EXPLORATIONS OF TENTH-GRADE STS[E] CURRICULA ACROSS THREE PROVINCIAL POLITICAL LANDSCAPES

by

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Abstract

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This thesis focuses on explorations of science, technology, society and the environment (i.e., STS[E]) outcomes/expectations in tenth-grade level science curricula across three Canadian provinces (i.e., Alberta, Manitoba & Ontario) with distinctive provincial political environments at the time of curriculum construction and/or implementation. Document analysis, discourse analysis and a range of theoretical frameworks (i.e., Levinson, 2010; Pedretti & Nazir, 2011 & Krathwohl, 2002) were used to aid in explorations of STS[E] curriculum segments and discourses in each provincial region. More detailed analysis and thematic exploration is presented for each unit associated with climate change as some interesting patterns emerged following initial analysis.

My findings are presented as three comparative case studies and represent a small and original contribution to the large body of scholarly research devoted to studies of STS[E] education, where each province represents a unique case that has been explored regarding some aspects the STS[E] curriculum outcomes/expectations and general political culture¹ as well as some other theoretical factors. Findings from this study indicate that Alberta’s STS[E] outcomes may be related to Levinson’s (2010) ‘deliberative’ citizenship focus. The following currents from Pedretti and Nazir (2011) appear to be emphasized: logical reasoning, historical, application & design and socio-cultural aligned outcomes when STS[E] is considered as an entity separate from the

¹ A selected provincial Speech from the Throne, party platform and an environmental action plan were used in each case to explore general provincial political culture.
Alberta curriculum combination of STS and Knowledge. Ontario’s STS[E] expectations may align with Levinson’s (2010) ‘deliberative’ or in some select cases a ‘deliberative’/’praxis’ framework category with some emphasis related to logical reasoning and socio-cultural awareness (Pedretti & Nazir, 2011) in their STS[E] curriculum. The Manitoba STS[E] outcomes may be aligned with a more ‘deliberative’ approach with some associations that could intersect with the framework categories of ‘praxis’ or possibly ‘dissent and conflict’ (Levinson, 2010) and the logical reasoning, socio-cultural and socio-ecojustice currents (Pedretti & Nazir, 2011).

General provincial political culture seems to play a limited role in the STS[E] outcomes/expectations as the provinces studied here all tend to align with Levinson’s (2010) deliberative citizenship stance (i.e., to varying degrees), with some caveats as explored throughout these cases. A chapter on cross-case analysis follows the three central cases and focuses on the following categories that emerged from this research: STS[E] ontology; STS[E] & citizenship and socio-economic thematic explorations.

The final chapter of this thesis focuses on some additional factors and theoretical explorations that may shape STS[E] curricula such as cultural-geographic considerations; educational-political interactions during curriculum construction processes and possible influences from academic scientists. This chapter also provides some recommendations for curriculum development as aligned with case study approaches and provides insights regarding possibilities for future research.
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This thesis is for Bernadette Phillips.
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Chapter One: Introduction

Our world is experiencing tremendous social upheaval and environmental turmoil. Some of this turmoil is associated either directly or indirectly with aspects of science and technology. There are many examples that are illustrative of these issues such as the potential deforestation of vast carbon sinks such as the Boreal forest located in Northern Canada (and other countries) for corporate gains. Another example may be the contentious oil sands in Alberta that require extraordinary natural resources for oil extraction, yet provide significant societal benefits such as employment and economic security. The interactions among science, society and politics serve as an additional layer of complexity regarding many issues pertaining to environments and sustainability.

Science and technology may provide some of the knowledge and know-how but political intervention tends to provide the societal structures for decision-making and possible actions that could determine the fate of many social and environmental concerns.

Science and technology have brought our societies countless benefits and comforts associated with modern civilization, such as improved health care, advances in transportation, increased life span and many others too numerous to mention. To address some of the concerns highlighted through the above examples, it may be necessary to encourage a different thought process when considering how we might choose to educate our children about science and technology. Orr (2004) cites Elie Wiesel who noted that the “perpetrators of Auschwitz, Dachau, and Buchenwald - the Holocaust - were the heirs of Kant and Goethe, widely thought to be the best educated people on earth” (p. 7). Wiesel (1990) commented that,


These notions eloquently articulated by Wiesel are important considerations regarding science education and raises questions about how we might present science and technology to students so as to cultivate more ethical and thoughtful considerations regarding issues related to science and scientific decision-making.

Initiatives linking science, technology, society and the environment (STSE) appear to be an excellent curricular advancement toward engaging and supporting a more
democratic, ethical and thoughtful approach to science and technology education. STSE curricular initiatives are not a new undertaking or approach in science education and may be a beneficial and important aspect to support the moral and ethical development of our children. Without this most important aspect of our science and technology curricula we may be supporting MacIntyre’s (1981) claim that the world is suffering from a type of ‘moral amnesia’ (as described in Orr, 2004).

Pedretti and Nazir (2011) state that, “It has been four decades since science, technology, society, and environment (STSE) was first introduced into the science education lexicon” (p. 602). ‘STS’ refers to ‘science-technology-society’ as described by Ziman (1980), whereas, ‘STSE’ acknowledges science-technology-society (STS) as well as the environment (the ‘E’). Often, these terms are used interchangeably as STSE has evolved from STS. I prefer the use of STS[E] because it is inclusive of both of these domains and also because some of the jurisdictions explored in this thesis use STSE or STS.

In Canadian contexts, provincial governments have jurisdiction over education and curriculum construction processes. This also extends to the provincial science curricula and choices regarding the presentation of STS[E] in these policy documents which are utilized by educators and other educational practitioners. Curriculum documents are arguably political constructions as they represent the consensus of many stakeholders and may provide insights about Apple’s (2004) provocative question, “Whose knowledge is of most worth?” (p. xix). This question might be considered regarding the science and technology curricula and the presentation of STS[E]. What does the science curriculum tend to emphasize? Does the discourse construct science as a collection of facts or is it about more than this? Whose knowledge is of most worth when we consider these documents and how might this influence our STS[E] education? Another timely consideration may be related to STS[E] and the science, technology, engineering and mathematics (STEM) movement in science education. What will happen to STS[E] in our next rounds of curriculum review and revision? Will it be phased out for STEM-related curricula? If we consider that each province has jurisdiction over this aspect of the curriculum, we might also consider how the general political culture could perhaps influence this aspect of the curriculum.
1.1 Research Questions

This doctoral thesis explores the science, technology, society and the environment (STS[E]) tenth-grade\(^2\) science curriculum outcomes/expectations across three different provincial jurisdictions in Canada that differed in provincial political representation at the time of the tenth-grade science curriculum development and implementation. The STS[E] curricula was selected for this study as it is arguably a more ‘political’ aspect of the science curriculum where there may be an emphasis on choice, deliberations, decision-making and aspects of democratic citizenship.

The provinces selected for this study were Alberta (i.e., represented by the Progressive Conservative Party), Manitoba (i.e., represented by the New Democratic Party) and Ontario (i.e., represented by the Liberal Party). To guide my research on STS[E] education in these provinces, my questions focus on the following explorations:

1. What are some of the STS[E] discourses present in the tenth-grade in the provincial science curriculum documents?

2. What are some possible factors (e.g., provincial political representation) that may influence curricular discourses present in tenth-grade STS[E] outcomes/expectations?

Tenth-grade science curriculum documents and a selection of provincial political documents (i.e., Speeches from the Throne, Party Platforms and Climate Change Action Plans) were selected to investigate these questions. The analytical tools of document analysis and discourse analysis were used in conjunction with the application of theoretical frameworks from Levinson (2010), Pedretti and Nazir (2011) and Krathwohl (2002) to explore and address my research questions. My findings are presented as three comparative case studies where each province represents a unique case. Following my cases, a chapter on cross-case analysis further explores inter-provincial considerations and themes that may influence STS[E] and finally, I present a chapter that explores additional theoretical considerations for this study and some possible future research directions.

\(^2\) The tenth-grade was selected because it had similar units of study represented in the science curriculum across these provinces to aid in the comparison of ontologically similar documents.
This study provides a unique contribution to the large body of scholarly research on STS[E] studies by exploring STS[E] curricula in the context of political landscapes, among other factors, as well as providing insights regarding the application of scholarly frameworks from Levinson (2010), Pedretti and Nazir (2011) and Krathwohl (2002) to the ‘official curriculum’ (Posner, 2004). The use of document and discourse analysis techniques provide a novel methodological approach when exploring and deconstructing the various social, economic, political motivations that may underpin curricula. Additionally, the use of this range of techniques provides a way to critically explore documents to support interpretations and implementations of ‘operational curricula.’

1.2 ‘De-Punctualizing’ Me!

My graduate studies in education have demonstrated that it is critical to be a reflective educator and a self-aware researcher. My personal perspectives, background and education will direct my research decision-making processes and how I have analyzed and interpreted the collected data regarding my research questions framed above. Merriam (2009) discusses how the researcher “…is the primary instrument for data collection and analysis” (p. 15). It is with this understanding and context that I present more about my background and educational experiences as I prepared to undertake qualitative research, I acknowledge that this information is important, as my background perspectives will influence how I explore and analyze the data that I collect in the aforementioned ways. Actor Network Theory (ANT) scholar, Callon (1991) (as cited by Cressman, 2009), uses the term, “punctualization,” to describe how networks, objects and people can be reduced to single entities. I decided to entitle this part of my thesis, “De-Punctualizing Me,” as I attempt to provide more detail and background regarding some of my perspectives as a researcher and how this may shape some perceptions of my data and analysis to be presented throughout this thesis.

I was fortunate to have spent most of my formative years growing up in Antigonish, Nova Scotia with the exception of one year living in Cambridge, England and time spent travelling to various locations around the world. Antigonish is a very small, rural community located in northeastern Nova Scotia. I am quite fond of David
Orr’s (2004) description of community as I feel it is reflective of my upbringing. He states,

By community I mean, rather, places in which the bonds between people and those between people and the natural world create a pattern of connectedness, responsibility, and mutual need. Real communities foster dignity, competence, participation, and opportunities for good work. (p. 143)

I have always enjoyed being outdoors exploring and examining the natural world. One of my most influential science experiences was taking a field biology course the summer going into my last year of study in my undergraduate science program. Prior to this, all of my science coursework and associated labs were spent indoors. It is amazing sometimes when we observe things that are in front of us yet we do not notice until it is pointed out. A trip to the animal ‘bone yard’ where the Ministry of Natural Resources deposited its road-kill carcasses with its heaps of bobcat skeletons was evidence that these wild cats prowled all around us, but remained largely unseen. That same summer, I also completed an expedition to a remote region in the Cape Breton highlands to collect insect samples and to scan for the saw whet owl. We had to prepare extensively for this trip by packing and fitting all of our food and supplies in our backpacks, as we had to reach our sites exclusively by foot. The trail system we followed wound around some difficult terrain including steep and wind-swept hills. Many of the small trees that framed the trail pathway were very old. These ancient trees remained stunted and twisted in stature as they were perpetually shaped by the winds that were swept up by the hills from the ocean below.

What stood out for me about this trip was that I remember the feeling of being a part of the ecosystem as opposed to observer of the ecosystem. As we hiked in to the first ranger’s cabin, you would hear distinctive snorts coming from nearby brush on the trail. I later learned that these sounds were made by nearby moose. Apparently moose can hide in plain sight. I would have never believed that a one-ton animal could be capable of this feat. Aside from the snorts and occasional drumming from pheasant, there were no planes flying overhead, no traffic, just footsteps and the ‘silence’ of non-human white noise. The beauty of such a remote region is difficult to describe and it puts the fragility of and our reliance on ecosystems into clear perspective. This experience deeply impacted my commitment to sustainability and educating students about the environment. STS[E]
educational initiatives resonated clearly with some of my early, formative experiences regarding the environment and have influenced what I have done in my science classrooms over the years.

I decided to enroll in a B.Ed. program after working for one year as an educational assistant with special needs students after I completed my undergraduate degree in biology. I was hired by York Region District School Board and taught mathematics and science for two years, but still had the research bug and was ‘itching’ to get back into the field! I decided to take a leave of absence to complete my master’s degree in forest conservation to gain some new perspectives about the environment and sustainability. My cumulating project involved me travelling to and living in my tent in various wilderness locations surrounding Temagami, ON, to conduct research with a non-governmental agency called Ancient Forest Exploration and Research on the American marten.

I returned to the classroom after my master’s degree and felt changed by my experiences. I have taught grades 9 through 12 general science, mathematics, biology, chemistry and student success (i.e. a specialized program to support ‘at risk’ learners) at many levels such as: applied, academic, college and university. My formative experiences have significantly impacted my science teaching and my classroom environment, especially when discussing issues pertaining to STS[E] and the environmental component. My involvement with Dr. Larry Bencze’s STEPWISE research project since 2008 has helped me to reflect more profoundly about the meaning of science and technology education, the pedagogical delivery of science and how science education may be used to engage students in awareness and action-based initiatives. STEPWISE has helped my students to engage more enthusiastically and critically with the science curriculum and to explore what they might choose to do with their science education. I also realized along this journey that my education was not complete. I had many questions remaining about science and education and fortunately

3 ‘Applied, academic, college and university’ level designations indicate various types of curriculum offered in Ontario.

4 STEPWISE (Science and Technology Education Promoting Wellbeing for Individuals, Societies & Environments) refers to Dr. Larry Bencze’s research project that supports students and educators in how to address various socioscientific and STSE issues.
was accepted to complete my doctoral studies at OISE to further explore these intersections.

My life and teaching experiences and educational background have alerted me to the importance of STS[E] education and ways that this can manifest in the curriculum and the classroom context. These lenses have provided me with both academic and practitioner experiences that I feel qualify me to explore this intersection in the study to be presented here. Additionally, some prior course work in political science, economics and international trade were beneficial when exploring some of the political discourses to be presented.

1.3 An Introduction to Discourse

This introductory segment will provide some background and theoretical knowledge about discourse as I will be using discourse analysis throughout my case studies and cross-case analysis chapters. This segment focuses on some methodological considerations regarding discourse as I will be comparing ontologically different documents in this study such as tenth-grade STS[E] curricula and a selection of political documents.

Discourse itself may be considered an ‘ontology’ if we consider that it represents a particular way of viewing the world or a perspective about the nature of reality. Morgan (2016) draws from the work of several scholars such as Dillon and Walls (2006) and Ramey and Grubb (2009) where he discusses how “ontology is concerned with the nature of social reality” (para. 2). Morgan (2016) discusses how there are two polarized ends of the ontological spectrum consisting of realists and relativists. Realists feel that the truth is ‘out there’ waiting to be discovered (Blaikie, 2007 as quoted by Morgan, 2016). Whereas relativists view truth and knowledge as social constructions such as described by Morgan (2016) here, “… ultra/hyper relativism suggests that there is nothing beyond the text; that reality is but a dance of signs” (Reason & Bradbury, 2006).

Discourse and discourse analysis (i.e., in conjunction with the other methods used in this study) are important topics and methods to aid in explorations of STS[E] curriculum across various political landscapes and at different ontological levels.
Very simply, Merriam-Webster defines ‘discourse’ as, “the use of words to exchange thoughts and ideas.” Fairclough (2003) challenges us to view discourse within texts as:

(a) representing some particular part of the world, and (b) representing it from a particular perspective. (p. 129)

Discourse may change depending on the context and to whom we are speaking. Gee (2011) reminds us that:

[language does, of course, allow us to inform each other. But it also allows us to do things and to be things, as well. In fact, saying things in language never goes without also doing things and begin things. (p. 2)

MacLure (2003) notes that Foucault is the theorist most often associated with the field of discourse. She elaborates about his perspectives regarding discourse in stating,

Within a Foucauldian approach, discourses are inextricably linked to institutions (the law, education, the family, etc.) and to the disciplines that regularize and normalize the conduct of those who are brought within the ambit of those institutions—psychology, medicine, science, psychotherapy, pedagogy, and so on. (p. 177)

She describes one of his more frequently quoted statements regarding discourse here, “practices that systematically form the objects of which they speak” (Foucault, 1972, p. 49 as quoted by MacLure, 2003, p. 175). She also cites the work of Britzman (2000) in relationship to ‘subjects’ here:

Every discourse constitutes, even as it mobilizes and shuts out, imaginary communities, identity investments and discursive practices. Discourses authorize what can and cannot be said: they produce relations of power and communities of consent and dissent, and thus discursive boundaries are always being redrawn around what constitutes the desirable and the undesirable and around what it is that makes possible particular structures of intelligibility and unintelligibility (Britzman, 2000, p. 36 as cited by MacLure, 2003, p. 175).

MacLure (2003) discusses the possible associations between power and discourse and cites how Foucault typically combined the two terms either as power/knowledge or pouvoir/savoir. She also notes that ‘power’ in these contexts is not a struggle of one group versus another, but rather a much subtler interaction that is played out through various discourses present in institutions. MacLure notes that, “…discourses are exclusionary: they rule out other ways of thinking, talking or acting” (p. 178).
These discussions and connections regarding power discourses and relationships may also be associated with Foucault’s notion of ‘biopower.’ Rabinow and Rose (2006) discuss how Foucault argued that power is “…exercised at the level of life” (p. 196) and summarize some of his conceptions of biopower presented in a series of lectures in 1976 here:

…one pole of biopower focuses on an anatamo-politics of the human body, seeking to maximize its forces and integrate it into efficient systems. The second pole is one of regulatory controls, a biopolitics of the population, focusing on the species body, the body imbued with the mechanisms of life: birth, morbidity, mortality, longevity. (p. 196)

MacLure (2003) notes how the field of discourse has associations and ties to the post-structuralist paradigm. She offers some perspectives here regarding some of these intersections:

- ‘Realities’ are discursive, that is, there is no direct access to a reality ‘outside’ discourse.
- Language is not ‘transparent’: that is, it is not a neutral medium or vehicle for providing access to the world, or to thought.
- People are ‘made subjects’ through their involvement as speaking subjects within discourses.
- The self is therefore ‘decentred’: instead of the self-actualizing individual conceived of in humanist philosophies, selves are multiple, fragmented and ‘subjected’ to the constrains of discourse
- Power, knowledge, truth and subjectivity are interlinked and produced in/through discourse.
- Language is never innocent.
- Ambiguity, uncertainty, irrationality and indeterminacy lie ‘at the heart’ of meaning, reason and truth. (p. 180-181)

Discourses in Science

Language use and discourse change when we enter into different social situations or perhaps in different classrooms. For example, the discourse used in a science classroom and English classroom may have some commonalities, but there will be differences that are apparent in the way that we describe and utilize language to convey concepts or describe relationships. This idea may be extended to the various disciplines of science at the high school level and their corresponding curriculum documents. Although central disciplines such as biology, chemistry and physics share some common elements, there may be differences in their associated discourses. These discourses could
impact the way that curricular topics are disseminated in the classroom and internalized by educators and students. The following sections explore some ideas related to discourse that may be present across the key science disciplines (i.e. biology, chemistry, physics) that one might encounter at the general science level (i.e., Grade 9 and/or 10 science).

