknowledgment that it seems to be within our human nature to draw conclusions and make generalizations based on our experiences (qualitative or quantitative,) as a way of organizing and making sense of the world (Wallace and Louden, 2000). Research, in its many forms, is a formalized expression of that human drive. I recognize that my attempt to organize and make sense of the data, as presented in the propositions and implications, is a subjective interpretation of, not only my reading of the data and participation in the project, but also my experiences of a teaching career spanning three decades. My subjective interpretations are impacted by recognized and unrecognized factors, by
the power structures within which I have worked, those which I created in the project, and by my personal biases.

Nevertheless, Wallace and Louden (2000) contend that a story, or as in this chapter, a series of statements, will be recognized by the audience as being truthful if there is an agreement with the researcher about what is considered important. In the case of this dissertation, it is hoped that educators with a background in secondary science and/or environmental education would experience a strong resonance with both the particulars of the project and the generalities of the implications which I will later outline. Further, to the issue of truthfulness, Larson (2009) suggested three lines of reasoning that would support generalizability in qualitative research: a selection of participants such that a maximum variation of cases are achieved, a similitude in context between audience and participants attained through the collection of rich data, and a recognition of parallel processes among different cases. These three elements, as they are combined in this project and outlined in this dissertation, underpin the legitimacy of any interpretations or opinions that might be herein suggested.

The Original Questions

As a way of focusing the ensuing discussion of the propositions and the implications of the research, I return now to the four original questions stated at the outset of this dissertation:

- What theoretical foundations, epistemologies and values underlie secondary science teacher praxis?
- How do secondary science teachers perceive EE? How do they understand it?
- In what ways will EE challenge the classroom practice of secondary science teachers?
In what ways is action research a suitable medium for secondary science teachers to accomplish the integration of environmental education into their praxis?

The first three questions attempts to identify and associate the education theories and epistemologies of secondary science teachers with both their current work as well as their additional efforts to embed environmental education within their practices. The last question focuses on the suitability of action research as a professional development and curriculum development strategy.

The answers to the questions do not present themselves algorithmically; there are no simple and tidy statements that will definitively satisfy each inquiry in the way that a mathematical problem can be solved. Rather, each of the questions above has served as a focal point around which data has been assembled and further coalesced into the ideas that are expressed as propositions that follow.

*The Propositions*

My exploration of the data and subsequent analysis, informed by my research questions, led me to a number of tentative assertions or propositions which serve as a means of organizing and synthesizing my thoughts. In place of irrefutable conclusions, I put forward below eight statements that express my learnings as they have been informed by the research project. It is my expectation and desire that one or more of these propositions echoes the reader’s experiences, that they evoke connections to the reader’s perspective, and that they find convergence with the reader’s opinions. It is through the parallel reflections of language and reality construction that the propositions might be recognized as meaningful and authentic statements (Wallace & Louden, 2000).
Each of the eight propositions (identified by italic text), are discussed below in relation to each of the original questions (identified by bold text).

What theoretical foundations, epistemologies and values underlie secondary science teacher praxis?

1. To a large extent secondary science teachers continue to view the discipline of science as a politically neutral and rule-structured human endeavour, and the knowledge derived from it as a sacrosanct component of science teaching.

It was a telling indication of their fundamental perspective that all of the participants, when asked to describe a scientist, detailed a white male, wearing a lab coat and glasses, working in a chemistry lab. The data suggests that for the participants this iconic image represents a deeply ingrained popular version of science and scientific method; that, despite their exploration of the nature of science, continues to portray a human endeavour that is purely motivated, politically neutral, rational and precise. Although the participants indicated their understanding that scientific research is significantly impacted by political, social and economic elements; nonetheless, they saw the rational nature of the scientific method as a means of nullifying those influences, thereby rendering scientific endeavours as the very best way of acquiring knowledge. The participants’ views on the nature of science echo Bowers’ (2002) assertion that Western privilege ascribes to scientific study the highest form of human progress, and Bencze and Hodson (1999) claim that science carries with it the illusion that it is value-free and produces reliable factual information.

The teaching practices of the participants, in the form of the lessons that they discussed, indicated a very traditional and deferential respect for the value of that scientific knowledge. For
example, during the first meeting, in discussing the design of secondary science curriculum they continued to accede to the importance of the traditional disciplines of chemistry, physics and biology, with their requisite reductionist lessons like, parts of the cell, and, parts of the atom. The position of most of the participants is consistent with views expressed by Venville, Sheffield, Rennie, and Wallace (2008) in describing the myopia of science studies as over-valued and discipline-focused. Moreover, the science studies to which several of the participants assigned lesser importance, such as weather, ecology and space studies were seen as less valuable to the academy overall, in part due to what George called their imprecise or fuzzy nature. An explanation for this assignation is offered by Bencze and Hodson (1999) who maintain that the myths surrounding school science teaching include a belief that “science comprises discrete, generic processes and that scientific inquiry is simple and algorithmic” (p. 522). Not every participant’s view was equal in this regard; most notably Harvey, who worked as a research scientist, had a more realistic understanding of how science is enacted, yet even he, as a teacher of senior students, was reluctant to step away from a traditional disciplinary-knowledge-based teaching practice. This finding echoes the study done by Rico and Shulman (2004) in which they found that the four science teachers with whom they worked had tremendous difficulty (and were unsuccessful) in shifting away from an overarching focus on content knowledge.

Scientific endeavour was not presented as a creative or cognitively messy undertaking; rather, as a rational, logical, and dependable route to explaining and predicting the workings of the world. Stated in terms of the theoretical underpinnings for this dissertation, the epistemological position of the teachers eschewed a realist/constructivist perspective of
knowledge building for one that was heavily dependent on a realist/positivist perspective. Most of the teachers did not easily acknowledge that their knowledge construction, and that of their students, might be strongly influenced by the very factors (social, political and prior experience) that they were hesitant to address in their teaching. Further, it was not recognized by the teachers that science knowledge might consist of more than the rational and explicable (a nod to the eco-feminist perspective of knowing).

It seemed that there were powerful undercurrents at work and these are addressed by the second proposition.

2. The culture of secondary science teachers, steeped in the ‘tradition of science’, is a powerful deterrent to meaningful change in science teaching, thus secondary science teachers continue to enact the position that knowledge of discipline-based facts, rather than interdisciplinary critical thinking, is the key to preparing students for success in society.

The proposition stated above is addressed by the data on two levels. On a philosophical level, all of the participants agreed that their practice should engage students in science-based problem solving activities. However, on a practical level, with regard to the development and implementation of science lessons with an EE component, the participants were hesitant, and three issues surfaced in the data. These were: the reluctance of some of the participants to tamper with what they perceived to be well-developed and long-standing traditions in science teaching, the pressure that some colleagues seemed to exert in order to maintain those traditions, and what the participants perceived as a limiting curriculum.

The data indicates that the participants wished to meet the needs of students by providing meaningful science experiences and topics; however, they spoke of the curriculum as a
constraint in both time allotted and topics provided, and thus when forced to choose between students and curriculum, the latter took precedence. This finding echoes that of Bencze, Bowen and Alsop (2006) in whose study the participants identified curricular demands, large class sizes, and lack of teacher training as reasons for limiting student-directed science activities. Moreover, the teachers’ efforts in regard to changing practice were further stymied by their own admitted reluctance, clearly voiced during the second meeting, to entertain discussions in politics, society or economic consideration, believing those to be outside their purview and the realm of high school science (a finding supported by Gayford, 2002). As pointed out in the first proposition, the teachers were not, to varying degrees, heavily invested in the recognition of prior experience, (in the form of social, political, economic or other experiences) as an important element of knowledge construction for their students. Furthermore, since the long-standing traditions in science (with which the participants were reluctant to tamper) tend towards the rational and the logical, the willingness to consider qualities like creativity or intuition (from the eco-feminist position) in science was not strongly evidenced in their teaching except by George in his narrative lesson.

During the first meeting, when given the opportunity to explore the nature of science, the data indicates that the participants grappled with the possibilities for an altered approach to science teaching, and to a limited extent, recognized the problems engendered by the ingrained culture of secondary science teaching: an emphasis on STSE, ethics, or critical thinking could be seen as tantamount to an abandonment of peer culture. For example, in the conversation concerning lab report assignments, the participants needed permission from each other in order to change their traditional practice. The confidence to surmount the obstacles presented by a
disciplinary culture varied amongst the participants, with Tess, the least experienced member of the group showing the least confidence and Jane, the most experienced member of the group showing the most confidence.

The attitudes that formed the culture of these secondary science teachers seem to be ingrained and resistant to change (although this group had self-selected to participate in a study that clearly was proposing change), perhaps because they are mired in the larger notion that factual scientific knowledge is paramount and perhaps because, as Hodson and Bencze (1998) suggest, science teachers’ never fully contemplate their own disciplinary balkanization. Thus real change in science teaching is a difficult undertaking.

Nevertheless, the revised secondary science curriculum in Ontario schools, which was the working document for all of the participants, calls for a fundamental shift in science teaching, with far more emphasis on STSE issues, and the relegation of factual information to a position that supports the STSE lessons. While this is a significant adjustment in the structure of Ontario science curriculum, I believe that only a shift in science teacher culture and epistemological position will signal a change in secondary science teaching.

3. *Textbooks play a central role in shaping secondary science teachers’ perceptions of science pedagogy and environmental education.*

Each of the participants, during various conversations, admitted to a lack of skills and knowledge in a particular area of science, and their consequent reliance on a textbook as an essential guide in both the organization of a topic or unit, as well as day-to-day lessons. The project data further indicates that a heavy reliance on the textbook for content information; as well as activity choice and sequencing occurred not only when a participant was faced with
teaching in an area of science with which they were unfamiliar, but also as part of their regular classroom routine when they were comfortable with the subject matter. Participants explained that relying on the textbook made their work simpler, and gave them and their students a point of focus for the lesson (a finding similar to that of Shibley, Dunbar, Mysliwiec and Dunbar (2008). For example, Jane was initially very dependent on her textbook’s chapter on ecology because of her weak knowledge base in that area, thus allowing the textbook to become the teacher in the context of requisite content information and relevant activities; and both Tess and George acknowledged the usefulness of reading and seat work provided by a textbook for the purpose of classroom management. The overt reliance on the textbook, voiced and demonstrated by almost all of the participants, parallels the findings of Ogan-Bekiroglu (2007) whose research targeted secondary physics teachers, and Tarr, Chlvez, Reys and Reys (2006) who worked with teachers of mathematics; both research groups found that the teachers in their projects relied heavily on their textbooks as curriculum authorities.

There are times when the absence of data is as significant as its presence, a situation which arose when it became apparent that at no point did any of the participants voice any concerns regarding possible disparities between their personal epistemologies, the targeted curriculum and the intent and format of their textbooks. The textbooks were not questioned as authorities on science teaching. Yet the textbook can suggest the importance and tone of topics, as evidenced by at least one of the teachers in the project. For example, as she strove to systemize her understanding of studies in ecology and environmental education, Sharon noted that EE topics were placed at the end of each chapter in her textbook, a position which she took to imply that EE was add-on rather than core material.
In my opinion, the considerable influence of the textbook in a science classroom is troubling for a variety of reasons. Foremost among them is that a publishing house, with both political and economic interests, potentially determines and designs the lessons that students are taught (Kirk, Matthews & Kurtts, 2001). One might ask, since it is in the best interest of the publishing house to turn a profit, what assurance is given that the textbook it produces will incorporate the most current science pedagogies (that might not be accepted or expected), rather than fall back on traditional and ensconced practices. There is no statement or guarantee of the epistemological or theoretical position of the authors of science textbooks, or a statement outlining how they view the nature and history of science, or which pedagogy they advocate for the teaching of science. Thus, I suggest that it is very plausible that, because the participants ceded so much authority to their textbooks, they consequently further diminished their ability to challenge their own practice, and thereby secondary science teacher culture and epistemology.

How do secondary science teachers perceive EE? How do they understand it?