Exploring various discourses present in different scientific disciplines may be useful in this study, since changes in discourse may impact the way that discourses could be represented in the curriculum. Sjöström (2007) states,

Such a discourse can be described as a broad societal and historically based flow of ideas that dominate the conceptions and practices of people without being necessarily aware of its influence. Education informs disciplinary discourses. (p. 83)

Biology is often perceived as a science discipline perhaps more open to interpretation. This public perception may be connected to the notion that some biological sciences may rely less on mathematical relationships and perhaps reductionist approaches. However, the public and perhaps even those who teach biology are perhaps less aware of how often statistical measures are employed in the biological sciences to make a case for a particular conclusion.

Chemistry is often regarded as the ‘central’ science as it is used in many scientific contexts and across fields. Sjöström (2007) argues that chemistry may be more of a blending of technology and science than perhaps other disciplines of science. Kovac (2002) describes the field of chemistry in the following way,

Chemists historically have been less concerned with probing the deep secrets of the universe than with the synthesis of new compounds. Chemists make fertilizers and fibers. Chemistry is closer to experiment than physics; chemists must ‘think with their hands’ more than most other scientists. (Kovac, 2002, p. 164 as cited by Sjostrom, 2007)

Sjostrom (2007) discusses how this may be a generalization as the field of chemistry encompasses so many different branches that study a diverse array of topics. Sjostrom (2007) argues that chemical discourse is

…based on objectivism, molecular reductionism, and rationalism. These views are important parts of the nature of chemistry, but become problematic when chemical researchers and educators are not open to philosophical reflection. (p. 86)
This description of chemical discourse may also be indicative of how some branches of physics operate as there also appears to be an over-reliance on reductionism and rationalism. For example, a more reductionist approach may involve attempting to distill a complex relationship down to a singular equation - which may be useful depending upon the context. A rationalistic approach may utilize testing various types of hypothesis or the null hypothesis after perhaps theories have been generated (i.e., as opposed to a more inductive approach where observations are made and then potential theories generated).

These issues pertaining to the philosophical nature of chemistry may have direct consequences for science educators and the students who elect to take courses in chemistry or general science that has a chemistry component. If Sjostrom (2007) is correct in his assertions that one of the principle aims of chemistry education is to select and streamline students into areas of research and engineering, then this discourse (please note that this may not be intentional) may have a profound impact on the ways in which teachers approach science education. Also, Sjostrom (2007) argues that the discipline of chemistry has a distinct flavour of positivism and reductionism. This may also limit how teachers approach certain topics such as STS[E]; for example, if they perceive that chemistry is a ‘neutral’ or objective discipline they might feel that it is not the place to discuss value-laden topics. This may have implications regarding imbedded messages to students about aspects of democratic participation. For example, if chemistry knowledge flow is primarily from “scientist-teacher-student” as depicted by Levinson (2010), then the implication for the student is that the establishment of this power relationship may limit democratic participation by the student as they are relying on other experts for knowledge and perhaps decision-making.

Physics conjures the image of a science discipline perhaps overly reliant on mathematical, objective, value-free and reductionist approaches. What is interesting is how the field of physics has evolved recently in the advent of the Large Hadron Collider. Theoretical physics is pushing the limits of what we think we know about the universe and how atoms function at the sub-atomic level. This branch of physics does not appear to be as reductionist.
Some Theoretical Perspectives on Discourse Analysis

Van Dijk (1985) contends that the study of discourses or discourse analysis is a process that has historical origins dating back 2000 years and is a cross-disciplinary field that draws from the work of many scholars in diverse fields (see Van Dijk, 1985 for an in-depth historical review of discourse analysis). Gee (2011) states that,

There are many different approaches to discourse analysis. Many of these are part of the discipline of linguistics and tied closely to the study of grammar, through there are also a number of different approaches to grammar. Some approaches to discourse analysis are not as closely tied to the details of language, but concentrate on ideas, issues, and themes as they are expressed in talk and writing. (p. i)

Gee (2011) concisely presents discourse analysis using the following characterization:

Discourse analysis is the study of language-in-use. Better put, it is the study of language at use in the world, not just to say things, but to do things. People use language to communicate, co-operate, help others, and build things like marriages, reputations and institutions. They also use it to lie, advantage themselves, harm people, and destroy things like marriages, reputations, and institutions. (p. i)

There are many approaches to conducting a discourse analysis that range from intensive grammatical and speech event exploration to utilizing a more holistic and critical lens. These approaches might be considered as a branch of epistemology where discourse analysis may be representative of how these documents (i.e., curricula and various political documents) construct knowledge. Fairclough (2003) makes the following recommendations regarding how to conduct a text-based discourse analysis:

(1) Identify the main parts of the world (including areas of social life) which are represented – the main ‘themes’.

(2) Identify the particular perspective or angle or point of view from which they are represented. (p.129)

Foucault (1977) offers many approaches when considering the art of discourse analysis and urges us to consider preliminary questions such as,

…who is speaking? Who, among the totality of speaking individuals, is accorded the right to use this sort of language (langage)? Who is qualified to do so? Who derives from it his [their] own special quality, his prestige, and from whom, in return, does he receive if not the assurance, at least the presumption that what he says is true? What is the status of the individuals who—alone—have the right,
sanctioned by law or tradition, juridically defined or spontaneously accepted, to proffer such a discourse? (p. 55)

Jaipal-Jamani (2014) comments here about some of these associations regarding the use of discourse analysis:

The analytical approach of discourse analysis is a methodological strategy that can be used to interpret data in situations where the researcher wants to illuminate meanings in text. I use the word text in a broad sense to include written and verbal language, as well as images, pictures, graphs, and other artifacts. (p. 3)

I concur with Jaipal-Jamani’s thoughts about the use of the word, ‘text’ as having a very broad interpretation that is inclusive of conversation, written works and also a wide array of artifacts.

Semiotics

Semiotics or the study of signs and symbols may be another field to consider when exploring the discourses associated with texts inclusive of curriculum or political documents. Foucault (1977) in his Archaeology of Knowledge speaks here regarding the important nature of ‘signs’:

…treating discourses as groups of signs (signifying elements referring to contents or representations) but as practices that systematically form the objects of which they speak. Of course, discourses are composed of signs; but what they do is more than use these signs to designate things. It is this more that renders them irreducible to the language (langue) and to speech. It is this ‘more’ that we must reveal and describe. (p. 54)

Eco (1976) defines a sign as, “everything that, on the grounds of a previously established social convention, can be taken as something standing for something else” (p. 16 as quoted by Jaipal-Jamani, 2014, p. 802). I found the work of Jaipal-Jamani (2014) to be illustrative of demonstrating connections between semiotics and discourse such as here where she shares an anecdote regarding her knowledge awakening about these connections:
As I broadened my reading on the topic of discourse analysis, I encountered other perspectives for interpreting data. Delving deeper into the literature on semiotics—the study of the meanings inferred from signs—I discovered the ideas of Charles Pierce, an American philosopher, and Umberto Eco, a European philosopher. The idea that any text can be viewed as a sign that has the potential to communicate meanings was fundamental to meaning-making in semiotics. Charles Pierce proposed that the process of meaning-making is triadic: involving the sign, the object the sign refers to, and the possible meanings that can be inferred from the sign. Umberto Eco proposed the idea that cultural codes provide the rules that generate sign-func. (p. 6)

Signs and symbols are embedded throughout texts such as curriculum documents in the form of organizational schematics, diagrams and sometimes in the form of photographs and images. Semiotics may also be applicable under the umbrella of discourse analysis when exploring political documents such as party platforms as photographs and images are frequently used to demonstrate connections among topics and also to introduce party leaders. Jaipal-Jamani’s (2014) description of Pierce’s social meaning-making via signs reminds me of the old saying of ‘…if a tree falls in the forest and no one hears it, did it fall?’ in the sense that there has to be a cultural receiver present to interpret the sign-event; in this case the tree falling. Signs, images and social conventions are all based on cultural norms that are so embedded in our daily interactions that they may go unnoticed until deconstructed. Jaipal-Jamani (2014) uses the description of traffic lights and how the red light is the sign that is interpreted by drivers to ‘stop.’ If we were alien visitors to Earth and simply observed the red light without the embedded social context, it would become somewhat meaningless and not take on the culturally-embedded ‘sign-functions.’

Another consideration when examining documents such as curricular materials in the context of discourse and semiotics may be the idea of translation from what we observe in everyday life to the abstractions that may be found in documents; and what perhaps may be lost in those translations. Roth and McGinn (1998) remind us of the visual nature of the world we are enveloped by. They state that,

…that instructional materials contain, in addition to written text, many graphics such as maps, charts, diagrams, tables, and graphs. Graphically oriented displays (tables, equations, histograms, graphs) are frequently used to integrate complex sets of information, to illustrate phenomena too difficult or cumbersome to describe in words, and to present data in succinct ways. (p. 34)
This may have implications for the teachers and other curriculum developers who use and need to interpret curriculum and other types of documentation that contain these types of abstractions. In the translation process, important details may be lost in the movement from a lived experience to an abstract representation such as an equation (Pozzer-Arhenghi & Roth, 2001). This may have implications for discourse analysis as it is important to be reflective of what may be absent from documentation. Representations that can be found on tangible materials (e.g., diagrams written on paper) are known as “inscriptions” (Roth & McGinn, 1998, p. 34).

1.4 Thesis Overview

This segment of my thesis will provide a brief synopsis of each chapter that follows this introductory section. My thesis begins with a broad survey of scholarly thought and perspectives pertaining to the topics associated with this study and gradually narrows in focus as described in the following two paragraphs.

Chapter Two provides some theoretical background in the areas of government, politics, democracy and educational linkages. Neoliberalism, curriculum ideology and a very brief overview of the curriculum construction processes present in each province are explored using primarily scholarly literature from these fields. Chapter Three presents theoretical considerations and perspectives about science, technology, society and the environment (STS[E]) beginning with a brief overview of some historical considerations that have shaped the STS[E] movement as well as other academic associations with STS[E], some possible challenges linked to STS[E].

Chapter Four focuses on both broad methodological paradigms that are relevant to my thesis and presents the specific research methods that I have used. This chapter also provides information about the case study approach and its appropriateness for this work followed by a through description of the documents that were selected for this study and analytical approaches (i.e., document analysis and discourse analysis).

Chapters Five, Six and Seven describe my provincial case studies. Chapter Five focuses on findings from Alberta beginning with organizational features of the tenth-grade science curriculum document followed by in-depth explorations of the STS[E] curriculum using various theoretical frameworks and discourse analysis. Factors that may
shape the curriculum are explored inclusive of curriculum construction processes, assessment practices and Alberta’s provincial political landscape. Chapter Six explores my findings from Ontario and represents a ‘two for one’ case study as both the applied and academic levels of curriculum have been considered. STS[E] discourses are explored followed by depictions of potentially influencing factors such as curriculum development processes, STS[E] and the Achievement Chart and Ontario’s political landscape. Chapter Seven explores STS[E] curriculum in Manitoba followed by some possible factors that may influence the curriculum including curriculum construction processes and Manitoba’s political landscape.

Chapter Eight centres on cross-case analysis work and explores relationships across the three provinces selected for this study. STS[E] ontology, citizenship, political culture and socio-economic thematic areas are detailed in this chapter. Chapter Nine centres on some additional theoretical considerations that may influence STS[E] curriculum such as cultural-geographic influences, educational-political intersections and the role of academic scientists. The concluding segments provide some suggestions regarding STS[E] curriculum development and possible revisions in alignment with a case study approach and lastly, some study limitations and possible future research directions are discussed.
Chapter Two: Theoretical Background: Exploring Intersections Among Government, Politics, Democracy and Education

This theoretical background begins with some thought and reflection on a broad selection of the literature pertaining to government and politics and its possible intersection with education. After this context is presented, I explore some literature that is more focused and relevant to the exploration of the tenth-grade science curriculum that pertain to the science, technology, society and the environment (STS[E]) learning outcomes or expectations across the provinces explored in this doctoral study.

2.1 Government, Politics, Democracy and Education

Government is a term that frequents our everyday conversations and also seems to be synonymous with ‘politics.’ Many political scientists would assert that to fully understand the concept of ‘government’ or ‘politics’ that we need to start with an understanding of what comprises the ‘state.’ The definition of ‘state’ remains contested as demonstrated through Hegel’s conceptualization where he states that, “…actuality of [a society’s] ethical idea” versus Max Webber’s definition of state as a body that, “…monopolizes legitimate violence over a given territory” (as quoted by Khan & McNiven, 1991, p. 26). They also discuss the origins of the state as a concept traced to prehistory where there have been many theories developed to describe the state such as, Natural Theory of State (i.e., origins in early Greece); Divine Theory of State (i.e., medieval European origins); Force Theory of State (i.e., state originates via force); The Social Contract (i.e., popular theory associated with Western governments based on ideas of Hobbes, Locke, Rousseau).

Khan and McNiven (1991) present four elements that comprise the ‘state’: “population, territory, government and sovereignty” (p. 27). If we focus in on the latter two terms; government can be thought of as, “…the agent which acts in the name of the state to make public social choices” (p. 28) with an important distinction that, “…the state is permanent and continuing: its government changes, is altered, modified, and even overthrown” (Khan & McNiven, 1991, p. 28). Sovereignty may be defined as, “…the government of the state has absolute and final legal authority over all matters and is not subject to any power outside of itself” (p. 29). Khan and McNiven (1991) discuss French
political philosopher Jean Bodin’s conception of ‘popular sovereignty,’ which may arguably be more applicable to Canadian sovereignty where, “…popular sovereignty, thus means that the existence of the state, its activities, and the nature of its government are subject to the wishes of the people” (p. 29).

The terms ‘politics’ and ‘political’ are used in varying contexts and may elicit strong emotional reactions and conjure various images, both positive and negative. Colin Hay (2007) discusses many definitions of what the ‘political’ might constitute such as “…politics is concerned with the distribution, exercise and consequences of power”, “…a set of processes and rituals” or a “…process of public deliberation and scrutiny of matters of collective concern” (as cited in Fairclough & Fairclough, 2012, pp. 25-26). Fairclough and Fairclough (2012) highlight Hay’s (2007) identification of four common themes that underlie his diverse array of political definitions as, “politics as choice, as the capacity for agency, as deliberation, and as social interaction” (p. 26). Fairclough and Fairclough (2012) promote the perspective that,

…politics is most fundamentally about making choices about how to act in response to circumstances and goals, it is about choosing policies, and such choices and the actions which follow from them are based upon practical argumentation. (p. 1)

They also discuss Hay’s (2007) perspective that political actions are defined and shaped by the presence of alternative options. Fairclough and Fairclough (2012) explain that,

Furthermore, political choices are characterized by uncertainty: both the nature of the situation we are responding to and how the choices that we make will affect or change the situation are inherently uncertain. This adds to the controversial character of political choices, because different agents and groups will interpret the situation in different ways, and advocate different possible lines of action in response to it even when they agree on the goals; most often there is also disagreement on the goals of action and underlying values, and on which value or goal should be given priority. (p. 26)

Democracy and what constitutes democratic values or democratic participation remain a contested area and may be connected to our conceptions of politics. The etiology of the word is quite straightforward, however, actually defining ‘democracy’ is rather challenging. Khan and McNiven (1991) offer the etiology of the word, citing its derivation from the Greek, “demos” as translated as, “government by the people as a whole” and also connect this definition to Rousseau’s Social Contract and state that both
of these principles assert that, “people as a whole should participate in the making of decisions which govern them” (p. 47). William Carr (1998) acknowledges this challenge in terms of providing a definition of ‘democracy’ where he states,

Democracy means ‘rule by the people’. However, the notion of ‘rule by the people’ is not unambiguous. Who are ‘the people’? Are certain groups (children, women) to be excluded? What is meant by ‘rule’? Does it mean that people actually rule themselves by participating in political decision-making? Or does it mean that political decision-making is restricted to a small group of political experts chosen by the representatives of the people? (p. 330)

Knowledge regarding what constitutes a democracy, the rights and freedoms of citizens and how to participate in a democracy may aid in the protection of society from various forms of oppression. Paulo Freire (1970) states that, “oppression—overwhelming control—is necrophilic; it is nourished by love of death, not life” (p. 77).

Vandana Shiva (2006) contends that, “democracy has become a much abused term” (p. 73). She is referring to issues such as the denial of food and water to vast numbers of people, the spread of torture and the robbing of basic rights under the veil of democracy and how economic markets associated with free trade have contributed to these issues (Shiva, 2006). She states that, “By deregulating commerce, corporate globalization takes the decisions about our everyday lives beyond the influence of democracy to the WTO, the IMF, the World Bank, Wall Street, and corporate boardrooms” (p. 73).

This has far reaching impacts on society, including what we choose to do or perhaps not do in our science classrooms regarding educational initiatives surrounding democracy and citizenship. Shiva (2006) asserts “citizens do change governments through the mechanisms of representative democracy” (p. 74) and that,

…for citizens to reclaim their freedoms, we have to reinvent democracy. We have to deepen it and broaden it” and that “it requires self-organization and self-rule (Gandhi’s swaraj). We must broaden democracy to include the excluded-disenfranchised communities, children, prisoners, the elderly, and the diverse species of the earth. (p. 74)

To encompass and explore a broader conception of democracy that Shiva imagines, we must examine schools and the purposes of education. This is a very complex undertaking. The purposes of schooling becomes arguably even more
complicated when moving into the realm of 21st century education as societies are grappling with a rapidly changing world coupled with many uncertainties. Children must deal with marketing on a daily basis that sends the message that, “self-worth and social status are dependent on appearance, purchasing power and conspicuous consumption. We are measured by what we own rather than who we are as people” (Hyslop-Margison & Thayer, 2009, p. xvi). Apple (2004) may concur with these perspectives where he states that,

Social and economic values, hence, are already embedded in the design of the institutions we work in, in the “formal corpus of school knowledge” we preserve in our curricula, in our modes of teaching, and in our principles, standards, and forms of evaluation. (p. 8)

2.2 Neoliberalism

Ball (2012) comments that the term ‘neoliberalism’ has been widely used and is challenging to define concisely. He cites Shamir (2008) to aid in providing a description of some of the characteristics of neoliberalism in stating:

Is treated neither as a concrete economic doctrine nor as a definite set of political projects. Rather, I treat neoliberalism as a complex, often incoherent, unstable and even contradictory set of practices that are organized around a certain imagination of the ‘market’ as a basis for ‘the universalization of market-based social relations, with the corresponding penetration in almost every single aspect of our lives of the discourse and/or practice of commodification, capital-accumulation and profit-making. (Carvalho & Rodrigues, 2006, citing Wood 1997 in Ball, 2012, p. 3)

Ball (2012) asserts that neo-liberal reforms are globally circulated using “transnational advocacy networks” (p. 12) and states that,

These relationships span nation-state boundaries. They differ from other types of networks in that they exist to promote principled causes, ideas and values. They exist to change international policy as well as make these changes real in the day-to-day lives of ordinary people. (p. 12)

Bencze and Carter (2011) also speak to these relationships and connect with the work of Foucault (1991) where they connect neoliberalism with his notion of ‘governmentality.’ They describe this as people feeling as though they are autonomous, but are in fact being governed by influences from the corporate world that value neoliberal tenents.
Neoliberalism may impact the daily decision making of individuals and could also extend into the management of educational institutions. Bencze (2010) provides additional commentary here regarding how neoliberalism may manifest throughout society:

…under neoliberalism, profit-oriented government intervention has been encouraged—often in the form of: tax reductions and, related to that, reduced social spending (e.g., health and education); more emphasis on individual responsibility, rather than the public good; reduced regulations on business activities, such as transnational trade and environmental and labour standards; and, privatization of some government services (e.g., forms of transportation). (p. 294)

Vandana Shiva (2006) writes about several of these issues with respect to other socio-economic principles such as ‘enclosures’ and ‘commons.’ At one point in our societies, commons were essential to all communities as they provided common resources such as forests and forest products, pastures and many other shared benefits. She comments on how many of our current societies have moved toward the idea of enclosure on various levels here:

Land and forests were the first resources to be enclosed and converted from commons to commodities. Later, water resources were enclosed through dams, groundwater mining, and privatization schemes. Now it is the turn of biodiversity and knowledge to be “enclosed” through intellectual property rights. (p. 39)

Hyslop-Margison and Thayer (2009) draw from the work of Habermas (1996) to suggest that instead of education providing outlets for agency that counter some of these issues associated with neoliberalism that,

…we are witnessing the complete invasion of what he describes as the life world by the creation of false consumer needs and the rapid decline of public spaces. The life world for Habermas consists of those fundamental human experiences and interactions that generate a sense of inner peace or individual wellbeing, and provide the necessary community space, such as liberal learning institutions, for democratic discussion. (p. 7)

This alternation of Habermas’ “life world” may connect with Pierce’s (2013) portrayals of “disposability models of education” where he draws from the work of various scholars and comments on the impact of neoliberalism on society:
The disposability perspective, for example, argues for the necessity to address how neoliberalism as a pedagogical practice and a public pedagogy operating in diverse sites has succeeded in reproducing in the social order a kind of thoughtlessness, a social amnesia of sorts, that makes it possible for people to look away as an increasing number of individuals and groups are made disposable, relegated to new zones of exclusion marked by the presupposition that life is cheap, if not irrelevant, next to the needs of the marketplace and biocapital. (Pierce, 2013, p. 35)

To counter these messages, Hyslop-Margison and Thayer (2009) advocate for an education founded in democratic beliefs. They comment on what they feel the role of schooling must be:

Our role in education is not to prepare students for a new economic reality designed by others, but to prepare them to shape social reality in more progressive and socially just sorts of ways. Our citizenship mission ought to teach students what is possible rather than objectifying them as human capital being prepared for the inevitable impact of policies implemented to protect the interests of the economic elite. (p. xvii)

This perspective may share commonalities with educating for social justice. Hyslop-Margison and Thayer (2009) envision an engaged citizen participating in democracy in the following manner,

Participatory citizens are constantly engaged in public debate, they participate in their community by volunteering or engaging in various forms of political activism. Being a democratic citizen is a full time endeavor that involves seeking new knowledge and reflecting on that knowledge again and again. The idea of a democratic citizen cannot be neatly separated from our occupational lives. (p. 2)

To achieve these goals, they advocate for a much more critical consideration of the “organization and delivery mode of classroom material and discussion design” (p. 4) (i.e., this analysis could extend to the exploration of what is present or perhaps absent from the curriculum). This may enable students to more thoughtfully examine issues instead of being a more passive consumer of the knowledge. This could provide a pathway to what Hyslop-Margison and Thayer (2009) describe as our “existential need for agency” (p. 7).

Curriculum may serve as an important foundation to promote and protect democratic values and to enable a more inclusive and socially just paradigm for which Bencze, Shiva and others advocate for, especially regarding children in this school-based context. It may be a way for people in our society to counter oppressive forces that exist
both globally and here in Canada as students may be able to think more deeply and critically about various social and environmental issues.

2.3 Curriculum Ideology

*Whose meanings are collected and distributed through the overt and hidden curricula in schools? (King, 2004, p. 43)*

What is curriculum? Carr (1998) offers a succinct answer to this complex question here in stating,

In the English-speaking world curriculum used to be defined in a narrow and specific way to refer to the content or subject matter that is taught in schools. More recently, this definition has been broadened so as to include learning objectives, teaching methods, assessment procedures and classroom organization as well. (p. 325)

Carr (1998) also points out that this is not a comprehensive definition as it omits other important factors such as, “…the important social and political role that the curriculum plays in initiating pupils into the culture, practices and social relationships of their society” (p. 325).

Posner (2004) discusses and describes five different types of curriculum that may operate at any time through curriculum documents or educational activities here:

1. Official curriculum. The curriculum described in formal documents.
2. Operational curriculum. The curriculum embodied in actual teaching practices and tests.
3. Hidden curriculum. Institutional norms and valued not openly acknowledged by teachers or school officials.
5. Extra curriculum. The planned experiences outside the formal curriculum. (p. 14)

He also discusses the influential works of Tyler and his four central questions related to planning a curriculum, sometimes referred to as the ‘Tyler Rationale’ (1949) as described here:
1. What educational purposes should the school seek to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these experiences be effectively organized?
4. How can we determine whether these purposes are being attained? (p. 15)

To begin some of these explorations regarding curriculum and its various manifestations, Poser (2004) suggests asking the following questions:

- How is the curriculum documented?
- What situation resulted in the development of the curriculum? What perspectives does the curriculum represent?
- What are the purposes and content of the curriculum? How is the curriculum organized?
- How should the curriculum be implemented? What can be learned from an evaluation of the curriculum?
- What are the curriculum's strengths and limitations? (p. 19)

Based on Posner’s (2004) discussions, we can see how schools and a curriculum transmit many messages to students both implicitly and explicitly. Apple (2004) raises some complex and critical questions regarding the association between knowledge and power that are entwined in our educational institutions including our curriculum. He challenges us to reflect upon, “…whose knowledge is ‘official’ and about who has the right to decide both what is to be taught and how teaching and learning are to be evaluated” (p. vii). These are important and complex points to consider when thinking of the role of both schooling and the associated curricula that are delivered to students.

Apple (2004) argues that schools and curriculum may act as hegemonic agents and states,

Schools in the words of British sociologists of the curriculum, do not only “process people;” they “process knowledge” as well. They act as agents of cultural and ideological hegemony, in William’s words, as agents of selective tradition and of cultural “incorporation”. (p. 5)

When considering these perspectives, it may be considered that the curriculum or associated documents are not neutral dispensers of knowledge and information to be taught. Apple (2004) presents an argument from Michael Young where he states,

…those in positions of power will attempt to define what is taken as knowledge, how accessible to different groups and knowledge is, and what are accepted relationships between different knowledge areas and between those who have access to them and make them available. (p. 34)
Apple (2004) discusses this point raised by Young regarding the relationship between knowledge and power in the context of “high status knowledge” that he defines as “knowledge that is considered of exceptional import and is connected to the structure of corporate economies, is related to and in fact seems to entail the non-possession by others” (p. 34). Regarding whose knowledge counts, Apple (2004) presents Bourdieu’s perspectives on the “middle class culture” here:

For example, schools partly recreate the social and economic hierarchies of the larger society through what is seemingly a neutral process of selection and instruction. They take the cultural capital, the habitus, of the middle class, as natural and employ it as if all children have had equal access to it. (p. 31)

Gee (1992) speaks to this unequal access to aspects of middle class culture through his discussion of language, discourse and how parents may initiate their children into these cultures. He states,

They engage their children in conversations and keep them on a single topic even when the children can hardly talk at all. […] They play alphabet games, recite nursery rhymes, read books aloud with great affect. They ask their children ‘What’s that?’ and ‘What’s that say?’ of pictures in a book they’ve both seen a hundred times. […] They encourage children to pretend they can read when they can’t; they let them manipulate magnetic letters on a refrigerator; and they get them to watch ‘Sesame Street’ for hours on end. They send them to preschool and constantly relate what the children have seen or heard in books to the children’s daily experience of the world. (Gee, 1992, p. 123 as cited by MacLure, 2003, p. 177)

Carr’s (1998) perspectives on the relationship between curriculum and democracy may intersect with these notions of what knowledge has been presented as ‘official’ and which voices ‘count.’ He contends that, “My general argument will be that the curriculum in any contemporary democratic society always reflects the definition of democracy which that society has accepted as legitimate and true” (p. 324).

As indicated from the literature, there are potentially ‘politicized’ connections when considering the inclusion of knowledge, what knowledge counts and the curriculum decision-making process. Carr (1998) presents an overview of three curriculum ideologies that intersect with varying political perspectives. Carr (1998) also asserts that curriculum may overlap among these categories. His first curricular ideology described is
the “classical-humanist” where society is governed by a group of elites that reproduce traditional values via the educational systems in place.

The second curriculum ideology described by Carr (1998) focuses on what he calls the “liberal-progressive” ideology. Carr’s (1998) conception of this stance is that instead of the locus centering on cultural reproduction as with the “classical-humanist” stance, the goal of this type of curriculum is political. The emphasis is on autonomy where, “…forms of social life in which free and equal individuals can determine their own version of the ‘good life’ and collectively participate in formulating the common good of their society” (p. 327). The “liberal-progressive” curriculum ideology promotes student-centred approaches that emphasize the learning and development of the student.

The final ideology presented by Carr (1998) is the “modernist-vocational.” He contends that the key outcome associated with this curricular focus is economic versus cultural or political reproduction. He summarizes this function here,

It thus supports and envisages a meritocratic society in which access to positions of wealth status and power is not restricted to an aristocratic elite, or governed by abstract principles of individual freedom and social justice. Rather, it is determined through open competition in which all have an equal opportunity to acquire meritorious reward for their talent, efforts and achievements. (p. 328)

The main focus inherent in the “modernist-vocational” stance involves preparing students for the “world of work.” It distinguishes between those who would serve various functions in a market-based society such as producers and consumers.

The work of Carr (1998) regarding the intersection between curriculum and politics may also connect to Habermas’ cognitive interests (Lovat, 2013). Lovat (2013) describes these interests here,

First, there is an interest in technical control which impels an ‘empirical analytic’ type of knowing. Second, the interest in understanding meanings gives rise to a ‘historical hermeneutic’ way of knowing, or ‘communicative knowledge’ (the knowing that results from engagement, interrelationship and dialogue with others). Third, there is an interest in being emancipated, a free agent as it were, which issues in a ‘critical’, or ‘self-reflective’ way of knowing (the knowledge that comes ultimately from knowing oneself). (p. 71 – 72)

The ‘empirical analytic’ type of knowing could be represented in the description of technocratic and vocational approach to curriculum where the practical is emphasized
and the connection between school and work is prominent. This may also be featured in the ‘classical’ curriculum which emphasis traditional subject-centred knowledge.

The ‘communicative knowledge’ focus may be associated with Carr’s (1998) progressive curriculum ideology. The progressive ideology is child-centred, experiential and uses flexible groupings. This approach may emphasize and build on Habermas’ ‘communicative knowledge’ as this learning acquisition is derived from interpersonal interactions.

The ‘self-aware’ or ‘critical’ knowledge piece might be found across all of these political ideologies, however, it may be more likely to be associated with the progressive ideology. The teacher acts as ‘facilitator’ in this focus and personalized learning experiences are emphasized. This may require a certain amount of self-reflective practice to be knowledgeable regarding personalized learning progressions.

2.4 Deciding What Makes the Cut: Curriculum Decision-Making Processes

The operational curriculum (Posner, 2004) and supporting policy documents guide and shape classroom activities, assessment practices and educational discourses on a daily basis. They govern the teaching profession as legal representations of what educators must teach students. The decision-making process that ultimately determines what is present or absent from curriculum documents is a complex undertaking. Goodlad (1991) states that, “Few matters are more important than who makes curriculum decisions for the nation’s schools” (p. 9). He also asserts that this is a political process that governments and officials are keenly interested in what and how information is presented in these documents. Goodlad (1991) argues that,

Their desire to be key players has been heightened in recent years by the degree to which our schools are seen to be instrumental in worldwide economic competition. Indeed, many politicians perceive themselves to have a public mandate to intervene in the goals and content of the K-12 curriculum. (p. 9)

This process of developing and assembling curriculum appears to be a political undertaking. Goodlad (1991) further explains this point where he states that,
Unfortunately, the ground rules for decision making rarely are neatly demarcated, whatever the political arena. In state legislatures, the stakes are high because of the dollars and public constituency involved. The role of power is accepted and refined to a high level of sophistication. In academe, where the public stakes are considerably lower, the power game is conducted with such subtlety that is it scarcely observable to the outsider (but usually understood and often even relished by players on the inside). (p. 16)

Klein’s (1991) work may be beneficial in gaining some additional understandings of the complexity of this politicized decision-making process that seems to govern curricular constructions. He conceptualizes this process as involving many levels of decision-making (i.e., from academic to experiential curriculum decision-makers) and their influence on the various elements of the curriculum.

Klein (1991) claims that the academic level of decision-making is most removed from what happens in the classroom; yet this influence may be quite significant. He summarizes some of his observations here,

The scholars are usually very visible and prestigious participants in curriculum development who make persuasive arguments in support of the decisions they believe ought to be made. Participants at the academic level of curriculum are usually on the forefront of change; their recommendations are generally received with considerable interest; and sometimes they generate extensive debate by all those interested in the school curriculum. (p. 27)

He explains that students who would be located in the experiential category represent the group closest to the actual curriculum in the decision-making process. Klein (1991) also claims that,

The amount of political power the participants have will help determine whose ideas about curriculum will become the most influential and dominant and thus will potentially find their way into classroom practice. (p. 31)

He also presents a critique of some of his conceptualization of this process in stating that the underlying assumption in his framework is that the curriculum development process is rational; whereas, many scholars would argue this point and conjecture that this process in action is much more flexible and relatable to classroom teachers and their students.
2.5 Curriculum Construction Processes Across the Provinces

As demonstrated above in the review of some more general literature, the curriculum construction and development process is complex and as Klein (1991) describes, perhaps dependent upon the stakeholders and the relative amount of ‘power’ or influence that they hold regarding curriculum deliberations and discussions. In this segment of my thesis, I will explore some introductory aspects of curriculum development or revision processes found in Alberta, Ontario and Manitoba (i.e., these processes will also be re-visited in each provincial case study).

Education and the development of curriculum, including the science curriculum, across Canada is under provincial and territorial governmental jurisdiction. A document that underpins some of the foundational work associated with each provincial and/or territorial science curriculum is the Common Framework of Science Learning Outcomes K to 12, developed by Council of Ministers of Education in 1997. This framework provided an overview or set of guiding principles about various themes that were considered of import to the team developing these foundations to be used to develop the various provincial science curricula.

Typically, many educators are involved in the curriculum construction process alongside government representatives. Pinto (2012) states that:

The significance of curriculum policy documents is that they define what is to be taught and often how it is to be taught. Curriculum policy documents also may indicate why the curriculum decisions were made. As a result, curriculum policy reflects a certain set of values, defining priorities and legitimating what is worth learning. Whose voices and values are reflected within curriculum policy is dependent upon the policy production process in any given jurisdiction (p. 1)

She provides further commentary about the political nature of curriculum policy and development here in the following quote,

Curriculum policy is highly political, regularly garnering attention from politicians and the media. What students ought to learn, and what teachers ought to teach, is argued to have an impact on the social fabric of society and on a nation’s or region’s ability to compete globally. (p. 4)
2.5.1 An Introduction to Curriculum Construction Processes in Alberta

Curriculum construction processes in the provinces as mentioned are quite complex and involve myriad participation from various stakeholders. Beauchamp and Parsons (2012) produced a circular schematic to deconstruct some of these interactions that places consultation, collaboration and communication at the heart of these negotiations in Alberta. They indicate that research, identification of issues, linkage to goals & policy, planning and development are all integral parts of the development process. The use of a circular organizer may imply that there is equal import assigned to every component. This diagram also indicates that the Ministry or Minister of Education needs to provide their authorization regarding the program of study.

There appear to be several linkages to politicized structures in this process, including connections between curricular goals, policies and plans. A much more detailed overview of this process is provided in the work of Beauchamp and Parsons (2012) where linkages to the various political structures of government are in place as the finalized curriculum document is subject to Ministerial approvals. What is unclear from their representations and discussions is the extent to which political representatives are actively involved in curriculum construction processes or if stakeholder perspectives hold equal weight and subsequence representation in curricular document content. Panwar and Hoddinott (1995) assert that while many stakeholder groups such as, “…classroom teachers and principals, Alberta Education staff, educational associations, post-secondary institutions, school superintendents, parents, school trustees and other governmental agencies and departments” (p. 505) that the, “…provincial minister of education makes the final decisions” (p. 505). It remains unclear as to the extent to which a Minister of Education would veto or disagree with collective decision-making of the curriculum teams.
2.5.2 An Introduction to Curriculum Review Processes in Ontario

The curriculum construction process in Ontario is under the supervision of the Ontario Ministry of Education. According to the Ontario Ministry of Education website\(^5\), Ontario curriculum documents are subject to periodic review as described here,

In 2003, the Ministry of Education established a schedule for ongoing curriculum review. Each year, a number of subject areas enter the review process, to ensure they are kept current, relevant and age-appropriate. The current review cycle will be completed in 2012. ("The Ontario Curriculum," 2015).

There are many levels of consultation and approval involved in the curriculum review process as demonstrated in the schematic presented on the Ontario Ministry of Education website\(^6\). Of note, is that the final approval and release of the document is under the Ministry or government control. The use of the oval/circular graphic organizer to depict these processes does not seem to convey a hierarchical approach to the construction process; however, we do see the approaches moving toward the inner circles of curriculum design culminating in the hitting of a bull’s eye target of “Approval and Release.”

2.5.3 An Introduction to Curriculum Development Processes in Manitoba

Underpinning the Manitoba Senior 2 Science curriculum, is the Common Framework of Science Learning Outcomes K to 12, collaboratively developed by Council of Ministers of Education in 1997 as acknowledged here in this intertextual reference (i.e., this may have both manifest intertextual considerations as it directly references the Common Framework and constitutive intertextuality (Fairclough, 1992 as cited in Oliveira et al., in press) as this text is influential,

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\(^5\) The Ontario Ministry of Education website is located here: http://www.edu.gov.on.ca/eng/
Manitoba’s initial curriculum development in the four core subject areas (mathematics, language arts, social studies, and science) was undertaken in collaboration with other ministries of education in Canada. The work of participants in the Western and Northern Canadian Protocol (WNCP) for Collaboration in Education, K-12, produced common curriculum frameworks for mathematics (1995), language arts (1996), and social studies (2002). Similarly, the broader Pan-Canadian Science Project, coordinated by the Council of Ministers of Education, Canada (CMEC), resulted in The Common Framework of Science Learning Outcomes, K-12 (1997).