Although this is the second of the research questions, I will briefly continue the discussion of textbooks, since the data indicated a notable reliance, by the participants, on their classroom textbooks for information and lessons regarding not only the traditional topics of physics, chemistry and biology, but also the topic of environmental studies. The data indicates that based on the positioning of EE within the textbook, the participants generally viewed EE as one of several branches of the study of ecology (itself a positivist undertaking including mathematical formula, graphs and structured labs). The next proposition identifies the view of EE that was most common to the participants in the project.
4. **Environmental education, beyond the scientific study of ecology, is understood to be a study of nature requiring specialized skills and knowledge and therefore is viewed by science teachers as an add-on to the regular science program.**

When asked what an environmentalist looked like, the participants’ answers conjured an image of a bearded, tousled hippy chained to a tree. The data further revealed that at the beginning of the project, the participants’ understanding of EE was underpinned by a perception that environmental issues are the domain of dissenters and eccentrics who exist on the periphery of social conformity. (I find myself wondering if this piece of data relates to the geographical location of the project in a northern Ontario town whose main industries are directly dependent on harvesting natural resources such as timber and ore.) The initial responses of some of the participants portrays environmental issues as insurgent, fringe topics, in sharp contrast to the respectable and conventional studies of science. A few participants, notably Harvey, took a more balanced view of EE, positioning it as a way of understanding human impacts on the environment.

Notwithstanding, environmental education, within the context of existing secondary science curricula, was initially perceived by the participants as comprising a largely theoretical study involving trophic levels, food webs, and population changes, as examples. It is evident that the participants adopted a certain perspective of EE that parallels the **naturalist or conservationist** current or conception of environment described by Lucie Sauvé (2005). The fifteen currents put forward by Sauvé have evolved over the last century. Those embraced by the educational community have become predictably institutionalized in the form of, for example, studies in ecology and environmental science, outdoor and experiential education centres, and
adventure education programs. During the first two meetings the participants described their experiences with environmental studies as safely neutral and knowledge-based, taking place almost entirely within the confines of their classrooms. Any active or hands-on environmental education that may have taken place beyond the classroom (and its textbook), was seen as requiring unique skills and knowledge, as evidenced by Jane’s repeated assertions that she was not knowledgeable enough to teach EE, and Sharon and Tess’ recounting of student management issues out of doors. The project participants spoke of EE as part nature study, part conservation study, part recycling program, and part adventure education; identifying only a few of the ways in which EE can be understood (refer to EE currents, Sauvé, 2005).

The data reveals that environmental studies lessons undertaken in the form of a field trip, or given over to experts at various centres or organizations, were considered by the participants as add-ons to their science programs. In my opinion, experts in field centers, and guests in the classroom are not unreasonable approaches to teaching environmental studies; since indeed there are highly knowledgeable and qualified individuals who can provide specialized EE programming. However, I would caution that by laying the teaching of environmental studies in the hands of experts, teachers may further distance the science curriculum from EE, rather than moving towards an integration of the two. Certainly, the project described in this study situated EE as separate from science, therefore requiring a conscious effort of integration.

Towards the end of the project, after working collaboratively to understand EE, and embed it in their science practice, most participants’ perceptions of EE had evolved considerably. The data shows that to varying degrees, each of the participants had begun to view EE as a natural component of multiple topics and lessons within science. In one instance Sharon
described environmental education as a way of thinking about teaching, and in another instance Jane stated that she was beginning to see the possibility of environmental connections in almost all of the lessons that she was teaching. Put another way, both Sharon and Jane were beginning to recognize the eco-feminist aspects of EE, particularly in terms of its connections, integrations, and pedagogies. Both Sharon and Jane found ways to embrace portions of EE in their science practice, however the next proposition identifies one of the elements of EE that remained problematic for the participants.

5. *Secondary science teachers do not feel comfortable addressing contemporary EE in terms of the political, economic and social ramifications inherent in environmental issues.*

A contemporary form of EE links environmental science studies to political, social, economic and/or technological issues. In other words, through STSE, science informed by EE should be grounded in relevant local and/or global contexts. Yet the teachers in the project expressed an ongoing reluctance to address pressing social, political and economic concerns that are linked to environmental issues. They cited a number of reasons for their reluctance. First and foremost, almost all of the participants argued that they were not trained in the humanities, and thus, might neither understand nor have the strategies required to adequately address social, political or economic issues with their students. Sharon was very emphatic in her pronouncement that she had no political acumen, that she felt entirely unable to tackle such topics with her students, and that her lack of knowledge would weaken her position as a teacher. Secondly, the participants in the study recognized that issues pertaining to environment, society, politics, and so forth have few straightforward solutions, are open to multiple interpretations and provide little in the way of resolution. They were uncomfortable with such a blatant disabuse of the
infallibility of scientific endeavours; preferring to view science as an effort to uncover answers moreso, than to think critically about the social, political or possibly ethical issues that arise from such an undertaking. The data reveals a strong belief by most of the participants that social, political, economic, and even ethical issues should largely be the concerns of teachers in the arts and humanities.

The requirement to emphasize STSE was seen by the participants as new territory, and for most of them, it represented a discomfiting evolution of their practice. Nonetheless, the data shows that each of the participants began the work of introducing environment-based teaching and learning in their lessons in small ways almost from the beginning of the project, and eventually each of them took on the challenge of designing and teaching an EE embedded science lesson on Shh! Environment Day. The results on that day varied among the participants: Sharon’s trip to the grocery story, Jane’s group work with environmental hormones, and George’s narrative approach to ecological attitude development, enabled all three teachers to challenge their teaching practice. On the other hand, Harvey’s water chemistry lab, while active and interesting for the students, only skirted STSE dimensions, remaining safely within the confines of a traditional science investigation. During the last two meetings, which took place after Shh! Environment Day, most of the participants demonstrated varying degrees of increased confidence in their perceived ability to address contemporary EE issues within science lessons.

The data points to one other factor that impacted how the participants viewed the inclusion of EE in their science lessons: the participants predicted that most of their students viewed science as a content-oriented discipline and further, that their students preferred the safe neutrality of content over the difficult and messy treatment of issues (a sentiment also proffered
by Breunig, 2006). However, the data collected during classroom visits and subsequent discussions demonstrates that the students’ responses to the EE embedded science lessons were very favourable. For example, Jane recounted that a group of her weakest students enthusiastically stayed after class to complete their assignment. While a generalization regarding student responses to EE is not appropriate at this point, it appears possible that the students involved in *Shh! Environment Day* found an issues-based approach to science a refreshing and relevant change from content-based lessons. The students’ responses may indeed reflect their appreciation of the recognition that their learning is an act of knowledge construction; their learning is directly related to their experience base rather than a simple desire for discrete facts.

Based on the comments and attitudes expressed by the participants, particularly towards the beginning of the project, one might conjecture that many secondary science teachers are most comfortable with the rational and soluble, and find the inclusion of EE to present significant challenges. The participants’ responses reflect a reliance on a positivist epistemology, wherein knowledge of factual content is transmitted to students; significantly different from both their students, and from the realist/constructivist position that I have proposed for this project.

**In what ways will EE challenge the classroom practice of secondary science teachers?**

6. *Embedded environmental education offers secondary science teachers the opportunities to broaden their repertoire of teaching strategies.*

The response of the project participants, when presented with specific teaching strategies most often associated with EE (Smyth, 2006; see *Appendix E, Meeting 3*), was three-fold: they all agreed that the strategies listed were the hallmarks of what they considered to be great
teaching, they felt that the assessment of those strategies would be problematic, and that action-based teaching presented serious ethical and epistemological difficulties.

The data indicates that upon reviewing the EE teaching strategies, all of the participants agreed that, taken as a group, the descriptors characterized the type of teaching that they felt would be extremely valuable for students and very rewarding for teachers. However, the teachers expressed their disbelief that it would be feasible to teach a secondary science course using many of the listed strategies, and even more difficult to assess student learning.

Most of the participants voiced the belief that the unit test remained the single most important method of assessment in secondary science; and lab reports, quizzes and skills demonstrations were also highly valued because they were well-developed and familiar methods of determining content acquisition. The data contains several discussions on the topic of assessment, with most of the participants expressing concerns that student learning associated with EE, (for example: interdisciplinary activities, out of classroom learning or student-focused topics) would require a different and unfamiliar set of assessment strategies and tools.

None of the participants, except George, were able to envision a science course that focused more on problem-solving and inquiry skills, and less on the acquisition of content. Yet, in the lessons that the participants prepared for the project there was ample evidence of the EE teaching strategies, and in further discussions the participants all expressed an increased comfort level with one or two of the new strategies. Unfortunately, the project data does not include

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4Environmental education, as described by Greunewald and Manteaw (2007), Hart (2007), Hodson (2003), Jensen and Schnack (2006) and Stevenson, (2007a) espouses pedagogies that go beyond traditional science teaching formats such as lectures, note-taking, textbook assignments or recipe-style labs, to encompass issues-based, interdisciplinary, critical-thinking models of teaching which have as their goal a transformation of the attitudes and behaviours of learners.
information on the subsequent assessment of student learning within the new teaching strategies.

The hesitation of participants to relinquish the dominance of content knowledge in their science teaching impacted their reactions upon reading about and discussing an action-based approach in secondary science (see Appendix E, Meeting 4). Essentially, the action concept in EE requires that students address an authentic STSE issue, and then go about the task of researching, problem-solving, designing and implementing a solution to the problem. Several of the participants were dismayed when they encountered the suggestion that simple classroom activities, games or simulations had little impact on student (environmental) behaviour; rather only an action-based project would have long-term effects in that regard. After lengthy discourse, all of the participants agreed that an action-based project was very valuable for student learning, but problematic to enact in a secondary science classroom because action-based projects are often associated with interdisciplinary studies, and they take up much of the allotted curriculum time. The participants also debated whether values transformation and students’ politicization are professionally conscientious intentions, and went on to question whether it was in the best interests of their students’ futures to focus on issues, rather than pure knowledge acquisition. Lastly, they discussed whether students should be encouraged and enabled to take action in their communities. The participants did not arrive at any definitive conclusions, but they did express their satisfaction in having grappled with the ideas; a number of them discussed action-based projects that might be workable in their science classes in the future.

As the study indicates, to embed the pedagogies of EE in current practice is a daunting undertaking that requires a considerable investment of time and energy by teachers to acquire additional knowledge and skills, and a commitment to explore pedagogical opportunities. More
importantly, teachers must wrestle with the epistemological underpinnings of pedagogical change. In the case of this study, the realist/constructivist paradigm might have offered a bridge towards the constructivist pedagogies that the teachers found valuable but had difficulty implementing in a secondary science class. The realist/constructivist paradigm that I outlined in chapter three acknowledges the existence of facts to be discovered and learned, but also recognizes individual agency in constructing personal knowledge. Within that framework there is a space for educators to facilitate contextual (EE and science) knowledge building through the constructivist pedagogies mentioned earlier in this proposition, rather than a rote transmission of facts.

7. **Narrative and story are valuable teaching strategies in secondary science studies.**

The participants’ use of narrative in their classroom practices was very evident in the data, particularly in the areas of classroom management (George and Tess), and as an informal teaching aid to further explicate a lesson (George, Harvey and Jane). Indeed, all of the participants agreed that stories were a useful method for supplementing student understanding of knowledge and skill concepts. George pointed out “they remember those moments (stories) more than they remember the abcs [sic] that we taught them” (audio-recorded meeting, December 4, 2008). Both Jane and Harvey alluded to sharing personal narratives with their students: Jane connected science lessons to her two children, and Harvey connected science lessons with stories of his travels.

Many of the participants believed that the telling of a story was sufficient to internalize and contextualize information for the learner; particularly if the story resonated with the student. Notably, the participants’ beliefs regarding the power of story are corroborated by the work of
Melville and Wallace (2007) and Wallace and Louden (2000) in which the authors argue that story gives context to information, making story a powerful influence in how students learn. The eco-feminist position asserts that story, as part of the creative and intuitive self, is a legitimate form of knowledge and understanding.

Again, in agreement with the literature, the data reveals that all of the teachers felt that the science lessons with the most lasting impact on their students were those with one or more elements of story; these might have characters (various teacher and student personalities, fictional or historical figures), settings (a local field or stream or a distant, exotic location), and plots (the journey to the setting, the quest for specimens or information, the unexpected slip into the mud and subsequent uproar).