The Manitoba Ministry of Education describes a “development team” approach to curriculum construction. They assert that this process involves, “curriculum development teams, review panels, field validation, authorized provincial use and continual updating”. The curriculum development team is a group comprised of, “a departmental project leader/specialist who has expertise in the subject area/course under development, in curriculum planning and design, in pedagogy, in assessment and evaluation, and in leadership skills” where “The project leader also accesses advice and feedback, as required, from key advisors such as scholars, industry representatives, parents, and educational organizations and associations.”

2.6 Chapter Summary

Perhaps initially the array of topics explored in this chapter including some theoretical perspectives on government, politics, democracy and the purposes of education might appear to be disparate, however, we can see some of the interconnections and possible associations that may exist between these areas. Neoliberalism has become a pervasive term in many scholarly disciplines inclusive of education, yet, remains somewhat elusive to clearly and concisely define and may have implications for education and educational systems.

Curriculum ideology has been briefly explored including some perspectives about the various types of curriculum such as those described by Posner (2004). Some intersections have been presented between curriculum and political perspectives such as those proposed by Carr (1998), Goodlad (1991) or Klein (1991). Lastly this chapter

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7 Please see the following website for more detail: http://www.edu.gov.mb.ca/k12/cur/process.html (Accessed July 22, 2015).
provides some introductory perspectives about curriculum construction and/or revision processes across the provinces explored in this thesis (i.e., Alberta, Manitoba and Ontario). The next chapter of this thesis will move from these broader perspectives to a much narrower focus on the STS[E] science curriculum to help situate this research in this context as this study primarily focuses on this part of the provincial curricula.
Chapter Three: Theoretical Background: Science, Technology, Society and the Environment (STS[E])

Curriculum and pedagogical practice that promotes a more scientifically informed and literate citizenship has many potential ties with supporting the development of democracy and mitigating social and environmental issues. STS[E] education appears to be an excellent curricular advancement toward enacting these goals in our educational systems. This chapter will provide some scholarly thought and perspectives about STS[E] beginning with some historical perspectives, an exploration of some currents and intersections in STS[E] education focusing on the work of Pedretti and Nazir (2011) and Levinson’s (2010) framework for democratic involvement in science education, other academic associations with STS[E] education such as socio-scientific issues (SSIs) and socially-acute questions and finally an exploration of some challenges associated with STS[E] education.

3.1 STSE Education

The science, technology, society and the environment (STSE) movement in science education has evolved of and from the science-technology-society (STS) movement that was influenced by many scholars and educational programs from the United Kingdom, which were implemented in the 1980s (Yager, 1990). Yager (1990) cites the influence of Science in Society (1981) and Science in a Social Context (1983) as contributing factors in STS education in the U.S. Pedretti and Nazir (2011) discuss the importance of Jim Gallagher’s (1971) early and influential writings that focused on “…concepts, processes, technology, and society” (p. 604). They assert that soon after his work emerged that many scholars commented and asserted that a new framework for science education was necessary.

Yager (1990) notes that the term STS was used by John Ziman in Teaching and Learning about Science and Society in 1980. He referenced a course entitled, “Science and Culture,” which was taught in the 1960s at the University of Iowa at their Laboratory School. The research based on the curriculum indicated that, “…students were able to

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8 Please note that as STSE has evolved of and from, STS, that these terms may be used interchangeably throughout this section.
attain and to retain many skills and competencies defined as a science literacy; skills and competencies that had not developed as a result of study in standard social studies or science courses.” (p. 198). Yager (1990) also describes how the STS movement did not really make much progress until 1981 in the U.S. until the report of Norris Harms’ Project Synthesis study (Harms, 1977). This project identified STS education as a way to provide a level of excellence in the science curriculum and was identified as an area of need or concern in this study. Yager (1990) contended that the STS movement in the U.S. seemed to be a response to several of the goal clusters of Project Synthesis (i.e. Science for Meeting Personal Needs; Science for Resolving Current Societal Issues; Science for Assisting with Career Choices).

Aikenhead (2005) provides some additional insights into the historical context of the STS educational movement. He contends that this major shift in science education was the result of influence from a combination of social need, environmental pressure and philosophical views of science or perspectives on the nature of science (NoS). Aikenhead (2005) describes how STS education was derived from the fusion of the following elements:

1. the interactions of science and scientists with social issues and institutions external to the scientific community
2. the social interactions of scientists and their communal, epistemic, and ontological values integral to the scientific community. (p. 384)

Traditionally, science education seemed to (and perhaps still does) revolve around collections of facts and knowledge framed in a positivistic fashion, emphasizing preparation of learners for additional levels of science education. Yager (1990) states that,

STS means viewing science in a way quite different from the post-Sputnik period where the emphasis was upon the identification of the central concepts, the unifying themes, and the major theories that characterized the various science disciplines if not science itself. The prevailing view was that science could be made meaningful, exciting, and appropriate for all if it were presented in a way known to scientists. (p. 199)

Another key notion that differentiates STS initiatives from more traditional presentations of science curriculum is the incorporation of technology education. Aikenhead (1994) differentiates between science and technology in stating, “The study of
the natural world we call science. The study of the artificially constructed world is technology” (p. 48). Yager (1990) describes this science and technology connection in the following quote,

During the 1960s every effort was made to distinguish between science and technology. Science was in and technology was out. STS means using technology as a connector between science and society. The application so for science are seen as closer to the lives of students, including food, clothing, shelter, transportation, communication, and careers. (p. 199)

The connections and interactions among science and technology can be quite diverse and somewhat complex. Gardner (1999) offers four characterizations that summarize these interactions: “science precedes technology,” “science and technology are independent,” “technology precedes science,” and “technology and science engage in two-way interaction” (p. 332 – 333).

Yager (1990) presents many interesting attitude associations between more traditional forms of science education and how they might contrast with an STS where he contends that:

- Student interest increases in specific courses and from grade to grade
- Students become more curious about the material world
- Students see teacher as a facilitator or guide
- Students see science as a way of dealing with problems. (p. 201)

It is also interesting to note that he contends that STS is not or was not a curriculum-based initiative. His work presented here focuses on student attitude regarding the instructional practices of the teacher (i.e., either using a more traditional approach to science or incorporating STS perspectives).

Yager’s (1990) insights appear to be in alignment with that of Aikenhead, perhaps suggesting that STS science education is a more student centered approach where pupils are able to engage in the material in a more meaningful manner and also see the value in what they are learning in the science classroom since it is connecting to their everyday life experiences (e.g. they are able to use their science knowledge to make decisions or to solve problems). The work of Roberts (2007) on science literacy and his characterization of a Vision I and Vision II perspectives may also intersect with the work of these scholars where Vision I focuses on the traditional aspects of subject knowledge and Vision II focuses on providing a more contextualized science experience.
Student learning and the overall educational outcomes associated with STS educational initiatives are quite broad and varied. Aikenhead (2005) presents the following overall learning outcomes associated with STS here:

1. to make the human and cultural aspects of science and technology more accessible and relevant to students (e.g. the sociology, philosophy, and history of science, as well as its interrelationships with society);
2. to help students become better critical thinkers, creative problem solvers, and especially better decision makers, in a science-related everyday context;
3. to increase students’ capabilities to communicate and be self-assertive with the scientific community or its spokespersons (i.e. listen, read, respond, etc.);
4. to augment students’ commitment to social responsibility; and
5. to generate interest in, and therefore, increase achievement in learning how to learn canonical science content found in the science curriculum. (pp. 390-391)

Aikenhead (1994) (p. 50) cites the work of Waks and Prakash (1985, pp. 108-114) to describe some additional goals or outcomes of a science education infused with STS objectives:

1. Cognitive competency – standardized knowledge and skills needed for reading and speaking accurately about STS issues
2. Rational/academic – a grasp of the epistemology and sociology of science required for understanding the dynamics at play in STS issues
3. Personal – students understand their everyday lives better
4. Social action – students participate in responsible political action.

Yager (1990) concurred with Aikenhead’s last point regarding social action and STS. He made reference to citizenship education and democratic participation when he stated:

Basic to STS efforts is the production of an informed citizenry capable of making crucial decisions and taking actions. STS means focusing upon current issues and attempts at their resolution as the best way of preparing people for current and future citizenship roles. (p. 199)

Aikenhead (2005) asserts that assessment of STS and its associated learning goals has been well documented in the literature where he cites the contributions of many scholars (Aikenhead, 2003; Manassero-Mas et al., 2001; Manassero-Mas & Vázquez-Alonso, 1998; Vázquez-Alonso & Manassero-Mas, 1999) (p. 389). He summarizes the findings of these scholars related to assessment outcomes here and notes the importance of the teacher in STS education:
• Students in STS science classes (compared with traditional classes) can significantly improve their attitudes towards science, towards science classes, and towards learning, as a result of learning STS content.

• Students in STS science classes (compared with traditional classes) can make modest but significant gains in thinking skills such as applying canonical science content to everyday events, critical and creative thinking, and decision making, as long as these skills are explicitly practiced and evaluated in the classroom.

• Students can benefit from studying science from an STS perspective provided that: the STS content is integrated with canonical science content in a purposeful, educationally sound way; appropriate classroom materials are available; and a teacher’s orientation towards school science is in reasonable synchrony with an STS perspective.

• Some students can enhance their socially responsible actions when taught by certain teachers. (p. 389)

Aikenhead (2005) concludes that this STS focus may help to support both students who might consider a career in science (e.g. engineers) and students who need to have a sound understanding of science to enable effective decision-making processes using science. In essence, the STS movement was a positive step toward providing a more equitable and interesting science curriculum that served a greater number of people while focusing on real-life problem solving and potentially providing a situated science education where students could learn about the connection between citizenship and science.

A distinction when first viewing the label ‘STSE’ compared to ‘STS’ is the addition of the ‘E’ to represent the environment. Aikenhead asserts that the addition of the ‘E’ for the environment occurred in both Canada and Israel and created the labels ‘STSE’ in Canada and ‘STES’ in Israel (Aikenhead, 2003). As in the case of STS, there appear to be numerous ways of defining what constitutes STSE education. Pedretti and Nazir (2011) state that STSE approaches in science reflect, “a post-positivist vision for science education that emphasizes a science for all philosophy. It places science squarely within social, technological, cultural, ethical, and political contexts” (p. 602). Hodson (2003) comments on the inclusion of the ‘E’ where he states,

…the broadening conception of STS to include environmental education (STS becomes STSE), extending the definition of scientific literacy to encompass a measure of political literacy, prioritizing the affective, and making much greater use of informal and community-based learning opportunities. (p. 648)

Pedretti and Nazir (2011) view STSE education using the concept of “currents” where they state,
We conceive of STSE education as a vast ocean of ideas, principles, and practices that overlap and intermingle one into the other. There are no mutually exclusive currents, but rather discernible currents or collections of ideas that come together to form potential routes available to teachers and academics as they navigate the STSE waters. These currents are not fixed, but are constantly changing and shifting. Some currents dissolve, while other more substantive ideas might merge to form new currents. (p. 603)

Yoruk, Morgil and Secken (2010) seem to echo Hodson’s (2003) connections to place-based learning where they state that,

STSE stems from the belief that a connection between the student and the real world should be established. This process would lead the student to recognize possible problems that s/he has. (p. 1417)

The Ontario government has recognized the importance and significance of the STSE movement to frame science in a more humanistic and holistic fashion by placing these curriculum teaching and learning goals first. The previous Ontario curriculum listed the teaching and learning expectations in the following order: Understanding Basic Concepts; Developing Skills of Inquiry and Communication; Relating Science to Technology, Society, and the Environment (MoE, Grades 9 and 10: Science, 1999). This may grant teachers more freedom to examine issues of a scientific nature in the context of societal, environmental and technological frameworks. Additionally, framing science in the context of society, technology and the environment may enable citizens to make more informed choices about various consumer products, lead to increases in critical thought where deeper insights as to the benefits and risks of a situation are more effectively evaluated and to increases in participatory citizenship where individuals may feel empowered to take action if they so choose.

Pedretti and Nazir (2011) discuss some pivotal influences on the current Ontario science curriculum’s shift to explicitly incorporate STS[E] outcomes. They cite the influences of the 1997 Common Framework of Science Learning Outcomes: Pan-Canadian Protocol for Collaboration on School Curriculum by the Canadian Council of Ministers of Education on the development of STS[E] across the provinces and territories in Canada. They state that,
…this national document, disseminated to all provinces as a guide for provincial curriculum design and development, provided a vision for scientific literacy in Canada that included STSE, skills, knowledge, and attitudes. More importantly, the document emphasized that “the STSE perspective must be a major driving force in science education, to make student learning relevant and meaningful. (p. 258 as cited by Pedretti & Nazir, 2011, p. 603)

3.2 Currents and Intersections in STS[E] Education

After exploring some of the literature connected with the history and some of the present scholarly thoughts about STS[E] education, it may be beneficial to more closely examine what types of themes and ‘currents’ may be present in the science curriculum and in the pedagogical delivery of STS[E] in various learning environments. Pedretti and Nazir (2011) provide many insights regarding how STS[E] education manifests through their examination of the various themes and ‘currents’ present in the curriculum and pedagogical practice (please see Table 3.1) that may also intersect with the work of other scholars in this area. The first current mapped out by Pedretti and Nazir (2011) focuses on application and design. They state that,

It focuses students on solving utilitarian problems through designing new technology or modifying existing technology. There is a definite emphasis on the transmission of disciplinary knowledge and the development of technical and inquiry skills. (p. 606)
TABLE 3.1: Pedretti and Nazir’s (2011) STSE Currents (Adapted by Bencze, 2016).

This knowledge transmission style may intersect with Levinson’s (2010) deficit category where instructional strategies focus on dissemination of knowledge from scientific expert to teacher to student (please see Table 3.2 for more detail). These works may also intersect with Hodson’s (2003) first pedagogical category, “Learning Science and Technology: acquiring and developing conceptual and theoretical knowledge in science and technology, and gaining familiarity with a range of technologies” (p. 658). Additionally, Callon (1999) describes this knowledge transmission process in his Public Education Model. He contends that the,

…public does not participate directly in knowledge production; it consists of individuals who, either as citizens or as consumers it consists of individuals who, either as citizens or as consumers, delegate the satisfaction of their expectations and demands to intermediaries who are in direct contact with scientists. (pp. 82 – 83)
The historical STSE education current discussed by Pedretti and Nazir (2011) frames science as a “uniquely human endeavor” (please see Table 3.1 above) (p. 610). The use of this current may parallel Levinson’s (2010) ‘deliberative’ approach to science education or even his ‘science education as praxis’ framework categories as historical cases and studies may highlight that science can be uncertain and that the knowledge is more situated (please see Table 3.2 below). There may also be parallels to Hodson’s (2003) second pedagogical category, “Learning About Science and Technology: developing an understanding of the nature and methods of science and technology, an awareness of the complex interactions among science, technology, society and environment, and a sensitivity to the personal, social and ethical implications of particular technologies” (p. 658). There is more emphasis placed on the socioscientific context and personal decision-making regarding science. Political action is not explicitly modeled.
TABLE 3.2. Levinson’s (2010) four frameworks for democratic participation in a school context (Adapted by Bencze, 2015).

**Summary of four frameworks for democratic participation in a school context**

<table>
<thead>
<tr>
<th>Framework</th>
<th>Socio-epistemic relations</th>
<th>Epistemology</th>
<th>Controversy and participation</th>
<th>Pedagogy</th>
<th>Implications for democratic participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficit</td>
<td>Knowledge flow is from scientist-teacher-student</td>
<td>Science is the corpus of knowledge</td>
<td>Ability to engage is constrained by access to technical knowledge</td>
<td>Knowledge for addressing an issue can be brought to the attention of the student.</td>
<td>There is a socio-epistemic inequality between the scientist/teacher and students which limits ability to bring about political change from below but does not preclude influential specialists making a political impact.</td>
</tr>
<tr>
<td>Deliberative</td>
<td>Knowledge flow is predominantly from scientist to the teacher and students, the latter two might be working in concert.</td>
<td>Science is understood to be uncertain and fallible.</td>
<td>Dialogue is open. Lay participants are informed but often lack the political means to bring about change. In schools, students might have opportunities for deliberation through group work and school councils but action might be constrained depending on the democratic nature of the school.</td>
<td>Emphasis on critical thinking and understanding of scientific methods and procedures.</td>
<td>Participation is real but often ineffectual in generating democratic change because participants do not have the 'clout' to make crucial decisions.</td>
</tr>
<tr>
<td>Science education as praxis</td>
<td>Knowledge is distributed and emergent.</td>
<td>Knowledge is situated. Students become inducted into communal ways of knowing through legitimate peripheral participation in particular but changing contexts.</td>
<td>All participants work with a shared sense of social purpose.</td>
<td>Knowledge is provided on a need to know basis. The teacher is not epistemologically privileged.</td>
<td>Active and egalitarian participation to enhance change which might assume political literacy.</td>
</tr>
<tr>
<td>Dissent and conflict</td>
<td>This can be variable but is likely to have similar characteristics to science education as praxis.</td>
<td>What is known is contextualised by socio-political concerns.</td>
<td>Political action.</td>
<td>Knowledge provided on a need to know basis with an emphasis on political literacy.</td>
<td>Political understanding and action for change are foregrounded.</td>
</tr>
</tbody>
</table>


An educator that focuses on interpreting the curriculum in this fashion may promote more active citizenship on the part of students, as they may become more active participants in their own science education. This current also utilizes teaching strategies that tap into student emotion and creative processes (Pedretti & Nazir, 2011). They state that,

Although much of this work focuses on how historical matter can be used to teach more authentic views of NOS, the conclusions are not antithetical to an STSE approach. Indeed, emphasizing that science is a human endeavor seems to be an overlapping purpose of both NOS and STSE education. (p. 610)
Pedretti and Nazir (2011) affirm that there are many possibilities for inclusion of historical facets of science such as the H1N1 pandemic or the Chernobyl nuclear incident and that these perspectives may provide a human touch, so long as these studies portray a balanced version of science. I can recall teaching science students about X-ray crystallography and bringing in a historical connection to Rosalind Franklin. We had discussed how she was the first person to use crystallography to determine a shape associated with DNA and some of the controversy associated with how her findings were not properly acknowledged in the literature. This led to many other interesting discussions about the interface between science and gender and the current status of women in scientific disciplines. Pedretti and Nazir (2011) also discuss how this current may intertwine with politics when they cite Kolsto (2008) and state,

Kolsto (2008) suggests that studying the history of science may encourage democratic citizenship, since the development of science and technology parallels the development of modern democratic societies. The assumption here is that studying one inherently leads to an understanding of the other. (p. 611)

The logical reasoning current as described by Pedretti and Nazir (2011) connects with elements such as critical thinking, decision-making processes and teaching students about how to debate an issue (please see Table 3.1 above). Pedretti and Nazir (2011) comment that,

The logical reasoning current is based on the fundamental principle that any socioscientific issue, no matter how complex, can be effectively handled through consideration of the science behind the issue and logical reasoning in a positivist mode about its consequences. The focus is to enhance student understanding and/or decision making about SSIs by encouraging them to think “the way scientists do.” (p. 612)

They cite many ways regarding how the logical reasoning current may manifest in the science classroom, such as stakeholder analysis or decision-making models, and assert that this current is one of the most prevalent in science education (Pedretti & Nazir, 2011). They recommend careful use of this current as an STSE strategy in stating that, “…poorly constructed activities of the logical reasoning type may unwittingly endorse a cold, mechanistic view of science…” (p. 613). I have used this current in my science classroom where students have completed consequence-mapping activities. I have had
students work in groups to map out the complexity and consequences that may result when a nuclear isotope production facility such as the Chalk River \(^9\) operation has a shutdown. They were able to map out how a shutdown has significant economic, social, environmental and technological impacts.

Pedretti and Nazir (2011) argue that this current may support more active citizenship through the exchange of ideas. This current may align with Levinson’s (2010) descriptions of either science education as praxis or dissent and conflict as the knowledge appears to be situated and could be connected to socio-political concerns depending upon the approach that the educator decides to take (please see Table 3.2) and also Hodson’s (2003) third category, “Doing Science and Technology: engaging in and developing expertise in scientific inquiry and problem solving; developing confidence and competence in tackling a wide range of ‘real world’ technological tasks” (p. 658). This, in turn, could help to support more progressive citizenship initiatives both inside and out of the classroom environment.

The value-centered current explored by Pedretti and Nazir (2011) focuses on STSE education from the perspective of ethically infused science (please see Table 3.1 above). Pedretti and Nazir (2011) comment that, “The focus is on enhancing student understanding and/or decision making about SSIs\(^{10}\) through an explicit consideration of ethics and moral reasoning.” They argue that this current offers many connections to the promotion of democratic principles and citizenship. Pedretti and Nazir (2011) state,

> The overall aim of science education here seems to be the promotion of citizenship and civic responsibility through the transaction of ideas. Activities within this current tend to target students’ moral and emotional identities to stimulate cognitive and moral development. As such, the dominant approaches are affective, moral, logical, and critical. (p. 614)

This approach may echo Levinson’s (2010) deliberative, praxis or dissent and conflict framework categories (see Table 3.2), since students are actively using their situated knowledge surrounding the presentation of the scientific concept and also Hodson’s

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\(^9\) Chalk River Laboratories refers to a nuclear research facility in Deep River, Ontario (see: [https://en.wikipedia.org/wiki/Chalk_River_Laboratories](https://en.wikipedia.org/wiki/Chalk_River_Laboratories) for more information).

\(^{10}\) SSIs refer to socio-scientific issues.
(2003) pedagogical level,

...Engaging in Sociopolitical Action: acquiring the capacity and commitment to take appropriate, responsible and effective action on matters of social, economic, environmental and moral-ethical concern. (p. 658)

The final STS[E] educational themes mapped out by Pedretti and Nazir (2011) are the sociocultural and socio-ecojustice currents, which also may reflect aspects of Levinson’s (2010) dissent and conflict citizenship goals and objectives (please see Table 3.2 above). The sociocultural and socio-ecojustice currents explore science in the context of culture that may help to alleviate some of the concerns that science favours a white-male and predominately Western focus (Pedretti & Nazir, 2011). They cite an example where astronomy may be taught from a cultural lens where various non-Western perspectives could be explored. I enjoyed reading this example as I have done a similar activity with a past science class. They wrote research reports about global and cultural astronomical perspectives. Pedretti and Nazir (2011) assert that students may benefit from this approach as it is more inclusive. These approaches seem to place scientific knowledge in context and may enact a science education as praxis approach to STS[E] (Levinson, 2010). The socio-ecojustice current focuses on the infusion of political and economic literacy in conjunction with scientific topics. Pedretti and Nazir (2011) characterize this STSE current as, “the dominant pedagogical approaches are creative, affective, reflexive, critical, place based, and experiential” (p. 617). Learning opportunities enacted by science teachers often take the form of “…developing action plans, changing their own habits, educating others, lobbying for change, raising funds, planting trees, and litter cleanups” (Pedretti & Nazir, 2011, p. 618). The presentation of science in this vein could support the dissent and conflict category of democratic participation (Levinson, 2010) as the science knowledge is placed in a more explicit social and political context (please see Table 3.2).

The socio-political framing of STS[E] issues may be problematic for some educators as activities may, “navigate the fine line between indoctrination and empowerment” (p. 618). Winton (2010) reminds us that educators make many choices regarding how they might decide to enact policy, that may apply to policy about STS[E].
educational initiatives, where she states that,

In education, policy decisions are continually made by principals, teachers and students as they go about their work (Ozga, 2000). Rather than simply implementers of others’ policy decisions, actors at all levels of the education system make and remake policy in light of their local contexts, beliefs, knowledge, experience and needs (Ball, 1994; Bell & Stevenson, 2006; Bowe et al., 1992). (pp. 87-88)

Choices and decision-making at schools and in classrooms are always arguably ‘political,’ including what approaches a science educator might choose to explore or not explore regarding STS[E] topics or issues even if a person chooses to appear to be, ‘apolitical’. Winton and Gonzalez (2014) claim that,

Public education is inherently political because it involves making decisions about how to organize schools, what knowledge children study, and which goals are pursued. (p. 123)

Science knowledge co-constructions that might occur when educators utilize a dissent or socio-ecojustice approach could arguably be linked to aspects of political competency and citizenship objectives. An example of how this might look in practice could be Bencze’s STEPWISE framework and action project. Student learning in the STEPWISE approach is centred around student-directed projects involving SSIs and problematic STSE issues where students participate in an inquiry-based apprenticeship and then engage in a research-informed and negotiated action about their studied topic(s) (e.g., making a video about a problematic consumer product such as foundation makeup as described on the STEPWISE website).

Steele (2014) presents an argument for inclusion of a seventh current devoted exclusively to the environment (i.e., she also acknowledges that the environment is represented in several of Pedretti & Nazir’s (2011) currents). She raises the point that, in many cases, studies of environmental education (EE) are restricted to the elementary grades and that less emphasis has been placed on looking at the interface between STS[E] and EE in the secondary panel.

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11 For more information about the STEPWISE framework please see: [http://webspace.oise.utoronto.ca/~benczela/STEPWISE_Framework.html#ON_Framework](http://webspace.oise.utoronto.ca/~benczela/STEPWISE_Framework.html#ON_Framework)
Steele (2014) cites the Ontario curriculum policy document, Acting Today, Shaping Tomorrow: A policy framework for environmental education in Ontario schools (i.e., this supports the inclusion of EE as a cross-disciplinary initiative) as a bridging agent to support incorporation of EE in STS[E]. She presents the following quote from the Ontario science curriculum expectations to illustrate this connection between EE and STS[E] here:

The increased emphasis on relating science to technology, society, and the environment (STSE) within this curriculum document provides numerous opportunities for teachers to integrate environmental education effectively into the curriculum. The STSE expectations provide meaningful contexts for applying what has been learned about the environment, for thinking critically about issues related to the environment, and for considering personal action that can be taken to protect the environment. (OME, 2008, p. 36). (p. 241)

Steele (2014) conducted research with two teachers to explore this connection between EE and STSE using both Pedretti and Nazir’s (2011) currents and Sauvé’s (2005) framework depicting themes in EE. Sauvé’s (2005) framework for EE focuses on the following 15 currents that are associated with environmental education that focus on: naturalist; conservationist/resourcist; problem-solving; systemic; scientific; humanistic/mesological; value-centred; holistic; bioregionalist; praxic; socially critical; feminist; ethnographic; eco-education; sustainable development/sustainability (pp. 33-34). Steele (2014) found that both the EE and STS[E] frameworks were useful in analyzing the teachers’ science lessons. She states,

For example, there are overlaps/similarities in the lessons between the EE scientific current and the STSE logical reasoning current in terms of empirical data collection and analysis; there are obvious enactment similarities between the value-centered currents of both frameworks; the enactment of EE bioregionalist and sustainability currents bear resemblance to those of the STSE sociocultural current in that all three address the need for context as necessary for understanding and working toward sustainability. It could be claimed that for the purposes of lesson analysis, both frameworks prove functional. (p. 244)

After Steele (2014) had explored both frameworks in terms of their analytical abilities when examining classroom pedagogical practices, she commented that,
Though the analysis confirms that EE had been addressed in the science program and had been provided a context in the themed lessons about food, using the EE framework to analyze secondary science lessons in detail is most likely misguided. The EE framework is a compendium that identifies broad strokes in EE; its greater usefulness lies in analyzing programs or courses, not specific lessons. (p. 245)

This might suggest that Sauvé’s (2005) currents may be more useful to explore a curriculum or policy document as opposed to using her framework to categorize individual lesson plans.

3.3 Other Scholarly Associations with STS[E] Education

The science-technology-society (STS) movement in science education has not remained static and has adapted different characteristics and practices, at given moments and also in various locales. There are many associated labels that may indicate various scholarly stances on STS[E] education and may be indicative of these diversified characteristics and global perspectives. For example, in Aikenhead’s (2005) historical overview, he details various labels linked to STS[E] education in different locales. Some of these global STS[E] labels discussed in Aikenhead (2005) include: “science-technology-citizenship” (Kolsto, 2001; Solomon & Thomas, 1999 in Aikenhead, 2005), “nature-technology-society” (Andersson, 2000), “science for public understanding” (Eijkelhof & Kapteijn, 2000; Osborne et al., 2003 in Aikenhead, 2005), “citizen science” (Cross et al., 2000; Irwin, 1995; Jenkins, 1999 in Aikenhead, 2005) and “functional scientific literacy” (Ryder, 2001 in Aikenhead, 2005).

Another significant scholarly area that seems to be associated with STS[E], would be socio-scientific issues (SSIs). The SSI (socio-scientific issue) movement in science education has some characteristics that differentiate it from the earlier STS movement. Distilling a singular definition of what socio-scientific issues may be or look like in practice is quite challenging. Sadler and Zeidler (2005) claim that socio-scientific issues (SSIs) are the “…processes of science and create social debate or controversy” (p. 112). Additionally, Forbes and Davis (2007) offer the following conception of SSIs:
Socioscientific issues are those that exist at the intersection between science and the broader social context in which the products and processes of science are situated (e.g., stem cell research, evolution, climate change). They are typically part of public discourse, contentious in nature, and require certain sets of skills and abilities from those engaged in reasoning and argumentation about them. (p. 829)

Topeu, Sadler and Yılmaz-Tuzun (2010) claim that, “SSI represent ill-structured problems that lack clear-cut solutions” (p. 2476). Bencze and Sperling (2012) offer the following perspective regarding SSIs, “Although there is no widely accepted definition of SSIs, we suggest that they may refer to disputes about the merits of relationships among fields of science and technology and societies and environments (p. 62).” It appears that a commonality among these conceptualizations is that SSIs involve debate and an in-depth awareness of how science might interact with societies, fields of technology and environments.

SSI education seems to differ from STS and STSE educational approaches to science in a few significant ways. Zeidler, Sadler, Simmons and Howes (2005) comment that STS education tends to examine,

…the impact of decisions in science and technology on society, it does not mandate explicit attention to the ethical issues contained within choices about means and ends, nor does it consider the moral or character development of students. (p. 359)

Zeidler et al. (2005) further differentiate between STS and SSI approaches in stating,

Whereas the overarching purpose of the STS approach is to increase student interest in science by placing science content learning in a societal context, SSI education aims to stimulate and promote individual intellectual development in morality and ethics. (p. 360)

They contend that SSI is a pedagogical strategy whereas STS education focuses on situating science in context. Zeidler et al. (2005) offer the following framework to illustrate areas of teaching importance regarding socioscientific issues to enhance “a student’s personal intellectual development” (p. 361):

1. nature of science issues,
2. classroom discourse issues,
3. cultural issues, and
4. case-based issues. (p. 361)
Zeidler et al. (2005) feel that careful consideration of the intersection between science and societal issues used to make thoughtful decisions may foster “functional scientific literacy” (p. 372).

Another lens associated with STS, SSI and STSE initiatives would be the field of ‘socially acute questions’ (SAQ). Jean Simonneaux and Alain Legardex (2010) describe socially acute questions as “a question which is acute in society, in background knowledge and in knowledge taught” (p. 24). Additionally, they state that, “SAQs are often “hot questions” because they have not yet been backed up or stabilized from a scientific point of view” (p. 25). They feel that examining these acute questions will, “give priority to interdisciplinary, scientific and ethical reasoning” (p. 24).

Future Studies is another focus in science education that may be connected with socioscientific issues (Pedretti & Nazir, 2011). Lloyd and Wallace (2004) describe ‘futurists’ where they state, “Futurists clarify goals and values, analyse and interpret the recent past and the present, explore projections of current trends, and carry out systematic studies of possible, probable and preferable futures” (p. 140). This is an interesting way to frame science education as it may enable students to project future alternatives and explore ways to improve their lives and their environment. They assert that, “Futurists explore alternative futures in order to assist people in choosing and creating the most desirable future” (p. 140).

### 3.4 Some Potential Challenges Associated with STS[E] Education

Although STS[E] is currently at the forefront in the Ontario science curriculum, it may still go unaddressed in science classrooms for a number of complex reasons such as a lack of understanding about what STS[E] can be, limited professional development and other resources to support implementation, time challenges, assessment and teacher identity.

Pedretti and Bellomo’s (2013) work with 24 teachers of varying experience levels in the context of a professional learning network may offer insights about educator perspectives on STS[E] and also information about what may be implemented in science classrooms regarding STS[E] curriculum. There seems to be a lot of confusion regarding the meaning of STS[E] education, perhaps not surprisingly as this is a complex and
multi-faceted disciplinary integration. Pedretti and Bellomo (2013) found that regarding teacher perspectives and interpretations of STS[E] education that:

…the majority of participants did not demonstrate a comprehensive understanding of STSE education—responses were generally vague and lacking in detail. Few participants wrote or talked about STSE and its relationship to agency or politicization at the beginning of the PLC. However, analyses of data from the latter part of the project revealed some shifting views and perceptions of STSE education that went beyond simple connections and interfaces across science and society. Latter views began to acknowledge values, advocacy, and/or change as part of STSE education. (p. 424)

It seems that practitioners of science may lack a clear understanding of what STS[E] education may look like in action or what the end result of this type of education could/should be used for (i.e., not that there is a singular approach or definition associated with STS[E]).

Advocacy or associations with Pedretti and Nazir’s (2011) socio-ecojustice STS[E] current may be a more challenging approach for some educators. Pedretti and Bellomo (2013) affirm that with professional development about STS[E] advocacy and agency were included as part of the teachers’ conceptions of STSE education. They state that, “Furthermore, STSE orientations need to be explicitly explored, which means that teachers need time, resources, critical readings, and support” (p. 432). Pedretti and Bellomo (2013) also reported that although there is a large body of literature which promotes activism and agency in science that they found that, “there was some resistance to the notion of action and even more so to the idea of politicization within the science classroom setting” (p. 432). This is an interesting consideration regarding the implementation of STS[E] and whether resistance using these approaches tends to vary with experience or perhaps with grade level.

MacLeod’s (2012) work with physics preservice teachers may offer some additional insights regarding the various teaching challenges surrounding STS[E] from those new to the teaching profession. She states,
The main challenge of an STSE-oriented physics curriculum, which was voiced by the pre-service teachers, was primarily logistical in nature and resources were their main concern, i.e., the preparation time for lessons, having adequate resources. They also commented on the stigma attached to teaching physics (that it was all formulas and textbook problems to solve) so they felt that others (staff, administration, parents, and students) might have a difficult time understanding why physics was no longer being taught ‘traditionally.’ (p. 160)

She comments and connects to the literature regarding the apprehension surrounding a ‘lack of resources’ through her citations of Aikenhead (2005), Pedretti et al. (2008), and Hughes (2000). Less experienced teachers may struggle sufficiently with science content alone and wonder how to approach STSE content adequately without resources to support their lessons.

Nashon, Nielsen and Petrina (2008) echo these challenges regarding the implementation of the history and philosophy of science (HPS) in physics classrooms where they comment on their work with preservice teachers. They state,

These teachers expressed concern over time constraints, low student interest, amount of examinable material, limits to teacher knowledge and challenges to everyone’s notion of what counts as science. These teachers saw curricular constraints in terms of time allowable for classroom instruction:

…fitting extra material into curriculum (will have to change things rather than add or subtract). When students, parents, teachers and administrators hold strong beliefs in their understanding of what counts as physics, then any change to what is taught is seen as contentious. (p. 397)

Assessment is another challenge that MacLeod (2012) discusses regarding the implementation of STS[E]. Assessment strategies are a complex undertaking in any educational field and for educators of all experience levels. She states that, “tensions or challenges emerged as they considered how they would ‘evaluate’ students’ work” (p. 166) and that, “pre-service teachers were keen on the notion of teaching values education in physics yet were unsure of how to assess work that is subjective” (p. 155).

A study conducted by Pedretti et al. (2008) offers some insights about these tensions that may be present in STS[E] education that support MacLeod’s (2012) findings and also offer ways to potentially overcome some of these complex challenges. Pedretti et al. (2008) studied preservice science teachers and their perspectives on STS[E] educational initiatives. They noted a number of interesting patterns such as the students’
enthusiasm regarding STS[E] and their perceptions regarding the reality of implementing such a curricular initiative. Pedretti et al. (2008) acknowledge that teacher identity may play a role as to how STS[E] is taught. For example, if a teacher feels that a pedagogical approach such as a debate belongs in a history as opposed to science, the educator may be faced with, “thorny problems of practice, and challenges science teachers’ professional identities” (p. 943). They also noted the following emergent themes regarding STSE in preservice education:

Although teacher candidates expressed confidence and motivation, they also expressed decreased likelihood to teach STSE perspectives. Particular tensions or problems of practice consistently emerged across multiple data sources that helped explain this paradox. Tensions included issues related to: (1) autonomy and control, (2) support and belonging, (3) expertise and negotiating curriculum, (4) politicization and action, and (5) biases and ideological bents. (Pedretti et al., 2008, p. 948-949)

STS[E] education encompasses many approaches and clearly there are some challenges to overcome regarding implementation as explored in this chapter section. Another important aspect of STS[E] education and possibly overcoming some of these challenges is to consider the presentation of this curricular segment in curriculum documents. There are particular styles of discourse or ‘discussions’ associated with science, politics and many other areas that may influence how science and technology manifest in the classroom which could extend to STS[E] education. The next chapter delves into some exploration of science discourses and then presents some background on both document and discourse analysis which are central to the presentation of my study findings in the case study chapters.
Chapter Four: Methodology

This chapter explores relevant perspectives on methodologies pertaining to this study and describes the specific methods that I have used to construct the three provincial case studies that follow. Ethical considerations are briefly described followed by a segment that closes the chapter on case study format and scope.

4.1 Some Theoretical Paradigms and Perspectives

Qualitative and quantitative approaches encompass techniques that may enable the exploration of a variety of research questions depending upon the context. Qualitative research approaches may be most beneficial to explore my aforementioned research questions as I am interested in examining STS[E] science curriculum in a more holistic fashion across three provincial curricula. In the following paragraphs I will differentiate between these approaches and present my rationale as to why qualitative methods may be more suitable for this study.