The participants’ use of story as a component of a science lesson was not unexpected, however, George was the only participant who used story as a primary teaching strategy for the project lesson that he designed and implemented. Using the structure of the well-known fairy tale of the Three Little Pigs with a contemporary environmental twist, George used the story both as an allegory and a challenge to his students. Afterwards he felt that the lesson was very successful for three reasons: it had elicited substantial student response in terms of discussion addressing personal relationships to environment, it seemed to have been successful in challenging student attitudes and behaviours, and it had an action-based environmental component that could be assessed.

In my opinion, a mindful engagement of the student through story (as demonstrated by George) is valuable component of student-focused teaching and learning, therefore one should
ask why story is not employed more often in secondary science class, and how it can be
legitimized as a teaching method, rather than viewed as a peripheral tactic.

In what ways is action research a suitable medium for secondary science teachers to
accomplish the integration of environmental education into their praxis?

Again, I will extend the discussion of a proposition into the next research question, in
this case, to address briefly the use of story as an important component of the action research
process. Certainly, the project data is rich with the stories that the teachers told as they connected
their classroom work, their collegial work, and the work of improving their practice. The data
further provides ample evidence that the participants communicated many of their thoughts
about their work through narrative. For example, during project meetings, Tess used story as a
way of recounting and explaining her classroom management problems, and Jane used narrative
to describe her teaching experiences in the outdoors. It is accurate to say that narrative was the
primary method for each of the participants to describe the actual events that took place in their
classrooms when they presented the science lessons embedded with EE. This finding in the data
is supported by Cotton and Griffiths (2007) who stated that “the only way that teachers can
really understand their work and the work of others is through articulating their own stories and
through hearing the stories of others” (p.547). Indeed, in providing a theoretical basis for the
research undertaken in this study, the eco-feminist perspective, described in detail in chapter
three, readily embraces and supports storytelling as a means of describing knowledge. Narrative
was a significant tool for communication amongst the participants throughout the action research
project and it is woven throughout the data.
8. Action research is a form of professional development that offers potential for knowledge and skill development and coincident evolution of science teacher culture, but only under certain conditions.

In a number of ways the participatory AR project described herein fell short of the models of action research outlined in the literature; nonetheless, it had significant impact for the participants. The most troubling aspect of the AR project described here was the lack of systematized, concrete or hard copy evidence collected by the teachers in their work, particularly on *Shh! Environment Day*. Since data collection is considered an integral component of research, this problem deserves some attention. Foremost, the responsibility lies with me, the researcher/facilitator, in that I did not explicitly insist on some form of systematic data collection; however, to do so would have been to assert myself in a hierarchical role of authority which I had been very careful to avoid throughout our meetings. It would have been very useful to compile evidence of student work, as well as consistent journal entries by the teachers, describing their thinking (and changes in thinking) over time. Robottom and Sauvé (2003) refer to this as *building a research culture* and identify it as a critical element in successful action research with practicing teachers.

However, the eco-feminist position, which is the theoretical underpinning of this project, is helpful in making the determination of what may be recognized as admissible data. Voices and forms of data that might be conventionally ignored, or at least attributed a lesser value, are deemed useful. The data that can be considered evidence of change in teacher work and learning over the course of the project, culminating in *Shh! Environment Day* can be found within each teacher’s account of their experiences. The affirmation of changes in practice and understanding
resides in the telling of each of the teachers’ stories as they worked with their students over

course of the project and the semester. By way of examples: Jane described at length the changes

in her students’ attitudes towards an ecology lesson, and she chronicled her own journey towards

a deeper understanding of EE; Sharon detailed her changes in epistemology moving toward an

increasingly action oriented approach to teaching science; and Bart succinctly remarked, “It’s

going to kind of change my philosophy going into the (new) course”.

Proposition # eight clearly states that AR has a potential for teacher development but

only under certain conditions. In my view, that potential is dependent on a number of factors;

including a clear understanding of what is considered data collection in an action research

project, and a facilitator who is adept at guiding without controlling the work of the group. In

addition, it is advantageous to create a time-frame for an AR project that allows for more than

one cycle in the research process, and certainly it would be very fruitful to work with a group of

participants that has had previous experience with action research. Thus, the action research

project undertaken and detailed herein could be more correctly described as a facilitated

professional learning community that was given tacit permission (by the researcher/facilitator

and by themselves) to explore their practice beyond the normal delineation of secondary science

culture. Such a descriptor downplays the importance of data collection for the success of the

project.

While the project may not have maintained strict adherence to the AR model, it

nonetheless fulfilled many of its intentions with regard to the professional development of

teachers in the area of EE and secondary science. The data indicates that the teachers were

pleased and excited to be given the time and support for professional dialogue with a view to
improving their practice. This was most apparent during the first meeting, as the teachers met and introduced themselves; and during the last meeting as the teachers reviewed the work they had done, and provided feedback to myself as the researcher/facilitator. More specifically, Harvey voiced the opinion that while most professional development in which he had participated occurred over just one session, the action research model allowed the participants to collaborate over a period of time which provided opportunities for them to try different strategies in their classrooms, discuss the outcomes, and return to the classroom with modified strategies. In essence Harvey was describing a constructivist model of learning.

Further, the participants commented at various times on the level of trust which seemed to exist amongst the group members from the first meeting; a number of the participants expressed how much they appreciated the support and encouragement they derived from the group, and George observed that they could speak freely about their weaknesses and doubts without fear that they would be professionally marginalized. George’s comment is consistent with the view that the AR model can provide a haven where teachers, as participants in a learning community, can explore new attitudes and new practices (Altrichter, 2005; Cotton & Griffiths, 2007).

While the potential of AR as a professional development model is becoming well established, it cannot be assumed that participants, even secondary science teachers, will understand the nature of the research they have agreed to undertake, nor that they will necessarily step outside of the zones of comfort dictated by the overarching science teacher culture. The data shows that during the third meeting, after the nature of science teaching and the nature of action research had been investigated, the participants struggled with the establishment
of a formal research project. Their initial ideas centered on providing professional development for their peers, either in the form of resource packages or workshops; methods of professional development with which they were most familiar. It was only after repeated reminders that their research should address their own practice that they were able to settle on the project they eventually named *Shh! Environment Day*. As proposition #8 suggests, in order for AR to be considered a useful form of professional development it is a necessary condition that the participants, and the researcher/facilitator, fully understand, and have some experience, with the model.

Although AR accommodates multiple cycles of lesson design, implementation, reflection and redesign; the time allotted to this project, and the experience level of the participants and the RF; allowed for data to be collected for only one full cycle. Nevertheless, during the last two meetings, most of the participants expressed a much greater confidence in their understanding of AR. Also, George and Jane, and Tess and Harvey, who are respectively colleagues at the same schools, discussed how they might together make further use of AR. In my opinion, it was at the point of planning to continue their collaboration beyond the project that the participants named above had truly embarked on the journey of challenging the science teacher culture that influences their professional work.

*Implications of the Project*

At the heart of this project was the attempt to integrate or embed EE within secondary science studies; to provide a confluence for the two seemingly disparate traditions. The eight propositions detailed above helped me to find meanings in the various tributaries that arose from the project; for example: understanding how secondary science teachers perceive the nature of
environmental education, and its importance in secondary curriculum; the enculturation of
science teachers, and the institutionalization of secondary science teaching with its deeply
ingrained dependence on content, and its weak emphasis on critical thinking; the influence that
textbooks have on teachers’ work; and the importance of professional learning communities, as
enacted (albeit imperfectly) in the AR mode, and their potential to address changes in science
teacher culture.

Those tributaries hold a number of implications for secondary science teacher work;
particularly in Ontario where the project took place, and where a revised science curriculum will
mandate the inclusion or embedding of EE within science lessons. I believe that the central
question now, and for that mandate, is one of enactment: how can teachers transform the theory
of embedding EE in science, into a practical and workable curriculum? Stated another way: how
will EE and science converge in the pragmatic eddies of the science classroom?

Teachers of secondary science face unique barriers to changing their practice to
accommodate environmental education. Based on evidence provided by the project, it appears
that many secondary science teachers do not perceive the limitations placed on them by the
institutionalization, balkanization and enculturation of science teaching; therefore they are not in
a position to challenge and interrupt that hegemony. Their perceptions stem from a history of
separate disciplines, professional isolation, and a safely neutral version of science, which
combine to make interdisciplinary, contextual, student-centered efforts difficult. Their
pedagogies are still rooted, to a large extent, in the traditional positivist position that values
discrete content, while downplaying the importance of a constructivist position in knowledge
building both for themselves and for their students.
In order for those teachers to fully embrace an integration of EE and science, and to experience and create a transformative experience for their students, they must have available to them a powerful structure for professional development that includes the tools to question their science teaching practices, and a variety of avenues by which they can effect significant change. In addition, teachers must have a source of support to bolster the confidence required to resist the conventions of history and peers, and to embark on a new pedagogy. Lastly, as evidenced in the project, secondary science teachers need a measure of leadership to focus their professional development efforts.

The project also presented evidence that story is an underrated learning tool in the secondary science classroom. I believe that it would be useful to better understand the potential importance of story in the learning process, with particular attention given to secondary science students. Numerous questions come to mind, including: whether the right and left brain hemispheres are differently engaged by story, whether story has applications in all science disciplines, whether story has interdisciplinary applications and, how the use of story might impact evaluation and assessment. Story seems to be a perfect fit with EE, in the sense that issues become contextual stories with which students can identify and interact critically.

Perhaps story as a teaching and learning tool is also a natural juncture where eco-feminism and realist/constructivism might meet, inasmuch as the first philosophical position values the emotional, creative and intuitive aspects of story, and the second philosophical position recognizes the importance of the storied experience in determining and constructing individual knowledge. This juncture is worthy of further exploration.
In addition, story should be considered a valuable conduit for STSE studies, for the same reasons named above. Not much attention has been paid in academia to the use of story as a learning strategy in science except at the post-secondary level where Shibley, Dunbar, Mysliwiec and Dinbar (2008) discuss and recommend the use of popular novels such as *The Double Helix* (1968), *How We Die* (1993) or *The Seven Daughters of Eve* (2001) as supplements to studies in genetics. The authors suggest that science in the form of story addresses the processes and foibles of science as well as the scientific information inherent in the account.

There is also general agreement that story/case/narrative are useful tools for teacher professional development (for example: Cotton & Griffiths, 2007; Melville & Wallace, 2007; Shulman, 1986; Wallace & Louden, 2000), so it should be no great leap to anticipate the value of story in preparing and assisting teachers in integrating or embedding EE in their science practices. Indeed, there is ample confirmation in the project results that narrative and story are potent communicative devices used by teachers both in their classroom practice, and in their collaborative work with AR.

The ability of AR to challenge teacher culture makes it a useful method of professional development for secondary science teachers who seek to integrate EE in their practice. At the same time, it is the nature of EE to connect ideas and understandings across the disciplines into a form of learning that is relevant and contextual both locally and globally. Melville and Wallace (2007), in their work with Australian secondary science teachers, describe a remarkable exchange of knowledge, skill, and pedagogical information within a science teacher learning community engaged in a form of action research. However, beyond the sharing of information, AR sets the stage for teachers to challenge the values and assumptions surrounding their
practice, thereby opening the door to actual changes in beliefs and consequent changes in their practice.

Given these factors, I would propose that action research addressing environmental education, enacted with professionalism and integrity, has considerable potential to assist teachers in shifting those attitudes and assumptions of their culture that constrain positive changes in praxis. Meaning, it is within the scope of EE, and within a professional development AR model, to encourage interdisciplinary attitudes, to embrace interdisciplinary, student-focused teaching and assessment strategies, and thereby disrupt the isolation and balkanization that plagues so many secondary educators.

**Final Thoughts**

I began this project with a weakly conceived notion that, rather than sit on the fringe of widely accepted secondary curriculum, EE should take a prominent position in the secondary curriculum along with subjects like English and Science. Moreover, I believed (and was supported by the data) that many secondary science teachers’ basic attitudes and assumptions are inconsistent with a change from a knowledge-based, teacher-centered practice to one that is contextual and student-centered. However, through the progression of the project and the writing of the report, my views have been considerably revised and refined, and my perspective sizably broadened (I suppose that is the merit and intent of a doctoral research project and dissertation.) My many conversations with the participants of the project, along with their preparation and implementation of science lessons embedded with environmental studies, enabled me to see the nuances of science teacher culture and its relationship to their understanding of the nature of science. The metaphor of a confluence of rivers (or traditions) helped me navigate the waters, so
to speak, of the complex elements that impact the enactment of an integration of environmental and science curriculum. That metaphor also allowed me to better understand the different ways in which EE might be incorporated into existing science curricula: for example, the acceptance of EE as a separate subject, an integration of EE and science, and/or an embedding of EE within science akin to the STSE model.