The field of qualitative research and its associated approaches is quite broad and complex. Denzin and Lincoln (2011) acknowledge the difficulties inherent in attempting to define the field of qualitative research and state,

Qualitative research is a situated activity that locates the observer in the world. Qualitative research consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. (p. 3)

This contrasts with approaches that are quantitative in nature. Hoepfl (1997) characterizes quantitative research as, “…experimental methods and quantitative measures to test hypothetical generalizations” (pp. 47-48). She comments here that, “…quantitative researchers seek causal determination, prediction, and generalization of findings…” (p. 48).

Qualitative and quantitative methods both seek to explore and describe observations. Merriam (2009) offers the following distinction between qualitative and quantitative research where she states,
Rather than determining cause and effect, predicting, or describing the distribution of some attribute among a population, we might be interested in uncovering the meaning of a phenomenon for those involved. Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences. (p. 5)

Depending upon the research study and the questions asked, qualitative, quantitative or a blend of these approaches may be appropriate. Hoepfl (1997) draws from the work of Strauss and Corbin (1990) to suggest that qualitative approaches may be appropriate to use if there is limited information available about the topic in question, if new insights regarding the topic are desired or if it would be difficult to describe the results of a study using statistical measurements. She states that in qualitative approaches, “research problems tend to be framed as open-ended questions that will support discovery of new information” (p. 49).

Based on these descriptions and perspectives, I feel that quantitative data and analysis strictly in the form of statistical measurements and reporting may have little to offer this exploration of STS[E] discourses represented in the science curriculum as situated in varying political climates (i.e., with the exception of some statistical assessments such as ‘counting’ rather than statistical analyses). Qualitative approaches would enable a more in-depth description and analysis of the documents. Hoepfl (1997) states,

The ability of qualitative data to more fully describe a phenomenon is an important consideration not only from the researcher’s perspective but from the reader’s perspective as well. “If you want people to understand better than they otherwise might, provide them information in the form in which they experience it.” (Lincoln & Guba, 1985, p. 120 in Hoepfl, 1997, p. 49)

Mathematical modeling certainly has its place in research contexts and can be informative and useful, but I do not feel that quantitative approaches in the form of strict statistical analyses would be beneficial here to describe the details of my data collection (i.e., excluding the use of some basic numerical strategies to illustrate a selection of points).
4.2 Philosophical Orientations

Qualitative research has many philosophical orientations. Denzin and Lincoln (2011) state that, “all research is interpretive: guided by a set of beliefs and feelings about the world and how it should be understood and studied” (p. 13). I have reflected on Lather’s (as cited in Merriam, 2009) descriptions of the various epistemological perspectives and carefully thought about the positivist/post-positivist, interpretative, critical and postmodern/post-structural domains and where I potentially fit and also where this research would perhaps be situated. I was drawn to different aspects of the interpretative, critical and post-structural orientations since these perspectives differ from a positivist perspective (Merriam, 2009).

The post-structural perspective is associated with deconstruction, questioning dichotomies and re-thinking our notions of reality and the idea that there are “multiple truths” (Merriam, 2009, p. 10). MacLure (2003) discusses post-structuralism here in stating,

Poststructuralist theorists reject the idea of universal truth and objective knowledge, delivered through the proper use of reason, and assert, on the contrary, that truths are always partial and knowledge is always ‘situated’ – that is, produced by and for particular interests, in particular circumstances, at particular times. Poststructuralist work also challenges belief in progress as the inevitable result of scientific and philosophical rationality. (pp. 174-175)

Merriam (2009) points out that post-structural orientations may also be combined with other approaches such as “feminist, critical theory, and queer approaches” (p. 10) as these viewpoints offer various lenses to glean insights about social constructs.

I was drawn to aspects of the critical paradigm where discussions centre on “multiple realities, situated in political, social, cultural contexts (one reality is privileged)” (Merriam, 2009, p. 11). These themes may be important to my research as curriculum and political documents may privilege certain stakeholder viewpoints and perspectives.

The interpretativist perspective seeks to “describe, understand, interpret” and is also associated with “multiple realities and is context-bound” (Merriam, 2009, p. 11). Merriam (2009) discusses how interpretive research is the most typical approach used in qualitative research and that it assumes that reality is a socially constructed event. She
states that, “Researchers do not “find” knowledge, they construct it” (p. 9). Merriam (2009) discusses how the terms ‘constructivism’ and ‘interpretativism’ are often used interchangeably. She cites Creswell (2007) to aid in the understanding of this association:

In this worldview, individuals seek understanding of the world in which they live and work. They develop subjective meanings of their experiences…These meanings are varied and multiple, leading the researcher to look for the complexity of views…Often these subjective meanings are negotiated socially and historically. In other words, they are not simply imprinted on individuals but are formed through interaction with others (hence social constructivism) and through historical and cultural norms that operate in individuals’ lives. (pp. 20-21)

According to Denzin and Lincoln (2011), the constructivist paradigm assumes the following perspectives:

…a relativist ontology (there are multiple realities), a subjectivist epistemology (knower and respondent co-create understandings), and a naturalistic (in the natural world) set of methodological procedures. (p. 13)

I feel that this thesis exploration may be aligned with an interpretivist approach to research with some potential linkages to the critical perspective (i.e., as socio-political explorations are often linked to discussions of power and privilege) and influences from post-structuralism (e.g., “Power, knowledge, truth and subjectivity are interlinked and produced in/through discourse”; “Language is never innocent” (MacLure, 2003, p. 181)). These approaches may support my explorations of the rather complex area of curriculum development in the area of STS[E] and socio-scientific education where the co-construction of outcomes/expectations may emerge after stakeholder discussions and debate.

4.3 A Case Study Approach

Merriam (2009) defines a case study as, “an in-depth description and analysis of a bounded system” (p. 40). She also draws from the work of Yin (2008), who offers the following description of a case study:

A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. (p. 18 as cited by Merriam, 2009, p. 40)
A bounded system refers to the notion that a case study examines, “…a single entity, a unit around which there are boundaries” (Merriam, 2009, p. 40). In the context of this study, the bounded system would refer to each province. Merriam cites Creswell’s (2007) definition of case study where she quotes,

…case study research is a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual material, and documents and reports), and reports a case description and case-based themes. (Creswell, 2007, p. 73 as cited by Merriam, 2009, p. 43)

It should also be noted that case studies can be used for quantitative studies in addition to qualitative.

The case study approach has several unique and distinguishing features. Merriam (2009) suggests that case studies are “particularistic, descriptive and heuristic” (p. 43). The ‘particularistic’ refers to how a case study focuses on a specific situation or occurrence. The ‘descriptive’ nature connects to the presentation of “rich, ‘thick’ descriptions of the phenomenon under study” (Merriam, 2009, p. 43). Heuristic pertains to how the case study connects to the “…reader’s understanding of the phenomenon under study” (p. 44). Merriam (2009) draws from the work of Stake (1981) to provide some additional characteristics of the case study:

- More concrete—case study knowledge resonates with our own experience because it is more vivid, concrete, and sensory than abstract.
- More contextual—our experiences are rooted in context, as is knowledge in case studies. This knowledge is distinguishable from the abstract, formal knowledge derived from other research designs.
- More developed by reader interpretation—readers bring to a case study their own experiences and understanding which lead to generalizations when new data for the case are added to old data
- Based more on reference populations determined by the reader—in generalizing as described above, readers have some population in mind Thus, unlike traditional research, the reader participates in extending generalization to reference populations. (Stake, 1981, pp. 35-36 as cited by Merriam, 2009, pp. 44-45)

There are several classifications of the ‘case study,’ such as historical, observational, intrinsic, instrumental and multisite (Merriam, 2009). Since I am exploring three unique provinces for this study, I feel it would most closely align with the multisite,
collective or comparative style (Merriam, 2009). The comparative case study is characterized by, “collecting and analyzing data from several cases” (Merriam, 2009, p. 49). Through the inclusion of three case studies, arguably I will have greater variety that may lead to a more compelling interpretation of the data (Merriam, 2009).

The case study approach has several limitations. Researcher time and money may serve as impediments to developing an in-depth case (Merriam, 2009). In addition to these factors, a lack of concrete guidelines surrounding how to present the finished case study and researcher-experience with how to interview participants may limit this approach (Merriam, 2009). Merriam (2009) cites Guba and Lincoln (1981) regarding the “…unusual problems of ethics. An unethical case writer could so select from among available data that virtually anything he wished could be illustrated” (p. 63). She also cites concerns regarding generalizability. As I will be examining specific provincial environments, it may be that certain aspects are not generalizable, however, it does not mean that the case study is any less important or valid. Educators or policy-makers may be able to glean additional perspectives about STS[E] education that could be explored in curriculum revision or construction and pedagogical considerations. Flyvbjerg (2011) offers a summary of some of the strengths and weaknesses associated with using the case study approach:

Strengths: depth, high conceptual validity, understanding of context and process, understanding of what causes a phenomenon, linking causes and outcomes, fostering new hypotheses and new research questions.

Weaknesses: selection bias may overstate or understate relationships, weak understanding of occurrence in population of phenomena under study, statistical significance often unknown or unclear. (p. 314)

Based on these scholarly ideas and discussions, the case study approach may be an appropriate way to explore and present my research findings. I do not feel that selection bias would be an issue for this type of work (i.e. although, the selection of additional provincial representatives could further substantiate findings). Statistical analysis (i.e., exclusive of simple numerical representations and presentations) would not render additional insights into these distinctive cases for the purposes of this study; so arguably, statistical significance would not be a consideration for this thesis.
4.4 Case Study Inclusion/Exclusion Criteria

I selected three Canadian provinces to explore my aforementioned research questions through the use of a case study approach. My inclusion criteria for the selection consisted of the following considerations regarding provincial representation:

Case Inclusion or Selection Guiding Criteria
- Three Canadian provinces for building case studies (i.e., as it would be more representative than selecting two provinces for comparison).
- The provinces selected must differ in terms of their provincial political representation at the time of tenth-grade science curriculum construction and/or implementation.
- Provinces selected must use a science curriculum that was developed by the same province (i.e., not comprised of a multi-province initiative such as found in the Atlantic region).

4.5 Methods of Data Collection: Document Collection

Documents include an assortment of various types of physical data such as “official records, letters, newspaper accounts, diaries…” (Merriam, 2009, p. 140). Merriam (2009) indicates, “documents are, in fact, a ready-made source of data easily accessible to the imaginative and resourceful investigator” (p. 139).

To address my outlined research questions, the following publically accessible documents were collected for provincial case study construction and analysis:

Documents used to explore the STS[E] segments of the tenth-grade science curricula:

- Provincial Ministry of Education websites: (e.g., http://www.edu.gov.on.ca/eng/; https://education.alberta.ca/; http://www.edu.gov.mb.ca/12)

12 These websites represent the main provincial Ministry of Education websites and have many linkages to other documents that were explored in this thesis that will be detailed in each provincial case study.
Documents used in the exploration of provincial political climate:

- Provincial political party platforms (i.e. Alberta, Ontario, Manitoba):
  - Progressive Conservative (PC) Party of Alberta’s election platform (2012)
  - New Democratic Party (NDP) of Manitoba’s election platform (2011)

- Provincial Speeches from the Throne¹³ (i.e., Alberta, Ontario, Manitoba):
  - Alberta Speech from the Throne (November 17, 2014)
  - Ontario Speech from the Throne (November 29, 2007)
  - Manitoba Speech from the Throne (1999)¹⁴

- Provincial climate change action plans (i.e., Alberta, Ontario, Manitoba):
  - Alberta’s 2008 Climate Change Strategy: Responsibility/Leadership/Action
  - Go Green: Ontario’s Action Plan on Climate Change (2007)
  - Manitoba’s Next Steps: 2008 Action on Climate Change

I have based these selections on documents that appear to be ontologically similar within each category (i.e., although there may be some inconsistencies among them).

Because I collected data from multiple sources at the political and curricular levels, this may aid in the credibility and validity of this research as in alignment with the interpretive paradigm as previously described (Merriam, 2009). Uses of different and selected analytical techniques, such as document and discourse analysis, may further support the validity of this proposed research, since these approaches may allow different themes and considerations to emerge from the data sources. Additionally, the data from each province has been explored using three different theoretical frameworks (i.e., Levinson, 2011; Pedretti & Nazir, 2010 and Krathwohl, 2002) to offer varying perspectives and to strengthen the credibility of the findings to be presented via theoretical triangulation (Denzin, 1970, as cited by Bryman, 2015).

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¹³ Speeches from the Throne or ‘Throne Speeches’ are addresses to the provincial members of parliament that outline political agendas for a given period of time (see also: https://en.wikipedia.org/wiki/Speech_from_the_throne).

¹⁴ This throne speech was selected as it would, in part, perhaps represent the governmental priorities of a newly elected party just prior to the release of the Manitoba science curriculum in 2001.
4.6 My Approaches to Analysis

4.6.1 Document Analysis

Documents and texts summarize perspectives regarding what is important for people and societies at a given time. Perakyla and Ruusuvuori (2011) comment that many qualitative researchers who incorporate texts and documents into their analyses do not follow a set protocol regarding how to proceed. They suggest that, “by reading and rereading their empirical materials, they try to pin down their key themes and, thereby, to draw a picture of the presuppositions and meanings that constitute the cultural world of which the textual material is a specimen” (p. 530). They further assert that,

…an informal approach may, in many cases, be the best choice as a method in research focusing on written texts. Especially in research designs where the qualitative text analysis is not at the core of the research but instead is in a subsidiary or complementary role… (p. 530)

For this study document analysis has been used in conjunction with a number of other analytical approaches (e.g., discourse analysis). Rapley (2007) offers some considerations when conducting analyses of documents and analyses of discourse (i.e., he notes that this is not to be viewed as a list of musts, but rather a compilation of potential actions to guide the process) which I have used in my study. He suggests the following overview in the process of discourse analysis and document analysis:

1. Formulate your initial research questions.
2. Start a research diary.
3. Find possible sources of material and begin to generate an archive.
4. Transcribe the texts in some detail.
5. Skeptically read and interrogate the texts.
7. Analyze through (a) examining regularity and variability in the data and (b) forming tentative findings.
8. Check ‘validity’ and rigour through (a) deviant case analysis, (b) comparing your findings to previous work and (c) showing other people your data and discussing your findings with them.
9. Write up. (pp. 130-131)

The coding segment of this process identified by Rapley (2007) is quite complex and perhaps warrants a bit of detail regarding some possible approaches. Saldana (2013) defines a ‘code’ as, “…most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of
language-based or visual data “(p. 3). Saldana (2013) cites Charmaz’s (2001) description here as, “… coding as the “critical link” between data collection and their explanation of meaning” (p. 3). Saldana (2013) provides a useful schematic to depict the ‘messy’ process of moving from coded data to theory generation where codes are assigned (i.e., if appropriate for the research study or topic); categories are generated which then potentially lead into thematic development and then the development of various assertions or theory (i.e., based on Saldana’s (2013) diagram a movement from the “particular to the general” regarding coding of data, p. 13). I have also used the Wordle™ tool as one approach to aid in these coding processes such as described here by Saldana (2013):

Wordle also provides a detailed word count of your entered text, but the program does not analyze data beyond this descriptive level. Nevertheless, this initial data entry gives you a “first-draft” visual look of your texts’ most salient words and thus potential codes and categories. (p. 199)

4.6.2 Discourse Analysis

Discourse analysis (DA) will be somewhat more ‘loosely’ applied and used to further explore the texts and themes and patterns present in these documents as there is an array of analytical tools being utilized in this study. Discourse analysis may offer both finer and coarser grained tools of analysis to complement an initial document analysis to establish and explore various themes that may emerge from the selected documents in conjunction with the application of various theoretical frameworks. I tended to focus my efforts on the ‘coarser’ aspects of discourse analysis as I did not conduct in-depth grammatical analysis work of the various sentence structures and clauses given my use of an array of techniques (i.e., with the exception of some verb analysis). Bloom’s revised taxonomy\textsuperscript{15} (Krathwohl, 2002), Levinson’s (2010) framework depicting linkages among science education and citizenship and Pedretti and Nazir’s (2011) STS\textsuperscript{E} ‘currents’ framework were applied to the STS\textsuperscript{E} outcomes or expectations from each province to explore possible areas of emphasis and interesting patterns.

\textsuperscript{15} Bloom’s revised taxonomy (Krathwohl, 2002) explores various cognitive learning domains through the use of verbs and categorization of different types of knowledge (i.e., factual, conceptual, procedural, metacognitive). See also: https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/#2001 for a brief description.
There are many ways to approach discourse analysis as previously described. Discourse analysis refers to a wide range of varying techniques to investigate written and ‘spoken’ texts (Perakyla & Ruusuvuori, 2011, p. 530). Gee (2011) offers many techniques to conduct a discourse analysis of various texts by combining coarse (i.e., macro-scale) and finer (i.e., micro-scale) grain tools to explore additional layers of understanding that may emerge from the curricular and political documents (please see Table 4.1). The following chart outlines some of Gee’s (2011) approaches or ‘tools’ that have been used to analyze the aforementioned documents:

<table>
<thead>
<tr>
<th>Selected Tools</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The Fill in Tool”</td>
<td>What is missing in the description to achieve full clarity of understanding for the reader or listener?</td>
</tr>
<tr>
<td>“The Making Strange Tool”</td>
<td>Pretend that you are an ‘alien’ visitor to the conversation. What are the underlying assumptions that clarify the conversation for the listener/reader?</td>
</tr>
<tr>
<td>“The Subject Tool”</td>
<td>Why is a sentence organized in a particular way regarding the placement of the subject and predicate?</td>
</tr>
<tr>
<td>“The Intonation Tool”</td>
<td>What does the speaker’s intonation contour tell the audience about importance and significance of the topic?</td>
</tr>
<tr>
<td>“The Vocabulary Tool”</td>
<td>Is the communication made up primarily of Germanic or Latinate words? Why is one type or a blending selected?</td>
</tr>
<tr>
<td>“The Why This Way and Not That Way Tool”</td>
<td>Why was the communication designed a particular way? What other ways could it be phrased?</td>
</tr>
<tr>
<td>“The Significance Building Tool”</td>
<td>How are vocabulary choices and grammatical stances selected to make certain items more important vs. less important</td>
</tr>
<tr>
<td>“The Politics Building Tool”</td>
<td>For the selected text, analyze how the vocabulary and grammar present are constructing social goods and how/to whom these goods are distributed</td>
</tr>
<tr>
<td>“The Situated Meaning Tool”</td>
<td>What are the meanings of the vocabulary selected? Why were these words chosen?</td>
</tr>
<tr>
<td>“The Figured Worlds Tool”</td>
<td>What figured worlds or stories are the selected wordings promoting to the reader?</td>
</tr>
<tr>
<td>“The Intertextuality Tool”</td>
<td>How are other texts or wordings woven into the discussion?</td>
</tr>
</tbody>
</table>

From Gee (2011).