What I failed to see at the outset, but now recognize, is that while establishing environmental education as a discipline would probably heighten its credibility and status among educators and administrators, such relocation could very well remove its flexibility and its passion, relegating EE to another predominantly knowledge-based, rather than action-based, partner to the discipline of science. This is in agreement with Greunewald (2004) who cautioned against the establishment of a formalized EE, arguing that as a separate, institutionalized discipline EE would become a collection of rote facts and activities growing ever more distant from the vibrant and transformative pedagogy that is hoped for. This caution was manifested in the project as the participants, struggling to embed EE in their science practice, continued to base their activity-oriented lessons on knowledge expectations rather than action-based applications and expectations. To align EE as one of the dominant secondary disciplines would dispossess it of its vitality, and its ability to effect transformation in students and teachers.

Nonetheless, environmental education, in my view, should be given prominence in the curriculum if teachers and their students hope to transform public knowledge and attitudes towards issues of environment. Many scholars (Bowers, 1993; Gough, 2002; Greunewald, 2004; Hart, 2007; Hodson, 2003; Jickling, 2001; Orr, 1992; Sauvé, 1996) have counselled, in their own way, that environmental education must become much more than a nature study or a canoe.
trip. But then what position should EE take in its association with secondary science? A number of possibilities present themselves. As a partner in the STSE model and one of several tributaries of science, EE could continue to be viewed as a separate component of the workings of politics and society, easily avoided when its issues and its pedagogies make it an uncomfortable topic. As a theme embedded in science curriculum, EE could be easily submerged in the stronger flow of conventional science pedagogy, surfacing only occasionally, when it was convenient and not too disagreeable. Yet, environmental education is interdisciplinary by nature, and as such it should be celebrated as a welcome perspective in secondary science studies. The strength of EE is that it can be interwoven into many disciplines and curricula. Furthermore, an eco-feminist foundation for EE gives it a robust and resilient identity: to connect and interweave, to remove hierarchies, to value all learners, to dispense with egocentric and androcentric paradigms, and to promote an ethic of care. The metaphor of confluence evokes a compelling and enduring partnership, which I propose should be a true merging of the two traditions of EE and secondary science education.

A confluence of secondary science and EE implies a convergent and equalizing collaboration between the two. Gough (2002) uses the term *mutualism* to describe a partnership between science education and EE; through which science becomes more relevant to a wider range of students by the inclusion of cultural and social elements, and EE gains a legitimate space in the curriculum. The question then becomes whether or not EE will be lost in the stream of traditional science pedagogy, succumbing to knowledge-based, teacher-centered curriculum, or alternatively as Gough suggests, that EE could reinvent science education based on critiques from other perspectives such as feminism, post-colonialism, anti-racism and constructivism. The
full merging of EE within science education would enable the two together to begin the task of moving a veritable mountain of public comprehension and action with regard to understanding the human relationship to environment. Environmental education/science education must make clear the pivotal lesson, that, because they are intrinsically tied together, degradation of the environment through human excess will inevitably lead to a deterioration of social, economic and political structures; and only coordinated and committed human agency will ameliorate that outcome.

Can EE be the transformative element that Greunewald (2004) envisions? I believe, or at least hold a great deal of hope, that it can, with one caveat: the foundation of the EE/science partnership must be the explicit acceptance of an eco-centric paradigm. An eco-centric perspective cannot be a simple nod to the superficial ‘green’ movement currently evidenced by a glut of consumer products with green labels, or the ability to ease the oil-dependent consumer conscience by making carbon credit off-sets available. It is, after all, the consumer-driven, industrialized, and ego-centric appetites of the West that have left the environment (meaning all life on the planet) vulnerable. Rather, an eco-centric paradigm makes clear that humans do not exist within environment (as if we were separate entities), but are indeed an integral part of environment, accountable in its food webs, nutrient/chemical cycles and climate. All human activity, including technology, industry, politics, economics and participation in society, takes place within environment, and thereby impacts and is reciprocated by environment.

It seems that I have come full circle back to David Orr’s assertion almost two decades ago, that “all education is environmental education” (Orr, 1992, p.90). The metaphor of
confluence is realized in the mingling of the waters of two traditions: science education is environmental education.
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*Interchange, 37*, 2-3.


*The Learning Organization, 9*(4), 143-149.
Appendix A. Letter to Administrators

September, 2008,

My name is Astrid Steele and I am currently a doctoral student at OISE/UT working on my research thesis for my dissertation. My interest has long been in environmental education and how it fits within the secondary school curriculum. I am especially interested in how environmental studies fit into traditional science education. As you might know, "Shaping our Schools, Shaping our Future" a report of the working group on environmental education, released in June 2007 had all 32 of its recommendations accepted for implementation by the Ministry of Education earlier this spring. Those recommendations call for the inclusion/integration of environmental studies in all grades and all subject areas in Ontario schools.

As part of my doctoral program at OISE/UT I will be examining the integration of environmental education and secondary science curriculum. Traditionally, secondary science programs are delivered with a very strong emphasis on content knowledge, while environmental studies are powerfully influenced by cultural, economic, social and political components. Of specific interest to me is how secondary science teachers will treat or incorporate the two since they have such different philosophical foundations.

Action Research

To do this research, I intend to offer an action research project for a group of four or five secondary science teachers during the fall semester (September 2008 - January 2009). Action research basically involves the cyclical model of a) reflection on practice, b) data collection and analysis, c) planning, d) implementation of new ideas and e) subsequent reflection again.

My request is for permission to work with one/two secondary science teachers (‘from your board’ or ‘from your school’) on an action research project in the coming fall semester. Specifically I respectfully asked the (name of school board) to release two teachers for 6 afternoons in the coming semester in order to participate in group work every 2-3 weeks beginning in late September.

While I recognize that release time comes at a premium for the boards and the schools involved, I do believe that there are will be significant benefits to the teachers participating and that this will no doubt be reflected in improved classroom instruction and student successes.

The model of action research is known to promote changes in educators' praxis through the cyclical model of reflection, data collection and analysis, planning and implementation of new ideas and subsequent reflection again. This is a very valuable form of professional development... it occurs over time working with a trusted group of colleagues. Facilitating the clarification of their values regarding
curriculum, science and environment has the potential to be a powerful process for educators, and one that they will be encouraged to share with their colleagues not directly involved in the study.

There are spinoffs as well for smoothing the transition of students from Grade 8 to Grade 9 science - elementary teachers traditionally understand and implement integration and interdisciplinary studies much better than their secondary counterparts. Thus, collegial professional development at the secondary science level will be no doubt be valuable.

The requirements of OISE/UT in terms of ethics in research are very stringent and privacy/confidentiality issues will be treated with utmost respect. School administrators will know who is involved in the project (in order to coordinate substitute teachers for classes) but beyond that they will not be privy to any individual information regarding teacher contributions or conduct within the group. Group members will be asked to maintain high standards of confidentiality with respect to the individuals involved in the project. Transcripts will use pseudonyms from the outset of the project and only myself and my research supervisor will have access to the data. A participant can choose to withdraw at any time during the project with no professional repercussions.

It is my intention that the results of the study will also be made available and be valuable to (name of school or school board) as a resource for all secondary teachers who will be required to include environmental studies in their curricula.

I look forward to this project very much and hope that it meets with your approval.

Should you have further questions please do not hesitate to contact me or my supervisor:

**Researcher:**  
Astrid Steele  
705-365-2117 (h)  
astrid.steele@ontera.net

**Supervisor:**  
Dr. John Wallace  
(416)978-0085  
jwallace@oise.utoronto.ca

Respectfully

Astrid Steele
INFORMATION CONSENT FORM

My name is Astrid Steele and I am currently a doctoral student at OISE/UT working on my research thesis for my dissertation. My interest has long been in environmental education and how it fits within the secondary school curriculum. I am especially interested in how environmental studies fit into traditional science education. As you might know, "Shaping our Schools, Shaping our Future" a report of the working group on environmental education, released in June 2007 had all 32 of its recommendations accepted for implementation by the Ministry of Education earlier this spring. Those recommendations call for the inclusion/integration of environmental studies in all grades and all subject areas in Ontario schools.

As part of my doctoral program at OISE/UT I will be examining the integration of environmental education and secondary science curriculum. Traditionally, secondary science programs are delivered with a very strong emphasis on content knowledge, while environmental studies are powerfully influenced by cultural, economic, social and political components. Of specific interest to me is how secondary science teachers will treat or incorporate the two since they have such different philosophical foundations.

Action Research

To do this research, I intend to offer an action research project for a group of four or five secondary science teachers during the fall semester (September 2008 - January 2009). Action research basically involves the cyclical model of a) reflection on practice, b) data collection and analysis, c) planning, d) implementation of new ideas and e) subsequent reflection again. The group will meet every 2-3 weeks, a total of 6 times during the semester, to engage in discussion and planning together. Teachers will be given classroom release time to participate in this research. In addition, teachers will be interviewed individually at the beginning and toward the end of the project to elicit their personal reactions and thoughts regarding the project and issues prompted by it.

What is Expected of Participants

- attend all meetings
- participate in discussions
- comply with a code of conduct and confidentiality regarding the project
- keep a journal of your activities and reflections based on the project
- write a narrative case (instructions will be given)

Confidentiality

I will be facilitating the meetings, as well as acting as observer of group and individual activity. All of our meetings and interviews will be audio-taped and then transcribed by me to be used as the data for the project, however pseudonyms will be used at all times. School administrators will...
know who is involved in the project (they need to coordinate substitute teachers for classes) but beyond that they will not be privy to any individual information regarding teacher contributions or conduct within the group. Group members will be asked to maintain high standards of confidentiality with respect to the individuals involved in the project.

Transcripts will use pseudonyms from the outset of the project. Only myself and my research supervisor will have access to the data. The transcripts will be stored on my personal computer and will be destroyed at the end of the research project.

Withdrawal

A participant can choose to withdraw at any time during the project with no professional repercussions. An email or phone call is requested as a courtesy, however, please remember that not only is this the basis of my doctoral thesis, it is also an opportunity for professional development for you; you should consider the requirements of the project carefully before you decide to commit.

How to Participate

After you have carefully read this Information page outlining the action research project, if you are a secondary science teacher and you think that you would like to participate, please read, initial and sign the Consent Form. From the signed consent forms I will select a group of four to five teachers such that the group will reflect a diversity of gender, age, experience and culture. You will be contacted via email to inform whether or not you have been selected and giving details of the first meeting date.

Contact Info

If you have further questions regarding this project, feel free to contact me or my supervisor:

Researcher:
Astrid Steele
705-365-2117 (h)
astrid.steele@ontera.net

Supervisor:
Dr. John Wallace
(416)978-0085
jwallace@oise.utoronto.ca

If you have any questions regarding your rights as a participant in this research please contact the Ethics Review Office at 416-946-3273 or ethics.review@utoronto.ca.
Consent Form  (you will be given a copy for your records)

Please initial each statement:

_______ I have read and understand the Information Sheet.

_______ I am aware of the time commitment that this research project entails.

_______ I understand that my participation in this research is voluntary and that I may choose to decline to participate in discussions or answer certain interview questions. I may also withdraw from the study at any time without fearing negative repercussions.

_______ I agree to the following code of conduct and confidentiality:
• I will maintain the strictest level of confidentiality regarding individual statements or contributions made by other group members.
• I will maintain the strictest level of confidentiality regarding students, discussing none by name.
• I will make every effort to be a positive and encouraging member of the group, listening carefully and valuing others’ opinions.

_______ I agree to keep a learning journal to record my reflections

_______ I agree to be audio-taped during interviews and group discussions.

_______ I agree to have my statements used (under a pseudonym) in the analysis of data and the resulting research paper.

_______ I understand that there may be times during discussions when my beliefs and values regarding education may be challenged, but that such challenges are part of the continual learning process of an educator.

I ________________________ have read the Information Sheet, spoken with the researcher and believe that I understand the nature of the research project and the nature of participant involvement. I would like to be considered as a possible participant in the action research project described above.

_________________________________  ____________________________________
(signature of participant)  (date)

_________________________________
(professional or preferred email)
## Appendix C: Chronology Of Data Collections

<table>
<thead>
<tr>
<th>date</th>
<th>type of event</th>
<th>time of event</th>
<th>what occurred</th>
<th>data collected</th>
</tr>
</thead>
</table>
| Oct. 2/08  | group mtg. #1 | 12:30-3:00 pm | **intro activity:** nuclear reactor game*  
**readings:** excerpts from Hodson (2003); Science Statements; see Appendix E  
**discussion topics:** the nature of science; action research | audio recording/ transcript |
| Oct. 16/08 | group mtg. #2 | 12:30-3:00 pm | **intro activity:** Conifer Identification  
**reading:** Shaping Our Schools, Shaping Our Future: [http://www.edu.gov.on.ca/curriculumcouncil/shapingSchools.pdf](http://www.edu.gov.on.ca/curriculumcouncil/shapingSchools.pdf); see also Appendix E  
**discussion topics:** the nature of environmental education; education *about, in and for* the environment | audio recording/ transcript |
<p>| Oct. 17/08 | interview #1: Sharon | 12:00-1:00 pm | discussion based on Interview Questions found in Appendix C | audio recording/ transcript |
| Oct. 29/08 | interview #1: Jane, George | 12:00-1:00 pm | discussion based on Interview Questions found in Appendix C | audio recording/ transcript, |
| Oct. 29/08 | interview #1: Tess | 3:15-4:00 pm | discussion based on Interview Questions found in Appendix C | audio recording/ transcript |</p>
<table>
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<tr>
<th>date</th>
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<th>time of event</th>
<th>what occurred</th>
<th>data collected</th>
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<tr>
<td>Nov. 5/08</td>
<td>group mtg. #3</td>
<td>9:00-11:30 am</td>
<td><strong>intro activity:</strong> tell the tracks story**&lt;br&gt;<strong>reading:</strong> Smyth (2006); see Appendix E&lt;br&gt;<strong>discussion topics:</strong> EE pedagogy; framing the action research question; setting a research schedule.</td>
<td>audio recording/transcript</td>
</tr>
<tr>
<td>Nov. 19/08</td>
<td>group mtg. #4</td>
<td>12:30-3:00 pm</td>
<td><strong>intro activity:</strong> the light fountain***&lt;br&gt;<strong>reading:</strong> action vs. activity; see Appendix E&lt;br&gt;<strong>discussion topics:</strong> politicizing science; lesson preparation for Sh! environmental Day</td>
<td>audio recording/transcript; posters from Bart’s class viewed by participants</td>
</tr>
<tr>
<td>Dec. 2/08</td>
<td>Shhh! Environment Day classroom visit: Sharon’s 3C biology</td>
<td>9:00-10:00 am</td>
<td>observed and interacted with students and their teacher after they had visited the local grocery store</td>
<td>observation notes, journal entry, student work</td>
</tr>
<tr>
<td>Dec. 2/08</td>
<td>Shhh! Environment Day classroom visit: Jane’s 2P Science class</td>
<td>10:15-11:00 am</td>
<td>observed and interacted with students and their teacher as they worked through an issues-based lesson on environmental hormones</td>
<td>observation notes, journal entry, student work in form of posters and discussion</td>
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<tr>
<td>Dec. 2/08</td>
<td>Shhh! Environment Day classroom visit: George’s 3C biology class</td>
<td>11:15 - 11:45 am</td>
<td>observed and interacted with students and their teachers as they worked through an eco-justice lesson</td>
<td>observation notes, journal entry</td>
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<tr>
<td>Dec. 2/08</td>
<td>Shhh! Environment Day classroom visit: Harvey’s 3U chemistry class</td>
<td>1:00-1:30 pm</td>
<td>observed and interacted with students and their teacher as they completed a water impurities lesson and lab activity</td>
<td>observation notes, journal entry,</td>
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<tr>
<td>Dec. 2/08</td>
<td>Shhh! Environment Day classroom visit: Tess’s 2P science class</td>
<td>1:40-2:30 pm</td>
<td>observed and interacted with students and their teacher as they worked through an indoor and outdoor lesson on vehicle use in the city</td>
<td>observation notes, journal entry, student work sheets</td>
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<tr>
<td>Dec. 4/08</td>
<td>group mtg.#5</td>
<td>9:00-11:30 am.</td>
<td><strong>discussion topics</strong>: Shh! Environment Day debrief; stories; writing narratives</td>
<td>audio recording/ transcript</td>
</tr>
<tr>
<td>Dec. 4/08</td>
<td>interview #1: Harvey</td>
<td>3:15-4:00 pm</td>
<td>discussion based on Interview Questions found in Appendix C</td>
<td>audio recording/ transcript</td>
</tr>
<tr>
<td>Jan 14/09</td>
<td>group mtg. #6</td>
<td>9:00-11:30 am.</td>
<td><strong>reading</strong>: revised Science curriculum: <a href="http://www.edu.gov.on.ca/eng/curriculum/secondary/science910curr.pdf">http://www.edu.gov.on.ca/eng/curriculum/secondary/science910curr.pdf</a>  <strong>discussion</strong>: where do we go from here?</td>
<td>audio recording / transcript</td>
</tr>
<tr>
<td>Apr 14/09</td>
<td>interview #2: Sharon</td>
<td>3:30-4:00 pm</td>
<td>discussion based on Interview Questions found in Appendix C</td>
<td>audio recording/ transcript</td>
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*, **, and *** details for the activities can be found in Appendix E
Appendix D INTERVIEW PROTOCOL

First Interview

Time of Interview:
Date:
Place:
Interviewer:
Interviewee:
Relationship:
Other data?:

(This interview is part of the environmental education and secondary science action research project with which you are involved. This interview will probably take one hour of your time and will be followed up by a second interview towards the end of the project. To ensure confidentiality, your name will not be used and will not appear on any data or transcripts. Your honest input and ideas are extremely valuable to the research project and to the work of the group. Your name will not be used in the study, and your comments will not be identified with you or your school. Your participation is entirely voluntary and you may withdraw at any time from the interview processes.)

1. How did you come to be a science teacher?

2. What do you believe are the goals or purposes of teaching science at the secondary level?

3. What are your favourite approaches, or strategies for teaching science?

4. How would you respond to the statement: “never let curriculum get in the way of a good lesson.”

5. What do you think are some of the most important aspects of science that secondary students should learn?

6. What are your favourite assessment and evaluation strategies in secondary science?

7. What are your initial impressions of the action research project?

8. Do you have any concerns regarding the work of the action research group?

9. What do you think is meant by ‘environmental education’.
Second Interview

Time of Interview:
Date:
Place:
Interviewer:
Interviewee:
Relationship:
Other data?:

(This second interview is part of the environmental education and secondary science action research project with which you are involved. It will probably take one hour of your time. To ensure confidentiality, your name will not be used and will not appear on any data or transcripts. Your honest input and ideas are extremely valuable to the research project and to the work of the group.

Your name will not be used in the study, and your comments will not be identified with you or your school. Your participation is entirely voluntary and you may withdraw at any time from the interview processes.)

1. Has participation in the project changed your views on teaching science?
2. Has participation in the project changed your views on what students should know or learn in science?
3. Has participation in the project changed how you view the Ministry of Education guidelines?
4. Was the collaborative approach of the project a positive one for you?
5. Have your views on environmental education changed? If so, explain how.
6. What other comments do you have now that we are nearing the end of the project?
Appendix E: Activity Instructions and Readings for meetings

Meeting 1:

Activity: the Nuclear Reactor

The apparatus used for this activity consists of a large rubber band to which are affixed, at equidistant points, as many strings as there are participants. The strings should be approximately 3-4 meters in length, allowing the participants to pull on the strings from a distance to change the shape of the rubber band.

The scenario recounted to the participants:

You are working at a nuclear reactor station … The reactor consists of three plastic containers stacked one atop the other with the top one filled with water. The reactor sits in the center of a 2-3 meter perimeter marked by masking tape, chalk, or a line in the sand. The participants, each holding a string sit or stand outside the perimeter.

when the reactor malfunctions… the three tubs are place in different parts of encircled area, in awkward positions

and you, as a group, must work to rebuild the reactor in exactly the position that it was originally in… group members use the strings to move the tubs; they may not allow any body part to enter the reactor’s marked area, as they will lose the use of that body part due to radiation.

Reading excerpted from:


Some shortcomings of existing practice:

Criticism of existing practice focused on what Bencze (1995) terms the illusion of certainty and the illusion of indispensability promoted by the current Ontario school science curriculum. With regard to the former, scientific knowledge is presented with little or no epistemological justification. Commonly, teachers present science as fixed, non-negotiable knowledge, without providing any of the background justification and 'students generally accept what teachers say without demanding (it)... simply because the teacher is the teacher' (Geddis 1991: 172). Students are encouraged to regard the processes of knowledge building in science as unproblematic,
leading unambiguously and inevitably to 'proven science', and scientists are regarded as 'experts', whose views have authority conferred on them by the power of the scientific method and its universal applicability. The illusion is reinforced by a heavy reliance on didactic teaching styles and by an approach to laboratory work in which students spend the bulk of their time on 'cookbook exercises' designed to reach particular, pre-determined outcomes. Because there is little in the curriculum to encourage the development and deployment of higher level thinking skills, students 'readily substitute external authority and rote learning for internal authority and understanding' (Driver and Bell 1986: 452). In other words, the curriculum tends to limit students' 'intellectual independence' (Munby 1980) - that is, their ability to judge the validity of knowledge claims for themselves.

Sample Science Statements for Discussion:

*(based on course materials from: CTL1212H Curriculum Making in Science, OISE/UT)*

Since scientific theories are creations of the human mind, they do not necessarily describe things the way they really are.

Science is never dogmatic; it is pragmatic - always subject to adjustment and revision in the light of new observations.

Science research is influenced by social, political and economic factors

Science is just one of the many ways in which people make sense of the world.

What counts as scientific evidence and explanation depends on the cultural values of the people involved in the science.

Some scientific studies are considered valid and significant even though they are not based on experiment.

Scientific theories and concepts affect what scientists observe.
Meeting 3

Activity: Tell the Tale of the Tracks

The individual or group is shown a series of photos depicting various animal tracks and then is encouraged to describe the various possible events that each of the sets of tracks depicted.

Two examples of the photos are included below:
The nature of environmental education and how it is approached in practice soon grew to differ from more traditional approaches to education. Certain words and phrases now recur so often that they can be used as descriptors.

- Lifelong
- Systemic rather than linear thinking
- Interdisciplinary
- Affective integrated with cognitive
- Holistic
- Flexible and adaptable
- Learner-centred
- Forward-looking, anticipatory
- Locally relevant
- Interpretative, synthetic, broadening
- Concentric, from local to global
- Operating in open situations
- Emphasis on quality and value
- Issue-based
- Problem formulating
- Field-based
- Normative rather than empirical
- Action-orientated
- Exemplary (for example with reference to the quality of the learning environment)

... the word sustainability... has provoked objections from policy makers in both industrialised and developing countries who suspect that it represents a ‘green’ attempt to get away from development, or that it disguises what is to be sustained, namely a ‘northern’ affluent lifestyle….Sustainable development is popular with governments and industrialists because it retains the principle of development, and with developing countries where it is seen to offer hope for a better share of the world’s wealth. Sustainability, now espoused by many reputable bodies (e.g. WWF and other major conservation organisations), is also a comforting word with a sense of continuity in a world of threatening change.

Meeting 4

Activity: The Light Fountain

An inexpensive light emitting diode emitting light into a cluster of thin clear plastic fibres: the light is not visible until it exits the thin plastic fibres, thus demonstrating the physics of fibre-optic cables.

This is intended as an introduction to an STSE perspective. Participants are required to work together to:

• explain the science of the light fountain
• discuss how the technology demonstrated by the light fountain has applications in areas such as telecommunications, etc.
• suggest how fibre-optics have impacted society
• suggest how fibre-optics and/or the construction of fibre-optic devices have impacted the environment

Two Readings:

The Action Concept in Environmental Education

In many schools' environmental education programmes the idea of involving the action perspective or, as it is often described, to work in an action-oriented way, is becoming increasingly important. There are several very different reasons for this, of which four will be mentioned here.