The work of Jaipal-Jamani (2014) and her presentation of a ‘transdisciplinary’ method of text interpretation may also intersect with some of the approaches presented here (i.e., although, my use of discourse analysis is a somewhat less stringent approach as it is being used in conjunction with other methods as aforementioned). She draws from a
number of scholars, including the work of Gee (2011) and suggests approaching discourse analysis from a number of perspectives such as the social structure and practices level/macro-level and the social event/linguistic level/micro-level.

4.7 Ethical Considerations

The use of publically available documents does not require ethics board approval, however, this study was submitted to the University of Toronto Ethical Review Board for approval because I was considering the use of interviews as a supplemental data source regarding the curriculum construction process in my research proposal phase.

4.8 Case Study Format and Scope

Each case study presented in this thesis is bounded by provincial jurisdiction. Some features of the STS[E] curriculum will be portrayed using theoretical frameworks (i.e., Krathwohl, 2002; Levinson, 2010 and Pedretti & Nazir, 2011) and additional analysis work will be presented on the climate change or climate change associated units from each province to address my first research question focusing on explorations of the STS[E] curriculum. To address my second research question that examines some facets of political climate in each region, various documents have been explored such as provincial party platforms, provincial Speeches from the Throne and provincially generated climate change action plans. The case study presentations differ slightly due to the complexity of this analysis work and the differences across these regions that manifest in the STS[E] curriculum. A cross-case analysis chapter and some additional theoretical explorations will follow the three provincial case study chapters.
Chapter Five – Explorations of STS[E] Education in Alberta at the Tenth-Grade Level

I focused my explorations and efforts on the Alberta Science 10 Program of Studies 2005 (Revised 2014) to address my two central research questions:

1. What are some of the STS[E] discourses present in the tenth-grade in the provincial science curriculum documents?
2. What are some possible factors (e.g., provincial political representation) that may influence the curricular discourses present in tenth-grade STS[E] outcomes/expectations?

This section of my Alberta case study will begin with a general overview of some facets of the curriculum document, some exploration of the science, technology and society (STS[E]) and knowledge¹⁶ curriculum outcomes and then elaborate on Unit D: (i.e., beyond the ‘STS & Knowledge’ outcomes) as I found this unit to be of interest after conducting some exploratory and initial analysis, which is presented after my initial explorations of the ‘STS & Knowledge-based outcomes. I have intertwined some theoretical constructs and frameworks that I found interesting and helpful to explain some of the ideas that emerged from my analysis. I found Posner’s (2004) process of curriculum analysis to be a useful general guide when exploring the curriculum in conjunction with document analysis and discourse analysis (i.e., as described in my introduction).

I selected the following three frameworks to aid in my initial explorations of the Alberta Science 10 ‘STS and Knowledge’ outcomes: Bloom’s revised taxonomy (Krathwohl, 2002) to explore the verbs present in the curriculum (i.e., along with the use of Wordle™), Levinson’s (2010) framework depicting possibilities for citizenship and democratic participation in science education and Pedretti and Nazir’s (2011) STSE framework to explore their ‘currents’ in the curriculum.

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¹⁶ The Alberta Science 10 curriculum document fuses the STS outcomes with knowledge outcomes to make a STS & Knowledge category and also uses the ‘STS’ designation.
5.1 Some Organizational Features of the Alberta Curriculum

The Alberta Science 10 Program of Studies (Revised 2014) is 35 pages long. The document contains mainly black and white font with various figures depicting organizational schematics. There is no artwork present throughout the document and no reference is made to the authorship or contributors. The tenth-grade curriculum document begins with the presentation of an overview of some key ideas and objectives including schematics depicting the flow and organization of the material.

The foundational areas mapped out throughout the curriculum document (i.e., Science, Technology and Society; Knowledge; Skills and Attitudes, Alberta Science 10, 2005, p. 3) appear to mirror the Common Framework of Science Learning Outcomes K to 12, where STSE, Knowledge, Skills and Attitudes are all acknowledged as important facets of science education (i.e., may be associated with the concept of intertextuality as other texts and their influences are interwoven, Gee, 2011). The organization of the units seems to be diagrammatically hierarchal\(^{17}\) (i.e., perhaps related to descriptions provided by Heimer, 1969 as cited by Posner, 2004, p. 133); however, the specific outcomes appear to be spatially equivalent; perhaps suggesting to the reader relatively equal importance. Of note, when examining their curriculum organizational diagram and more specific unit outcomes, is the language used to distinguish outcomes such as the difference between “students will…” as indicated in Foundations 1 – 3, and the language used in Foundation 4 which states, “students will be encouraged to…” This could produce a dichotomy where sets of curricular outcomes differ in terms of significance to the reader of this document. The discourse associated with, “students will…” is perhaps stronger wording than stating, “students will be encouraged to…”

The Alberta Science 10 (Revised 2014) document is structured around the aforementioned foundational map where each unit begins with STS and Knowledge fused outcomes followed by Skills and Attitudes. The content is organized into the following four major units of study:

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\(^{17}\) Please see the Alberta Ministry of Education’s website for a detailed description found here: [http://www.learnalberta.ca/ProgramOfStudy.aspx?ProgramId=302812&lang=en#](http://www.learnalberta.ca/ProgramOfStudy.aspx?ProgramId=302812&lang=en#)
-Unit A: Energy and Matter in Chemical Change (Nature of Science Emphasis)

-Unit B: Energy Flow in Technological Systems (Science and Technology Emphasis)

-Unit C: Cycling of Matter in Living Systems (Nature of Science Emphasis)

-Unit D: Energy Flow in Global Systems (Social and Environmental Contexts Emphasis)

The word, ‘energy,’ appears frequently in these unit titles. The inclusion of various emphases in the curriculum (i.e., as indicated in the bracketed information following the unit title) may represent an intertextual linkage to the work of Roberts (1982) and his discussions of curriculum emphases that he described later as, “companion meanings” (Roberts, 1995). This appears to be similar to what is depicted in The Common Framework of Science Learning Outcomes K to 12 (1997) which also denotes a similar focus when discussing science, technology, society and the environment (STSE); however, the Common Framework document clearly includes the ‘E’ in its title, whereas the Alberta curriculum document uses the title, ‘STS & Knowledge.’ Each emphases focuses on a slightly different aspect of STS[E] curriculum as explained in the front matter of this document here:

Nature of Science Emphasis: In these units, student attention is focused on the processes by which scientific knowledge is developed and tested, and on the nature of the scientific knowledge itself. The skills emphasized in these units are the skills of scientific inquiry.

Science and Technology Emphasis: In these units, students seek solutions to practical problems by developing and testing prototypes, products and techniques to meet a given need. The skills emphasized are those of problem solving, in combination with the skills of scientific inquiry.

Social and Environmental Contexts Emphasis: In these units, student attention is focused on issues and decisions relating to how science and technology are applied. Skill emphasis is on the use of research and inquiry skills to inform the decision-making process; students seek and analyze information and consider a variety of perspectives (Alberta Science 10, 2005, p. 7).

From a discourse analysis perspective, the relative positioning of the units of study may symbolize order of importance affixed to each unit perhaps indicating that there is a priority focus on the first few units and less importance associated with the last unit that
focuses on Energy Flow in Global Systems. Also of note may be how practitioners choose to interpret this document and the order in which they teach the units of study. Sometimes, when educators teach curriculum, they will follow the order in which the units occur; which, in some cases, means that there is less time for one of the four units of study (i.e., this is based upon my personal practitioner experiences). This may occur with the last unit of study in a given curriculum.

5.2 Explorations of the STS Outcomes and Selected Framework Applications

All ‘STS & Knowledge’ outcomes across the various units in the Science 10 curriculum were analyzed for themes and patterns (i.e., because Alberta Science 10 merges the ‘STS & Knowledge’ outcomes into a single category). One tool used to help explore more general word patterning was Wordle™ (Saldana, 2013). From a discourse analysis perspective, I was interested in the presentation of various verbs used in the curricular outcomes as they are never ‘neutral’ (MacLure, 2003) and could produce various social goods associated with how people may interpret the curriculum (please see Table 6.1 below). Verb connections and associations might have connections and intersections with citizenship objectives. If we consider representative democracies versus participatory democracies and verb linkage, we might additionally consider what verb selections could mean in these contexts. For example, ‘create’ or ‘evaluate’ might have more linkage to participation whereas ‘understand’ could be associated with more of a representation. After exploring some of these patterns using Wordle™, I thought that Bloom’s revised taxonomy (Krathwohl, 2002) may offer some additional theoretical insights to further explore these verb patterns and some of my analysis using this framework follows (i.e., please see Appendix A for additional analysis).
TABLE 5.1: Wordle™ depiction highlighting the most commonly used verbs in the ‘STS & Knowledge’ curricular outcomes from each unit of study in the Alberta Science 10 (2005) curriculum.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Wordle™ to Illustrate Verbs Appearing Frequently in ‘STS &amp; Knowledge’ Outcomes</th>
<th>Commonly Occurring Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Energy &amp; Matter in Chemical Change (NOS Emphasis)</td>
<td>describe; identify; classify; predict; explain; describe</td>
<td>Identify; classify; predict; explain; describe</td>
</tr>
<tr>
<td>B: Energy Flow in Technological Systems (Science &amp; Technology Emphasis)</td>
<td>describe; define; analyze; explain; apply</td>
<td>Describe; define; analyze; explain; apply</td>
</tr>
<tr>
<td>C: Cycling of Matter in Living Systems (Nature of Science Emphasis)</td>
<td>describe; explain; investigate; compare; identify</td>
<td>Describe; explain; investigate; compare; identify</td>
</tr>
<tr>
<td>D: Energy Flow in Global Systems (Social and Environmental Emphasis)</td>
<td>describe; investigate; explain; identify; analyze</td>
<td>Describe; investigate; explain; identify; analyze</td>
</tr>
</tbody>
</table>

Across the units of study, commonly used verbs associated with the curricular outcomes were to describe, identify and explain (please see Table 5.1 above). The analysis of these ‘outcome verbs’ may also intersect with the work of Bloom, Engelhart,
Furst, Hill & Krathwohl (1956) and the revisions to the original Bloom’s taxonomy by Krathwohl (2002) where verbs are associated with various cognitive processes (i.e., remember, understand, apply, analyze, evaluate and create) and also allows for further classification of these processes under the headings of: Factual Knowledge, Conceptual Knowledge, Procedural Knowledge and Metacognitive Knowledge. It would appear that the verbs ‘describe, identify’ may connect with “conceptual knowledge” and the cognitive process dimensions of “understand” or “apply.” The verb, ‘explain’ may be associated more so with the conceptual knowledge dimension and the “apply” or perhaps, “analyze” cognitive process dimensions. The usage of outcomes associated with the verbs: ‘analyze, investigate, apply’ such as those emphasized in Unit D (please see Appendix A).

From my perspectives and my use of Bloom’s revised taxonomy (Krathwohl, 2002), the ‘STS & Knowledge’ outcomes in the tenth-grade science course appeared to span a wide range of cognitive processing domains and also knowledge dimensions. Many of the curricular outcomes across the units appeared to focus on understanding, analysis and evaluation (please see Appendix A). I did not feel that these outcomes tended to fit into the “create” dimension; however, this is based upon the written ‘STS & Knowledge’ outcomes and not how a practitioner might decide to interpret the curriculum outcomes, which of course can be a highly creative endeavor. Also, this analysis is limited to the ‘STS & Knowledge’ based written outcomes and is not to say that outcomes associated with the “create” dimension are absent from the curriculum.

*Explorations of the ‘STS & Knowledge’ Curriculum using Levinson’s (2010) and Pedretti & Nazir’s (2011) Frameworks*

I found it useful to consider the ‘STS & Knowledge’ curricular outcomes across each unit of study in terms of both Levinson’s (2010) framework categories and Pedretti & Nazir’s (2011) STSE currents and I also made note of several overlaps that may be present across frameworks. Levinson’s (2010) framework categories depicting various forms of democratic participation in science education was illuminating in terms of helping to paint an illustration of some aspects of possible citizenship framing of the ‘STS & Knowledge’-based outcomes whereas Pedretti & Nazir’s (2011) descriptions of
STSE currents were helpful to explore the various themes that seemed to flow through the Alberta Science 10 units. As previously described in my literature review, I saw some possible theoretical overlapping patterns across these frameworks that I wanted to explore using the curricular data. I decided to code and categorize each ‘STS & Knowledge’ outcome using both frameworks to determine if these overlaps were substantiated through the outcomes. In this process, I went through each outcome (i.e., both overall outcomes and specific outcomes) and assigned one of the four framework categories described by Levinson (2010). I then went back to my data and assigned each curriculum outcome a ‘current’ based on the work of Pedretti and Nazir (2011).

This coding process proved to be challenging as I noted that there were many overlapping areas and depictions within the frameworks explored (i.e., this was also acknowledged by Pedretti & Nazir, 2011). For example, I found overlaps existing between the historical and socio-cultural STS[E] currents referencing First Nations, Metis and Inuit (FNMI) examples and, as such, it was challenging to dissect the socio-cultural aspects from the historical - as is shown here in the following examples:

- identify historical examples of how humans worked with chemical substances to meet their basic needs (e.g., how pre-contact First Nations communities used biotic and abiotic materials to meet their needs). (p. 18)
- analyze and illustrate how the concept of energy developed from observation of heat and mechanical devices (e.g., the investigations of Rumford and Joule; the development of pre-contact First Nations and Inuit technologies based on an understanding of thermal energy and transfer. (p. 18)

This process of overlaps and transitioning outcomes reminded me of ecological succession studies. For example, as a field gradually transitions to forest, we do not observe clear demarcations; rather it is a gradual process. In some cases, I needed to place certain outcomes in multiple categories; for example, when exploring an ‘overall’ outcome that was less specific but encompassed all of the more ‘specific’ outcomes could fall into either ‘deficit’ or ‘deliberative’ or both. When exploring associations with Levinson’s (2010) framework categories, I initially considered creating additional framework categories such as deficit/deliberate but then upon further reflection decided
to count the outcome twice if it reflected multiple categories (i.e., why the category count in some cases exceeds the total number of outcomes in a given category). Another complexity of applying these frameworks to the ‘STS & Knowledge’ outcomes is that STS is combined with Knowledge outcomes in Alberta. The Alberta Science 10 curriculum combines STS based outcomes with their science knowledge curriculum which would be more aligned with the ‘products’ of science such as knowledge about terminology, equations and calculations. This presented some challenges when exploring Pedretti and Nazir’s (2011) STSE currents and possible curriculum intersections, as this knowledge set might be found separate from STS[E] outcomes in other curriculum documents or the delivery of such outcomes. During one iteration of my analysis, I decided to place the outcomes that would be aligned more with science knowledge into their application and design current as they characterize this category in part as, “…a definite emphasis on the transmission of disciplinary knowledge and the development of technical and inquiry skills” (p. 606). I appended their application and design current with a ‘knowledge’ dimension to acknowledge this complexity and embrace the conceptualization of this part of the curriculum that is present in Alberta. In addition to this analysis work using the Alberta curriculum as it is depicted and written, I decided to also include analysis where I have isolated outcomes I associated with only STS to show interesting patterns and some explorations using Levinson’s (2010) framework and Pedretti and Nazir’s (2011) currents.

I felt that the following patterns emerged from my application of the two frameworks as depicted below (please see Tables 5.2, 5.3, 5.4 and 5.5). I found it useful to categorize and present numerically as one approach to gain some additional insights about some of the framework categories that might be associated with the STS curriculum and also to explore and substantiate some potentially overlapping regions between Levinson (2010) and Pedretti & Nazir (2011).
TABLE 5.2: A summary of some explorations of Levinson (2010) and the ‘STS & Knowledge’ based curricular outcomes of the Alberta Science 10 curriculum (please note that in some cases that the total number of outcomes and the summation across framework categories may not match due to some outcomes that could fit multiple categories).

<table>
<thead>
<tr>
<th>Unit of Study</th>
<th>Approx. # of Outcomes in the ‘STS &amp; Knowledge’ Category</th>
<th>Deficit-Related Outcomes</th>
<th>Deliberative-Related Outcomes</th>
<th>Praxis-Related Outcomes</th>
<th>Dissent &amp; Conflict-Related Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit A: Energy and Matter in Chemical Change (Nature of Science Emphasis)</td>
<td>23</td>
<td>10/23</td>
<td>14/23</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unit B – Energy Flow in Technological Systems (Science and Technology Emphasis)</td>
<td>27</td>
<td>10/27</td>
<td>18/27</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unit C: Cycling of Matter in Living Systems (Nature of Science Emphasis)</td>
<td>20</td>
<td>10/20</td>
<td>15/20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unit D: Energy Flow in Global Systems (Social and Environmental Contexts Emphasis)</td>
<td>24</td>
<td>5/24</td>
<td>17/24</td>
<td>5/24</td>
<td>0</td>
</tr>
</tbody>
</table>

TABLE 5.3: Some explorations of the application of Pedretti & Nazir’s STSE currents to the ‘STS & Knowledge’ outcomes in the Alberta Science 10 Curriculum (please note that due to the complexities of categorizing the outcomes that some outcomes have been classified twice and that the total per category may exceed the total number of outcomes due to this complexity).

<table>
<thead>
<tr>
<th>Unit</th>
<th>Approx. # of Outcomes</th>
<th>Application &amp; Design/ Knowledge-Related Outcomes</th>
<th>Historical-Related Outcomes</th>
<th>Logical Reasoning-Related Outcomes</th>
<th>Value-Centred-Related Outcomes</th>
<th>Socio-Cultural-Related Outcomes</th>
<th>Socio-Ecojustice Related Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit A</td>
<td>23</td>
<td>19/23</td>
<td>2/23</td>
<td>1/23</td>
<td>0</td>
<td>1/23</td>
<td>0</td>
</tr>
<tr>
<td>Unit B</td>
<td>27</td>
<td>20/27</td>
<td>3/27</td>
<td>1/27</td>
<td>0</td>
<td>3/27</td>
<td>0</td>
</tr>
<tr>
<td>Unit C</td>
<td>27</td>
<td>17/27</td>
<td>2/27</td>
<td>0</td>
<td>0</td>
<td>1/27</td>
<td>0</td>
</tr>
<tr>
<td>Unit D</td>
<td>24</td>
<td>17/24</td>
<td>0</td>
<td>4/24</td>
<td>0</td>
<td>3/24</td>
<td>0</td>
</tr>
</tbody>
</table>
TABLE 5.4: Explorations using Levinson’s (2010) framework with the STS outcomes present in the Alberta Science 10 curriculum (please note that due to the complexities of categorizing the outcomes that some outcomes have been classified twice and that the total per category may exceed the total number of outcomes due to this complexity).