First, the dominance of scientism in environmental education, where the focus is often on giving pupils knowledge about the seriousness and extent of the environmental problems, has not been capable of addressing the social and societal perspectives involved in questions about the root causes of problems and the action possibilities which are open to society and the individual.

Second, an awareness that moralising, behaviour-modifying teaching rarely if ever leads to intended behavioural changes has re-focused attention on 'action' in teaching.

Third, growing criticism of schools because of the priority they give to the academic dimension at the expense of the more practical has led to increased attention being given to 'action oriented' approaches.
Fourth, criticisms of simulations, games, role plays, etc. and their often artificial 'as if' situations, has led to increased demands for authenticity and, thus, also for participation in the reality of society as part of teaching.


**Action versus Activity**

Another strong tendency in environmental education is that, often as a reaction to the rather academically oriented content, different practical activities are incorporated into teaching. In many contexts this is described as 'action oriented'. These activities can consist of excursions to more or less untouched natural areas, physical, chemical and biological investigations of a polluted water course, etc. These various activities are obviously valuable and productive to the extent that they help motivation and the acquisition of knowledge but, in order to be characterised as actions, they must be addressed to solutions of the problem which is being studied.

For example, in the study of problems connected with fertiliser consumption in agriculture, investigating the amount of nitrate in drinking water could not therefore be characterised as an action, but rather as an activity (which, as mentioned, can easily be of value in the educational context). An example involving the action perspective in this sphere would be to explore ways of promoting products from organic agriculture or boycotting products from conventional agriculture and in that way aim at solving the problems of nitrate pollution.

Appendix F: Sample Group Meeting Transcript

Meeting #4 Nov. 19/08

Harvey: It goes back to the classroom. Because in the classroom, I mean, how many times have you asked students to go seek the answers to something right? And they just really look at you and say, “Can you just give me the answer? Just give me the notes,” rather than go search for it themselves. So maybe we’ve programmed our students.

George: It’s more efficient for us to give them the work and then get the test done.

Harvey: And that process just kind of continues. But I think it is changing top down, in some universities they are going to problem based learning. They don’t just give you all the answers, you have to go and find them.

Rf: How does that translate into your classrooms?

Sharon: Its time. You could do it (problem based learning). But you couldn’t do it every time, every concept, even though, especially things we teach in science, they have applications outside of school. Science is the easiest to apply outside of school. I can see math not being an everyday thing all the time like every single topic. I think most of our (science) topics are. We’re lucky with that. But to find those problems, I don’t know, it’s hard.

Rf: So you’re saying its not necessary.

Sharon: Maybe not always, its neat to maybe do it at the end with Making Connections in there to have that

Rf: At the end of the unit

Sharon: Maybe

Jane: Or to introduce, meaning if you present a problem at the beginning, they make an attempt or investigate the possibilities how you could possibly solve it and then you say because we’ve done all this its why we have to learn about… and that could lead you to the rest of the unit. c

Harvey: I agree with that

Bart: And its something you could revisit

George: It usually is at the end though we all of our awesome teaching and then you get your project at the end

Harvey: You need all your information, you get all your information first and then I’ll show you how to use it
Harvey: It would be better to start with a problem
Rf: Your problem or theirs?
Sharon: That’s what I was going to say, is that because of who we are? we’re not necessarily activists so are we always able to identify problems and is that why I’m not always comfortable with all sorts of issues sometimes, you know I have my academic background, maybe not my social,
Rf: Political?
Sharon: Political, no absolutely not, so I don’t have that background
Rf: Yes, but you’re a voter. You vote in this country maybe you don’t, you vote in town, you vote in the province and you are working with students who are on the very edge of becoming voters. Maybe political doesn’t mean just liberal or conservative, it has other meanings
Jane: In the last election it did come up about the carbon tax that was a real issue that people could talk about and it did come up in unit one..
Tess: Its perfect timing
Jane: It was good timing and I admit to them, “No I don’t want to pay another tax either but is it time that we should for the betterment of all,” and so that led to discussion. Even those young guys in grade 10, they know that they’re not going to like paying taxes either because they’ve heard about it, they know about it
Bart: Well and some of them do, even in grade 10 they’re...
Tess: Oh part time jobs. that’s true, they’ve got deductions already
Rf: Go ahead
Harvey: I was thinking even from a political standpoint you look at stephan dion and he was going to assess the issues and they were going to work together and figure out a solution, identify the problems and figure out a solution, he got crucified because he didn’t have a plan already saying this is what we’re going to do. So there’s a lot of impatience because people want to be told what to do and the second you don’t, the second you say, “Well we’re going to see what the problem is,” you get crucified for that… I don’t really like him but still I thought it was pretty unfair for somebody who said I’m not going to jump the gun, I’m going to see how things work and
Rf: yes
Sharon: Ok, take that into a classroom, but would students lose not necessarily respect, but confidence in a teacher, and if students don’t have confidence in you I don’t know, I think I’d feel a little more vulnerable.

Jane: All the time I have to reassure the kids I don’t have all the answers, that’s why we’re talking about this but they kind of think you do. By grade 11 they still think I should know about every topic under the sun

Sharon: I feel…. but in this kind of environment when its… its scary a little bit.

Rf: I’m not sure I completely…. you’re ok with saying you don’t understand

Sharon: Yes

Rf: To students, or you don’t know the answer

Sharon: I guess maybe not knowing the solution, maybe that’s where...

Harvey: Like you’re guiding them

Sharon: I mean they’re going to enlighten you and that’s (?) but at the same time its kind of… I don’t know, maybe you’re not the resource person that you often are with academic knowledge
Appendix G: Ethics Review Protocol submission

ETHICS REVIEW PROTOCOL SUBMISSION FORM FOR SUPERVISED AND SPONSORED RESEARCHERS
(For use by graduate students, post-docs and visiting professors and researchers)

SECTION A – GENERAL INFORMATION

1. TITLE OF RESEARCH PROJECT

2. INVESTIGATOR INFORMATION

Investigator:
Title: Mrs. Name: Astrid Steele
Department: CTL
Mailing address: Box 1654, Timmins, ON, P4N 7W8
Phone: 705-365-2117 Fax: Email: astrid.steele@ontera.net

Level of Project
Faculty Research Post-Doctoral Research Student Research: Doctoral

Faculty Supervisor/Sponsor:
Title: Dr. Name: John Wallace
Department: CTL
Mailing address: OISE/UT, 252 Bloor Street W, Toronto, ON, M5S 1V6
Phone: (416)978-0085 Fax: Email: jwallace@oise.utoronto.ca

Co-Investigators:
Are co-investigators involved? Yes No
Title: Name:
Department: Mailing address:
Phone: Fax: Email:
3. UNIVERSITY OF TORONTO RESEARCH ETHICS BOARD

**Education**
Please consult [http://www.research.utoronto.ca/ethics/eh_rebs.html](http://www.research.utoronto.ca/ethics/eh_rebs.html) to determine which Research Ethics Board your proposal should be submitted to.

4. LOCATION(S) WHERE THE RESEARCH WILL BE CONDUCTED:
If the research is to be conducted at a site requiring administrative approval/consent (e.g. in a school), please include all draft administrative consent letters. It is the responsibility of the researcher to determine what other means of approval are required, and to obtain approval prior to starting the project.

School boards in Timmins, Ontario:

District Ontario School Board Northeast - Timmins High and Vocational School, & Roland Michener Secondary School
Northeastern Catholic District School Board - O’Gorman High School

5. OTHER RESEARCH ETHICS BOARD APPROVAL(S)
(a) Does the research involve another institution or site? Yes
(b) Has any other REB approved this project? No

I have met with administrators of both school boards listed above, and they have approved my research project.

6. FUNDING OF THE PROJECT
(a) Please check one:

<table>
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<th>Fund #</th>
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This research project is unfunded.

If one protocol is to cover more than one grant, please include all fund numbers.

(b) If waiting for funding, do you wish to postdate ethics approval to the release of funds? Yes No
(c) For funded research, will more than one protocol be submitted to cover all research funded by the respective grant? Yes No

7. CONTRACTS

Is there a funding or non-funded agreement associated with the research?
Yes No

8. PROJECT START AND END DATES

Estimated start date for this project: September 15, 2008
Estimated completion date for this project: March 31, 2009

9. SCHOLARLY REVIEW

Please check one:

The research has been approved by a thesis committee, or equivalent (required for thesis research)

10. CONFLICTS OF INTEREST

(a) Will the researcher(s), members of the research team, and/or their partners or immediate family members:

(i) Receive any personal benefits (e.g. financial benefit such as remuneration, intellectual property rights, rights of employment, consultancies, board membership, share ownership, stock options, etc.) as a result of or in connection to this study? Yes No

(ii) If Yes, please describe the benefits below. (Do not include conference and travel expense coverage, or other benefits which are standard to the conduct of research.)

(b) Describe any restrictions regarding access to or disclosure of information (during or at the end of the study) that has been placed on the investigator(s). This includes controls placed by sponsor, advisory or steering committee.

none

(c) Where relevant, please explain any pre-existing relationship between the researcher(s) and the researched (e.g. instructor-student; manager-employee; minister-congregant).

Keeping in mind that my research will be done in a small northern town, there are only three English high schools from which to select participants and I have taught for many years in one of them. Consequently I will likely know one or more of the teachers involved in the study. It is my intention, however, to refrain from selecting any teacher with whom I have developed a personal friendship over the years. Instead, I intend to select newer or younger teachers and teachers with whom I have never worked.
List of appendices for all additional materials submitted:

Appendix A: Draft Administration Consent Letter
Appendix B: Information / Consent Form
Appendix C: Interview Protocols

11. RATIONALE

Describe the purpose and background rationale for the proposed project, and, if relevant, the hypotheses/research questions to be examined.

“Shaping our Schools, Shaping our Future” a report of the working group on environmental education, released in June 2007 had all 32 of its recommendations accepted for implementation by the Ministry of Education earlier this spring. Those recommendations call for the inclusion/integration of environmental studies in all grades and all subject areas in Ontario schools.

As part of my doctoral program at OISE/UT I will be examining the integration of environmental education and secondary science curriculum. Traditionally, secondary science programs are delivered with a very strong emphasis on content knowledge, while environmental studies are powerfully influenced by cultural, economic, social and political components. Of specific interest to me is how secondary science teachers will treat or incorporate the two since science and environmental studies appear to have such different philosophical foundations.

12. METHODS

Please describe all formal and informal procedures to be used, settings and types of information to be involved, as well as how data will be analyzed.

This is an action research project.

A group of four or five secondary science teachers will meet with me for half a day every two-three weeks (exact dates to be set by the group) to discuss their science and environmental studies curriculum practices. We will gather in an empty classroom or meeting room yet to be designated. The first meeting will consist of some ‘ice-breakers’ in order for the individual teachers to get to know each other and begin the formation of a cohesive and trustful group. Subsequent meetings will consist mainly of group discussion.

I will be conducting individual interviews both at the outset and toward the end of the research project.

Both the interviews and the group sessions will be audio-taped and transcribed.

Teachers will be asked to keep a journal recording their experiences throughout the project and also to collect and review relevant classroom data, (no more so than would be part of their normal activities to ensure their students’ success). Toward the end of the project teachers will be asked to use their journal entries to write an episodic narrative (a case) of one aspect of their learning.
I may observe the project teachers in their classrooms, but only upon their invitation, and only with the purpose of gathering further teacher praxis data.

All of the data will be analysed by me, with the purpose of identifying teacher’s practice and learning specifically pertaining to the inclusion of environmental studies within science curriculum.

Attach a copy of all questionnaires, interview guides or other non-standard test instruments.

13. PARTICIPANTS OR DATA SUBJECTS

Describe the participants that will be recruited, or the subjects about whom personal information will be collected. Where active recruitment is required, please describe inclusion and exclusion criteria. Where the research involves extraction or collection of personal information, please describe from whom the information will be obtained and what it will include.

Participants in the project will all be secondary science teachers from the two English speaking school boards, and representing three high schools, in this small northern town. No personal information, beyond the number of years that they have been teaching, will be required, and they will be referred to using pseudonyms in all resulting documents.

Participants will join the project by choice, and it will be made clear that they can leave it at any time without personal or professional repercussions. It will also be understood by all that they need only share their thoughts and values to the extent that they are comfortable doing so in the group and/or during interviews with the researcher. A very high degree of confidentiality will be stressed with the group on an ongoing basis. Upon deciding to join the research project each teacher will be required to sign an Information/Consent Form (see attached).

14. EXPERIENCE

For projects that involve collection of sensitive data, methods that pose greater than minimal risk to participants, or involves a vulnerable population, please provide a brief description of the researcher’s/research team’s experience with this type of research.

My experience with participating in and leading group discussion and discovery is extensive: I have been a pre-service and new teacher teacher mentor for many years. I have led mentoring workshops, professional development and leadership workshops for practicing teachers for many years.

In addition, my doctoral research supervisory committee have extensive experience in action research protocols and I intend to rely on their expertise whenever necessary.

15. RECRUITMENT

Where there is formal recruitment, please describe how and from where the participants will be recruited. Where participant observation is to be used, please explain the form of insertion of the researcher into the research setting (e.g. living in a community, visiting on a bi-weekly basis, attending organized functions).

At the beginning of the coming school year (September 2008) I have been invited by the three schools involved to give a brief description of my project to the science departments of those schools. I hope that those presentations result in four to five teachers expressing an interest and commitment in...
participating. Secondary science teachers in three high schools will be given a thorough description of the action research project and opportunity will be given to join the project as a participant. I will clarify the level of commitment and the work required by teachers participating in the project to ensure that participants understand the parameters of their involvement in the project. Once a teacher has indicated an interest in participating, they will be given the Information/Consent Form to read, discuss with me further and sign if they so choose.

From the signed consent forms I will select a group of four to five teachers such that the group will reflect a diversity of gender, age, experience and culture. Because the total number of secondary science teachers in this town is not large, I anticipate that the group will consist of equal numbers of men and women, ranging in age from 25 to 55, most likely white Caucasians with English as the primary language.

The project group will meet for three hours in the afternoon, six times during the fall semester (September 2008 to January 2009).

My role will be that of researcher and facilitator (an arrangement that has been used successfully by other researchers (OISE/UT researchers: Bencze, 2001; Pedretti, 2001*). Initially I will both facilitate the group meetings as well as observe participant learning. As the action research project develops and participants gain confidence and trust amongst each other, more onus will fall on group members to act as leaders and facilitators of the discussion and learning.

*(both in: D. Hodson, L. Bencze, L. Elshof, E. Pedretti & J. Nyhof Young (Authors) Changing Science Education Through Action Research: Some Experiences from the Field. Imperial Oil Centre for Studies in Science, Mathematics and Technology Education at the Ontario Institute for Studies in Education of the University of Toronto.)

Attach a copy of any posters, advertisements, flyers, letters, or telephone scripts to be used for recruitment.

16. COMPENSATION

(a) Will participants receive compensation for participation?

- Financial: Yes No
- In-kind: Yes No
- Other: Yes No

(b) If Yes, please provide details.

Teachers will be released from their classroom duties for the six afternoon meetings; the Directors of both school boards mentioned recognize this project as valuable professional development for their teachers and feel that they should participate in it during work time, not personal time.

(c) Where there is a withdrawal clause in the research procedure, if participants choose to withdraw, how will you deal with compensation?

Should a participant choose to withdraw from the project, they will resume normal classroom duties during scheduled meeting times.

SECTION C –DESCRIPTION OF THE RISKS AND BENEFITS OF THE PROPOSED RESEARCH
17. POSSIBLE RISKS

1. Indicate if the participants as individuals or as part of an identifiable group or community might experience any of the following risks by being part of this research project:

(a) Physical risks (including any bodily contact or administration of any substance)?  **No**

(b) Psychological/emotional risks (feeling uncomfortable, embarrassed, anxious or upset)?  **Yes**

(c) Social risks (including possible loss of status, privacy and/or reputation)?  **No**

(d) Is there any deception involved? (See Debriefing, #21)  **No**

2. If you answered **Yes** to any of the above, please explain the risks, and describe how they will be managed and/or minimized.

During group discussions or personal reflection regarding teacher praxis, it may occur that teachers’ view/values are challenged leading to feelings of emotional discomfort, however, no more so than is likely to occur at various times in a teaching career. It will be the role of the facilitator (myself) to value every participant’s opinions, to encourage participants to view the action research process as a positive learning experience and to remind participants of their commitment (signed Consent Form) to value another’s contribution and to maintain the confidentiality of group/individual issues.

18. POSSIBLE BENEFITS

Discuss any potential direct benefits to the participants from their involvement in the project. Comment on the (potential) benefits to the scientific/scholarly community or society that would justify involvement of participants in this study.

Whereas more southerly school boards frequently reap the benefits of having a faculty of education conducting studies in local boards, the school board by whom I am employed does not. Thus I have chosen to pursue this research in my hometown in northeastern Ontario because I believe that there are will be significant benefits to the teachers involved, which will no doubt be reflected in improved classroom instruction and student successes.

- Using the model of action research promotes changes in educators’ praxis through the cyclical model of reflection, data collection and analysis, planning and implementation of new ideas and subsequent reflection again.

- This is a valuable form of professional development ... it occurs over time working with a trusted group of colleagues.

- Facilitating the clarification of their values regarding curriculum, science and environment has the potential to be a powerful process for educators, and one that they will be encouraged to share with their colleagues not directly involved in the study.

- There are spinoffs as well for smoothing the transition of northern students from Grade 8 to Grade 9 science - elementary teachers traditionally understand and implement integration and interdisciplinary studies much better than their secondary counterparts. Thus pd at the secondary science level will be no doubt be valuable.
19. THE CONSENT PROCESS

Describe the process that the investigator(s) will be using to obtain informed consent. Please include the experience of the team member with this participant population and/or training that this person will receive prior to recruitment. If there will be no written consent form, please explain (e.g., discipline, cultural appropriateness, etc.). Please note, it is the quality of the consent, not the format that is important. If the research involves extraction or collection of personal information from a data subject, please describe how consent from the individuals or authorization from the custodian will be obtained.

For information about the required elements in the information letter and consent form, please refer to http://www.research.utoronto.ca/ethics/eh_best.html.

Secondary science teachers in three high schools will be given a thorough description of the action research project and opportunity will be given to join the project as a participant. I will clarify the level of commitment and the work required by teachers participating in the project to ensure that participants understand the parameters of their involvement in the project. Once a teacher has indicated an interest in participating, they will be given the Information/Consent Form to read, discuss with me further and sign if they so choose. From the signed consent forms I will select a group of four to five teachers such that the group will reflect a diversity of gender, age, experience and culture.

Where applicable, please attach a copy of the Information Letter/Consent Form, the content of any telephone script, letters of administrative consent or authorization and/or any other material which will be used in the informed consent process.

20. CONSENT BY AN AUTHORIZED PARTY

If the participants are children, or are not competent to consent, describe the proposed alternate source of consent, including any permission/information letter to be provided to the person(s) providing the alternate consent as well as the assent process for participants.

21. DEBRIEFING

(a) If deception will be used in the research study, please explain what information/feedback will be provided to participants after participation in the project.

Please provide a copy of the written debriefing form, if applicable.

(b) How will participants be informed of study results?

Participants will receive a copy of the thesis, outlining the results of the action research project.

22. PARTICIPANT WITHDRAWAL

(a) Where applicable, please describe how the participants will be informed of their right to withdraw from the project. Outline the procedures which will be followed to allow them to exercise this right.
Participants will have the right to withdraw from the project at any time, and they will be informed of this both verbally and in print on the Information/Consent Form. The withdrawal process will simply be to inform me via email or verbally, of their desire to no longer participate.

A participant who deliberately works against the objectives of the project or makes offensive or disparaging remarks, or who knowingly breaches confidentiality may be asked by me to withdraw from the group.

(b) Indicate what will be done with the participant’s data and any consequences which withdrawal may have on the participant.

Participants who no longer wish to remain in the project will be asked if they wish any data pertaining to them to be destroyed, or if it can be used for analysis and quotes using a pseudonym despite their withdrawal. There will be no significant repercussions for individuals who withdraw from the study, other than that they will be asked to honor their commitment of confidentiality to the remainder of the group. Their withdrawal will have no professional repercussions relating to their work at their respective schools.

(c) If participants will not have the right to withdraw from the project at all, or beyond a certain point, please explain.

SECTION E – CONFIDENTIALITY AND PRIVACY

23. CONFIDENTIALITY

(a) Will the data be treated as confidential? Yes No

(b) Describe the procedures to be used to ensure anonymity of participants or informants, where applicable, or the confidentiality of data during the conduct of research and dissemination of results.

The administrators of the schools in which the teachers work will know which of the teachers from their schools are involved in the project, however, they will not be apprised of the individual contributions of the participants, nor given any additional information regarding the performance of the teachers in the project.

Participants will be required to read and sign an Information/Consent Form which will specifically request that they maintain strict confidentiality of individual discussions and issues. That is, while they may discuss with other colleagues the issues, topics, etc. that are addressed during the project, they may NOT discuss individual contributions or 'who said what'.

Transcriptions will use pseudonyms from the outset of the project. Only myself and my research supervisor will have access to the data. The transcripts will be stored on my personal computer. Any hard copies of transcripts or data will be destroyed after use, e.g. after a group meeting.

Participants will be informed that they can choose to be quoted in my subsequent analysis/research paper under a pseudonym.
(c) Explain how written records, video/audio tapes and questionnaires will be secured, how long they will be retained, and provide details of their final disposal or storage.

The audio-tapes will be kept by me at my home. Transcripts and observation notes will be stored initially on my personal laptop computer, and eventually on CD. Teacher journals and other teacher generated materials will be stored at my home.

All data will be stored at my home in a safe filing cabinet until the completion of the doctoral thesis at which time it will be destroyed.

(d) If participant anonymity or confidentiality is not appropriate to this research project, please explain.

24. PRIVACY REGULATIONS

For research involving extraction or collection of personal information, provincial, national and/or international laws may apply. My signature as Principal Investigator, in Section G of this protocol form, confirms that I understand and will comply with all relevant laws governing the collection and use of personal information in research.

SECTION F – CONTINUING REVIEW OF ONGOING RESEARCH

RISK MATRIX: REVIEW TYPE BY GROUP VULNERABILITY AND RESEARCH RISK – check one:

<table>
<thead>
<tr>
<th>Research Risk</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Vulnerability</td>
<td></td>
<td></td>
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<tr>
<td>Low</td>
<td>1</td>
<td>1</td>
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<td>Medium</td>
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<td>2</td>
<td>3</td>
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<tr>
<td>High</td>
<td>2</td>
<td>3</td>
<td>3</td>
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See the Instructions for Ethics Review Protocol Submission Form for detailed information about the Risk Matrix.

Briefly explain/justify the level of risk and group vulnerability reported above (max 100 words):
Participants will be engaging in the types of discussion during the research (i.e., philosophical underpinnings of curriculum, teaching strategies, values clarification) that they would normally encounter during professional development in the course of their normal work and careers. Participants will join the research by choice and consent, and may leave the project by choice as well. Participants will have the right to a member-check the data and remove any data that they feel is unacceptable. The researcher has significant experience leading teacher professional development scenarios and will rely on the expertise of the research thesis advisory committee.

Review Type

Based on the level of risk, please submit the appropriate number of copies of the Protocol Submission Form for Review Type:

- Risk level = 1: Expedited Review
- Risk level = 2 or 3: Full Review

Information about individual REBs, including the number of copies required for each review type, can be found here: [www.research.utoronto.ca/ethics/eh_rebs.html](http://www.research.utoronto.ca/ethics/eh_rebs.html)

Please note that the final determination of Review Type and program of Continuing Review will be made by the University of Toronto REB and the Ethics Review Office.

SECTION G – SIGNATURES

All researchers and their respective Departmental Chair/Dean or designate must sign below:

As the Investigator on this project, my signature confirms that I will ensure that all procedures performed under the project will be conducted in accordance with all relevant University, provincial, national and international policies and regulations that govern research involving human participants. Any deviation from the project as originally approved will be submitted to the Research Ethics Board for approval prior to its implementation.

For student researchers, my signature confirms that I am a registered student in good standing with the University of Toronto. My project has been reviewed and approved by my advisory committee (where applicable). If my status as a student changes, I will inform the Ethics Review Office.

Signature of Investigator: Date:

For Graduate Students the signature of the Faculty Supervisor is required. For Post-Doctoral Fellows and Visiting Professors or Researchers, the signature of the Faculty Sponsor is required.

As the Faculty Supervisor of this project, my signature confirms that I have reviewed and approve the scientific merit of the research project and this ethics protocol submission. I will provide the necessary supervision to the student researcher throughout the project, to ensure that all procedures performed under the research project will be conducted in accordance with relevant University, provincial, national or international policies and regulations that govern research involving human subjects. This includes ensuring...
that the level of risk inherent to the project is managed by the level of research experience that the student has, combined with the extent of oversight that will be provided by the Faculty Supervisor and/or On-site Supervisor.

As the Faculty Sponsor for this project, my signature confirms that I have reviewed and approve of the research project and will assume responsibility, as the University representative, for this research project. I will ensure that all procedures performed under the project will be conducted in accordance with all relevant University, provincial, national or international policies and regulations that govern research involving human participants.

Signature of Faculty Supervisor/Sponsor: ___________________________ Date: ___________________________

As the Departmental Chair/Dean, my signature confirms that I am aware of the proposed activity. My administrative unit will follow guidelines and procedures which ensure compliance with all relevant University, provincial, national or international policies and regulations that govern research involving human subjects. My signature also reflects the willingness of the department, faculty or division to administer the research funds, if there are any, in accordance with University, regulatory agency and sponsor agency policies.

Name of Departmental Chair/Dean (or designate): ___________________________

Signature of Departmental Chair/Dean: ___________________________
Date: ___________________________

(or designate)
Appendix H

Tess’s Narrative: The Lesson That Went Awry

I am a relatively new teacher in my second year of teaching. Last semester I was assigned 2 sections of grade 10 applied science and one section of grade 10 academic science and I was looking forward to trying some new teaching strategies I had learned in the summer while enrolled in a professional development course. In addition, I was participating in an action research project focusing on incorporating environmental education into the science curriculum. All in all I was pretty happy and excited about the coming school year.

While teaching the ecology unit (the first unit of the semester), I had a difficult time engaging the applied level students. They didn’t seem to care much about the environment nor about the role they play with regards to pollution and its effects. They made comments like “Who cares?” or “This doesn’t affect me at all”. Although I felt that I explained the concept of sustainability and we had discussed it and I had made it clear to them that their actions would influence the resources available to future generations, I felt that I was making very little progress in the citizenship department.

On top of that, one of the two grade 10 applied science classes was very difficult to manage. Those eighteen students were constantly misbehaving and failing to follow instructions. Some of the students were incessantly throwing things (erasers, paper airplanes, sometimes even food) at one another. For some reason known solely to the computer that does the scheduling, only three of the students were girls, quiet and pleasant. The other fifteen were boys from various grades who needed to earn a second
science credit. Despite having an educational assistant in the room things were often chaotic.

In one incident a student teacher who was observing my class for a day had a snowball thrown at her. My classroom has a window located at the back and some of the students like to look out the window occasionally as it has a view of the roof and the back parking lot. Provided students have finished their work I normally let them do so. However, on this particular day although the students hadn’t completed their work they had opened the window. I instructed them to close it which they did. I didn’t realize that the reason they had it open in the first place was to get some snow from the roof below. Well, the student teacher just happened to be in the line of fire! Luckily she wasn’t hit, but nonetheless, the student who threw the snowball was sent to the office and dealt with by the vice principal.

As part of the action research group, I had helped to design an Environment Day. On a predetermined date all of the group members had agreed to subtly incorporate environmental education into their science lessons for the day. We decided that the actual lesson and/or activity would not deviate from the current unit of study and we would try to focus on having our students learn something about, for and in the environment. Well, on Environment Day the lessons for two of my classes went fairly smoothly, but the very difficult grade 10 applied class was another matter entirely. I was teaching the Motion/Physics unit so I started the lesson by discussing the different types of vehicles available for purchase and some of the benefits and drawbacks of each type. My goal was to introduce the concepts of fuel consumption and the
environmental impact (CO₂ emissions) of different vehicle types. I was surprised by the fact that a few students mentioned it themselves. Next I showed students the equation to calculate the carbon dioxide emission of a vehicle based on number of miles per gallon. I could see the students’ attention was fading fast as they were anxious to get outdoors. (I had mentioned to the students the previous day that we would be heading outside for part of the class to complete the lesson.)

At first I was a little apprehensive about bringing such a class outdoors but I had arranged to have the educational assistant and a colleague come along as additional supervisors. So I took my students to the sidewalk of the major road that passes the front of our rather expansive schoolyard. They were supposed to observe the vehicles passing the school and determine generally which type of vehicle was most popular in their city. Several students had volunteered to record the types and numbers of vehicles that we observed while outside. We were unavoidably stationed near a city bus stop but at that time of day it was very quiet.

It was sunny but quite cold that day and I was hoping that the fresh air might work to my advantage. Clearly I was wrong! Despite my reminders to them not to distract motorists, students were waving at drivers, pretending to hitch hike, pushing each other in the snow and generally misbehaving. Three students lit up cigarettes, testing the presumption that they were off school property so school rules would not apply to them. At one point, the city bus stopped due to the relatively large crowd around the bus stop. A few of the students who were pretending to hitch hike lined up as though they were

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getting on the bus. Even though we waved to the driver to continue along, they ran after
the bus as though they really did in fact want to get on.

It was then that I decided it was time to head back inside. Upon returning to class a
discussion ensued and students shared their findings and talked about what type of
vehicle they would choose to drive. They were required to create an advertisement for
their vehicle of choice, keeping in mind its environmental impacts. Their advertisement
was to be in the form of either a poster, a written ad or a skit. Even though I discussed
the environmental impact of SUVs and trucks, many students still chose vehicles such
as Hummers, one boy claiming that ‘gangstas’ would look good in his. Unfortunately,
and despite my best efforts, the students did not seem to take much away from the day’s
discussions and activities targeting the environment.

Questions for Consideration:

What might I have done differently on Environment Day?

Why do you think that those students had such a laissez-faire attitude toward the
environment?

What other issues surface in this narrative?
Appendix I:

JF’s Narrative:

I Hate Nature But I Love Teaching Environmental Issues

I have struggled with teaching environmental science my entire teaching career. I never felt that I knew enough about nature and I certainly was never the outdoors type.

I was born and raised in a northern Ontario city of 45000 people. It is surrounded by Boreal forests and lakes. A nature lover’s dream but not mine. My family didn't camp, cottage, hunt or fish. The only outdoor activity was blueberry picking which I hated and still do. As my parents picked berries I stayed by the side of the road watching for bears. I was convinced one was close by waiting to eat us. Winter was complete hibernation for us. Skating was okay at a public rink but no skiing or snowmobiling. Too close to nature. Maybe a bear would wake up from hibernation or worse wolves! Escaping to Florida every March break was the only way to survive the long cold winter. Even there I could not relax, always on the lookout for sharks or alligators.

After completing a science degree I decided to apply to a faculty of education to earn a teaching degree. I was planning to choose chemistry and biology as teachable subjects but unfortunately at FEUT (Faculty of Education at the University of Toronto) only a general science was offered. I had to pick another subject. The choice was between math and environmental science. I chose the latter and immediately regretted it the first day.

Bill Andrews was my professor and he was amazing. He made environmental science exciting and fascinating. So it wasn't him that made me want to quit my first week at FEUT. It was his announcement that one of our teaching placements would be at an outdoor education
centre where we would be living during the week and coming home on weekends. And lucky for me it was my first placement! I was seriously thinking of either quitting FEUT altogether or at least trying to change my teachable subject. I did neither. I sucked it up and went.

I was immediately happy when I got there when I discovered that the bathrooms were clean and had showers (my first priority). The staff were wonderful, the food was great and I actually had fun. They ran a wide array of programs, from making apple cider and cedar tea to canoeing and orienteering. Because we had elementary students one week and special needs students the next, I didn't feel too overwhelmed. The staff even got me into a canoe for the very first time. I sat in the middle with a life jacket on afraid that any slight movement would cause the canoe to tip.

After finishing at FEUT I was hired to teach chemistry at my old high school. Because I also had to teach grade 9 and 10 science, ecology would continue to haunt me. I would save the ecology unit until the end of the semester hoping we would run out of time or that I would only have to teach it for 2 weeks at the most. I think that I unknowingly passed on this feeling of dread to my students. Maybe I'd rolled my eyes when I mentioned the word ecology. I don't know. But whenever it was time to start the unit there was almost always a groan from the entire class.

During this time I met my future husband. He loved canoeing, hiking in the woods, camping, and off-roading. And he especially loved his family's cottage in the Muskokas. His attempts to get me to share in his interests were unsuccessful. I will go to the cottage but I truly hate it to this day. I have not gotten used to it although I have learned to accept the occasional mouse scurrying by. Before I continue I have to mention that this cottage is really a log house in
the middle of nowhere with a creek running behind it. At night you can sometimes hear wolves (or are they coyotes? Not knowing the difference only serves to validate the fact that I am unfit to teach environmental science.)

I have seen mother bears with their cubs running up the driveway and deer running in and out of the forest (okay, not so scary) to the delight of my inlaws. Everyone enjoys themselves, taking long walks through the woods and using the outhouse "just for fun". I just don’t understand their delight. It delights them if the road washes out and we’re stranded, or the well gets smashed and we have to carry water in pails and we can’t use the toilet. They’re so excited. But not me. I just can’t wait to pack up and leave. I literally count the days. But I do have to admit the nights are amazing. There is so little light pollution that the night sky is spectacular. I do of course remain on the deck.

When I teach a subject, I am only comfortable if I have a deep understanding of the material. I can think up great lessons and activities. My enthusiasm is contagious (usually). The exact opposite is true with environmental science. I have always avoided stream and field studies as I felt I did not know enough about the types of plants or creatures we would find. I hate saying "I don't know". I had students who knew far more than I did about what fish were in our lakes, etc. I didn't know how to engage the students. So I’d end up teaching straight from the textbook and that’s what I hate doing. That’s why I don’t like ecology because I’d always end up taking out the textbook and relying on it. It was deadly.

These past few years I have become very aware and concerned with the myriad of environmental problems affecting the earth. I’ve got children and I want them to live in a healthy world. I began to be disturbed by pollution for one thing. And how the climate is changing. But
my teaching of ecology did not change. I didn’t make a connection with my personal concerns and teaching about the environment. Then I believe things started to slowly change for me when "An Inconvenient Truth" came out. I first showed it to my university chemistry class when we finished up the gases unit. They were riveted and we had some great class discussions about it. I then showed it to my grade 10 students. Same effect. I started to realize that environmental issues are just as important to most students as they are to me. Even so I was still stuck on the idea that I did not have enough knowledge of nature to teach environmental science.

I am now at the point where my grade 10's were very excited this year to start the ecology unit. Instead of groans I heard "This is going to be fun!". And we did have fun. Perhaps the change was that I was involved in this action research project and our goal was to embed environmental education where ever and when ever we could. We talked a lot about how to do that in different ways. This time around I taught the course by looking at different environmental issues. I didn’t worry about teaching what each plant is, or get heavy on the content knowledge. We looked at what the students were interested in which is these bigger issues. If you need to learn what a cedar tree looks like, you will. Actually, we talked a lot about environmental estrogens and I was amazed at how much content and how many expectations we covered. Students would stay after class and they were just really excited. I had engaged them! Maybe it was only this particular group of students. I hope not, but time will tell. All I know is that I don't have to be able to identify all flora and fauna to do a good job teaching ecology and environmental science. But it hasn’t changed how I feel about being in nature.
Questions for Consideration:

Are the terms ecology, *environmental science*, *environmental studies* and *environmental education* interchangeable?

Should secondary science teachers have a deep understanding of all of the material that they teach?

Is it possible to cover required secondary science content through an issues-based approach?

How do you deal with topics that you hate teaching?