<table>
<thead>
<tr>
<th>Unit of Study</th>
<th>Approx. # of Outcomes Associated with STS</th>
<th>Deficit-Related Outcomes</th>
<th>Deliberate-Related Outcomes</th>
<th>Praxis-Related Outcomes</th>
<th>Dissent &amp; Conflict-Related Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit A: Energy and Matter in Chemical Change (Nature of Science Emphasis)</td>
<td>5</td>
<td>0</td>
<td>5 (e.g., outline the issues related to personal and societal use of potentially toxic or hazardous compounds)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unit B – Energy Flow in Technological Systems (Science and Technology Emphasis)</td>
<td>6</td>
<td>1 (e.g., apply concepts related to efficiency of thermal energy conversion to analyze the design of a thermal device (e.g., heat pump, high efficiency furnace, automobile engine))</td>
<td>5 (e.g., Apply the principles of energy conservation and thermodynamics to investigate, describe and predict efficiency of energy transformation in technological systems describe, qualitatively and in terms of thermodynamic laws, the energy transformations occurring in devices and systems)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unit C: Cycling of Matter in Living Systems (Nature of Science Emphasis)</td>
<td>2</td>
<td>1 (e.g., identify areas of cell research at the molecular level (e.g., DNA and gene mapping, transport across cell membranes))</td>
<td>2 (e.g., describe how knowledge about semi-permeable membranes, diffusion and osmosis is applied in various contexts)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unit D: Energy Flow in Global Systems (Social and)</td>
<td>7</td>
<td>0</td>
<td>5 (3 Deliberate; 2 Deliberate and/or Praxis)</td>
<td>4 (2 Praxis; 2 Deliberate and/or)</td>
<td>0</td>
</tr>
</tbody>
</table>
Environmental Contexts Emphasis

(e.g., explain how climate affects the lives of people and other species, and explain the need to investigate climate change)

Praxis) (e.g., investigate and identify human actions affecting biomes that have a potential to change climate)

| TABLE 5.5: Explorations of Pedretti & Nazir’s STSE currents (2011) and the STS outcomes in the Alberta Science 10 curriculum (please note that due to the complexities of categorizing the outcomes that some outcomes have been classified twice and that the total per category may exceed the total number of outcomes due to this complexity). |
|---|---|---|---|---|---|---|---|
| Unit A | Approx. # of Outcomes | Application & Design/ Knowledge-Related Outcomes | Historical-Related Outcomes | Logical Reasoning -Related Outcomes | Value-Centred-Related Outcomes | Socio-Cultural-Related Outcomes | Socio-Ecojustice Related Outcomes |
| Unit B | 6 | 1 | 4 | 1 | 0 | 3 | 0 |
| Unit C | 2 | 0 | 1 | 0 | 0 | 1 | 0 |
| Unit D | 7 | 0 | 0 | 4 | 0 | 3 | 0 |

It appears that the ‘STS & Knowledge’ outcomes overall may align with Levinson’s (2010) deficit and deliberate frameworks if we explore the curriculum as it is written. If we isolate the outcomes that appear to be associated with an STS approach, we see from Table 5.4 that the deficit framework category influence drops considerably which may not be unexpected and the overall emphasis in each curricular unit appears to focus on the deliberative with a tendency to move toward some potentially praxis-aligned outcomes in Unit D.

The outcomes may align more so with Pedretti and Nazir’s (2011) application & design current with some emphasis placed on the historical, socio-cultural and logical reasoning regardless of whether we isolate the STS from the knowledge-based curricular components or include them together. The value-centred current did not appear to be
clearly emphasized upon close examination of the curriculum, however, as previously discussed it is quite challenging to fully separate one current from another in some cases as they tend to ‘flow’ as discussed by Pedretti and Nazir’s (2011) descriptions. Value and ethically-related discussions and also decisions and choices could be associated with a number of other currents such as the logical-reasoning, socio-ecojustice and socio-cultural. I tend to associate a values-associated theme with notions centering on the ‘should we?’ aspects of a STS[E] related issue or choice.

Of note is Unit D: Energy Flow in Global Systems; as my exploration shows a shifting in this unit toward some outcomes that might be more in alignment with a deliberate/praxis or praxis style orientation where the enactment of such curricular outcomes could be tied with more collaboration, knowledge-sharing and the reduction of classroom hierarchies and also increased emphasis on the socio-cultural and logical reasoning currents. I did not feel that any of the outcomes found in the ‘STS & Knowledge’ section would align with a dissent and conflict approach (Levinson, 2010) or Pedretti and Nazir’s (2011) socio-ecojustice current where socio-political knowledge and actions are emphasized; however, in Unit D: Skill Outcomes, Communication and Teamwork the last curricular outcome in this section (i.e., beyond the ‘STS & Knowledge’ outcomes) may be aligned with a dissent and conflict (Levinson, 2010) or socio-ecojustice (Pedretti & Nazir, 2011) approach as perhaps illustrated here:

develop, present and defend a position or course of action, based on findings (e.g., a strategy to reduce greenhouse gas emissions caused by the transportation of people and goods). (p. 33)

This outcome may align with a socio-political approach to the science outcomes explored where students are to develop or defend a position or course of action related to information explored throughout the unit of study. Additionally, there may be outcomes in sections other than the ‘STS & Knowledge’ curriculum where a praxis-aligned association exists. I found the wording of this outcome to be interesting as to ‘defend’ a course of action could imply that this action was carried out by the students; perhaps indicating a more participatory approach.
After exploring the aforementioned theoretical constructs from both a theoretical perspective in my literature review and from an empirical stance after examining the ‘STS & Knowledge’ outcomes I feel that there may be some potential overlaps between Levinson’s (2010) democratic participation in science and Pedretti and Nazir’s (2011) currents could be constructed in the following way in Table 5.6:


<table>
<thead>
<tr>
<th>Framework</th>
<th>Epistemology</th>
<th>Controversy &amp; Participation</th>
<th>Pedagogy</th>
<th>Democratic Participation</th>
<th>STS[E] Currents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficit</td>
<td>Science is a body of knowledge (may be decontextualized)</td>
<td>Ability to participate is limited by understanding of technical knowledge</td>
<td>Knowledge to address issues can be brought to the student</td>
<td>Limited political participation</td>
<td>Application &amp; Design (i.e., if Knowledge-based outcomes are included); Historical</td>
</tr>
<tr>
<td>Deliberative</td>
<td>Science is uncertain</td>
<td>Discussion between teacher and students; cooperative strategies engaged</td>
<td>Critical thinking; scientific methods, procedures</td>
<td>Participation occurs but may be with or without potential for political agency</td>
<td>Application &amp; Design (Knowledge); Historical; Logical Reasoning</td>
</tr>
<tr>
<td>Praxis</td>
<td>Science is contextualized</td>
<td>Teacher and students work together to accomplish goals</td>
<td>Teacher engages as a facilitator</td>
<td>Active participation to enhance change</td>
<td>Socio-cultural; Value-centred</td>
</tr>
<tr>
<td>Dissent &amp; Conflict</td>
<td>Science is contextualized using socio-political issues</td>
<td>Political action</td>
<td>Teacher engages as a facilitator (emphasis on socio-political literacy)</td>
<td>Political understanding &amp; Actions are at the forefront of curricular delivery</td>
<td>Socio-ecojustice; Value-centred</td>
</tr>
</tbody>
</table>

The explorations of some possible overlaps between categories may be illustrative of the complexity of categorizing outcome data into distinctive frameworks. I have also added the word, ‘knowledge’ in brackets following Pedretti & Nazir’s (2011) application & design current to illustrate the ‘STS & Knowledge’ combination when viewing the Alberta curriculum as it is written. Although, as explored earlier, when the knowledge-
based outcomes are removed from the analysis we do not see as much possible alignment with the deficit framework category.

After conducting some introductory exploration of the ‘STS & Knowledge’ and isolated STS curricular outcomes as demonstrated above in Tables 5.2, 5.3, 5.4 and 5.5, it may be that deliberate or deficit/deliberate associations (Levinson, 2010) are possibly connected with the ‘STS & Knowledge’ outcomes with the exception of Unit D where there may be more outcomes associated with the praxis framework (please see Tables 5.2 & 5.4 above)\(^\text{18}\). This could be attributed to a number of factors; one being that in Alberta the STS outcomes are delivered with knowledge-based outcomes. This connection may speak to the work of Roberts and his work with STSE curriculum emphases where he feels that STSE must be clearly depicted in the knowledge components of science curriculum such as stated here,

…the STSE goals of science education are not made explicit in the knowledge column of curricula. The STSE goals then, most often, become part of the hidden curriculum (rather than part of the assessed curriculum)” (Accessed, Feb. 2016, http://www.cmaste.ualberta.ca/en/Outreach/TeacherEducation/CurriculumEmphas.aspx).

This may be an important consideration when exploring educator comfort levels with the delivery of STSE content if we do not want this curricular segment to become or remain ‘hidden.’

5.3 Discussions and Theoretical Perspectives

The work of Roberts (2007) on science literacy may offer some insights into some of the findings that have been presented here. Roberts (2007) broadly classifies science literacy into two main categories that he calls Vision I and Vision II. Vision I focuses on, “…the products and processes of science” (p. 2) and positions an individual who is literate in science as “…within science” (p. 2). Vision II can be characterized as, “…literacy (again, read through knowledgeability) about science-related situations in which considerations other than science have an important place at the table” (p. 3). It would appear from my explorations of the ‘STS & Knowledge’ outcomes that this

\(^{18}\) It is challenging to say with certainty that this is the case without pedagogical data to support how educations may choose to interpret the curricular outcomes.
curriculum might align more so with a Vision I perspective where the products and processes of science appear to be emphasized more (i.e. a more decontextualized emphasis) than a strict emphasis on contextualized science. An exclusively deficit/deliberate STS[E] approach could potentially send the message to learners that science and technology are not to be questioned; which arguably may have consequences for democratic involvement in both individual and societal decision-making.

Students for many reasons may feel somewhat alienated from more traditional science classrooms and pedagogical approaches as they may not see the value or connection to everyday life. This may be linked to earlier discussions regarding cultural capital (e.g., Gee’s, 1992 perspectives on access to middle class discourses) or access to non-monetary resources such as education. Aikenhead (2001) asserts that traditional approaches to science which may include rote memorization and cookbook style laboratory activities could lead to feelings that the students are being “…assimilated into a foreign culture” (p. 338). Aikenhead (2001) also links this observation with future citizens who may lack sufficient cultural capital.

Levinson (2010) presents some insights as to why, perhaps inadvertently, some science delivery may be functioning more so at the deficit/deliberative framework level where there is a dependence upon various experts and authorities for knowledge. He contends that, “Government and corporate innovations depend on public acceptance” (p. 80). If science and technology knowledge is presented in a more critical manner, it may threaten public acceptance of certain goods, services or products. This can be problematic regarding scientific issues commonly experienced in society such as informed consent in medical settings where information regarding what an intervention is for, potential harms and benefits and disclosure to the patient regarding any conflicts of interest. If science and technology information are consistently presented in a more deficit/deliberate style or Vision I alliance, students and citizens may be less informed about how to critique and ask questions about science and technology and perhaps could limit their capacity to make informed decisions.

Clayton Pierce (2013) discusses other factors which may influence the way that society chooses to respond to issues, perhaps which becomes transferred toward a more deficit/deliberative (Levinson, 2010) style of science education. Pierce (2013) draws from
the works of Foucault to describe other influential factors on society such as ‘biopolitics’ where he describes this as, “…the problematization of the population; that is, the state’s ability to make the population a political problem to be studied, measured, managed, and controlled in society through a variety of technologies of control” (p. 8). Pierce asserts that Foucault conceptualized this biopolitical movement here as,

…a shifting of focus of sovereign power from the individual to the population. Such a transition in sovereign power’s nature, according to Foucault, began with the state’s recognition of life within a territory of space as a political problem, something to be managed and controlled through a whole new series of statistical and measurement techniques and practices of governing. (p. 6)

5.4 Some Additional Analysis of Unit D: Energy Flow in Global Systems

This chapter segment will delve a bit deeper into themes that emerged from my analysis of Unit D which focuses on Energy Flow in Global Systems. I found this unit interesting as the ‘STS & Knowledge’ outcomes appeared to emphasize Levinson’s (2010) praxis category as opposed to a possible deficit/deliberative focus appearing in the other units at the tenth-grade level. This section also explores some of the curriculum appearing beyond the ‘STS & Knowledge’ domain where necessary.

Unit D: Energy Flow in Global Systems begins with a brief synopsis of the importance of the Sun and global climate. The United Nations Intergovernmental Panel on Climate Change (IPCC) is also specifically referenced and states that this organization “…has stated that the balance of evidence suggests a human influence on global climate” (p. 29). The use of the word, ‘suggests’ implies that perhaps this information is still debatable. It is of note that approximately 97% of climate change scientists concur that climate change is occurring and is largely of anthropogenic origins (Report by the American Association for the Advancement of Science, 2014 as cited in Klein, 2014). The unit also introduces a series of focusing questions perhaps to set the tone and offer a ‘big picture’ perspective on issues to consider as the document reader moves throughout the curricular outcomes. These questions include:
Are there relationships between solar energy, global energy transfer processes, climate and biomes? What evidence suggests our climate may be changing more rapidly than living species can adapt? Is human activity causing climate change? How can we reduce our impact on the biosphere and on global climate, while still meeting human needs? (p. 29)

The question of whether humans are responsible for climate change, again, may produce social and political goods via discourse that this is perhaps a debatable or questionable aspect of science. The final focusing question seems to acknowledge that anthropogenic activities are at least in part responsible for this phenomenon. The focus here appears to be striking a balance between mitigation of impact and meeting human needs. This may reflect Sauvé’s (2005) work with ‘environmental currents’ that are present in curricula. This type of stance appears to be associated with her sustainable development/sustainability current as the focus does not appear to be conservation oriented but rather to reduce impact while still satisfying and prioritizing human needs and lifestyles.

The specific curriculum outcomes that appear after this introductory matter are organized into the following categories:

1. Outcomes for Science, Technology and Society (STS) and Knowledge
2. Skill Outcomes
3. Attitude Outcomes

The first category represents a blending of two areas of knowledge: an STS focus and knowledge based outcomes. The STS curricular segment occurs first in terms of the unit titles and is blended with knowledge-based outcomes. If we consider the ‘why this way and not that way’ discourse analysis tool described by Gee (2011), it is of course beneficial to have knowledge blended into a focus on STS as students would not be fully able to grasp many of the complex associations when examining socio-scientific issues (and also speaks to the points raised by Roberts and the possibility for STS[E] to remain a part of the ‘hidden’ curriculum without a knowledge association). It is also encouraging to view a curricular document that has highlighted the import of such connections in science education from an early time period to place these outcomes first. This blending
could also potentially lead to a more ‘watered’ down version of STS education as educators must cover both sets of curricular outcomes.

*Anthropocentrism*

A theme that emerged was a more human focused or anthropocentric approach to the environment. This claim may be highlighted here in the context of the first curricular outcome and the first ‘sub-outcome’:

Describe how the relationships among input solar energy, output terrestrial energy and energy flow within the biosphere affect the lives of humans and other species -explain how climate affects the lives of people and other species, and explain the need to investigate climate change (e.g., *describe the responses of human and other species to extreme climatic conditions; describe housing designs, animal habitats, clothing and fur in conditions of extreme heat, cold, dryness or humidity, wind*). (p. 30)

The placement of the term, ‘humans’, in the first outcome may suggest to the reader that humans and their needs are to be prioritized over other species as they appear first in this sentence structure. Other species are mentioned in this outcome, however, they occur after humans. Aikenhead and Mitchell (2011) may speak to this human prioritization where they state,

*Anthropocentrism establishes a hierarchy of importance in which people have a special status within nature—above that of animals, plants, and non-living things in nature. As a result, nature can be seen as a servant to humankind. Anthropocentrism is sanctioned by some religious and philosophical doctrines, in particular by the Judeo-Christian tradition (Cajete, 2000; Reiss, 2008).* (p. 52)

Similarly, in the first sub-outcome, the focus appears to be on how the climate may impact humans as people are again cited first and then in the example component the responses of humans occur first. This connotation may support Aikenhead and Mitchell’s (2011) human-nature dichotomy where they state,

*Anthropocentrism creates a dichotomy of ‘humankind versus nature; which in turn conveys the value or ideology ‘power and domination over nature’ (Cajete, 2006; Mendelsohn, 1976) and the acceptability of using aspects of nature to further certain social objectives. (p. 52)*
The wording, ‘need to investigate’ also may be analyzed in terms of Gee’s (2011) discourse analysis tool, ‘why this way and not that way.’ The ‘need to investigate’ has a different connotation to the reader compared with a wording such as ‘need to act’ regarding climate change. This wording may connect with the work of Levinson (2010) as investigating versus acting could be more reflective of his stance on the interface of democracy and science education as being a more deficit/deliberative way to deliver knowledge versus an emphasis on action which could connect with his categories of praxis/dissent type of knowledge dissemination. The human-emphasis in context of environment concerns again seems to reflect the work of Sauvé (2005) and may posit these curricular connections in the sustainable development/sustainability environmental current as human needs seem to take priority.

Quantification

The second set of ‘STS & Knowledge’-based curricular outcomes seem to focus on mathematical and more analytical approaches to climate science. The key emphases throughout this next segment of curricular outcomes appear to focus on analysis, description, investigation, explanation, interpretation and uses of equations to calculate heat of fusion and vaporization (i.e., the amount of heat released from a reaction). This presentation of facts and emphases placed on calculation present a seemingly more reductionist and perhaps portrays to the reader or receiver of these outcomes a more ‘neutral’ or objective stance. How can we, for example, question the outcome of a calculation such as heat of vaporization? Aikenhead and Mitchell (2011) comment on quantification here,

The presupposition of quantification assumes that the material world is governed by objective mathematical relationships. Theoretical physicists are prone to say ‘the language of nature is differential equations.’ As a result, the quantification of natural phenomena is to be expected in ES. Although some ES are not known for their quantification, their status as a discipline within the larger scientific community varies accordingly. (p. 53)

It suggests that this is perhaps more definitive information and in this segment of outcomes may arguably appear more positivist versus STS[E] knowledge typically being associated with more of a post-positivist conception of science (Pedretti & Nazir, 2011).
This has other implications as noted by Aikenhead and Michell (2011) where they state,

> By representing things, events, and people by numbers, the presupposition of quantification encourages some scientists and others to believe that they can objectify things, event, or person by stripping them of their qualitative, human, or spiritual attributes—their intelligible essences. (p. 53)

These curricular outcomes may also reflect Sauvé’s (2005) scientific current as there is connection to the study of environment and climate using techniques of science such as modeling via equation use. For example:

- **Analyze the relationships among net solar energy, global energy transfer processes—primarily radiation, convection and hydrologic cycle—and climate.**
- **Investigate and explain how evaporation, condensation, freezing and melting transfer thermal energy; i.e., use simple calculations of heat of fusion \( H_{\text{fus}} = Q_n \) and vaporization \( H_{\text{vap}} = Q_n \), and \( Q = m c t \) to convey amounts of thermal energy involved, and link these processes to the hydrologic cycle (p. 30)**

The outcomes also appear to intersect with Pedretti and Nazir’s (2011) application and design current since there seems to be a focus on technical information and inquiry approaches. From my practitioner experience in teaching more technical types of science information (e.g., mathematical calculations), such as heat of fusion or vaporization, students may be less likely to debate origins of the information or its construction. From my perspective, students tend to view mathematics as non-debatable, with the exception of perhaps significant figures or digits. This curricular outcome introduction may also intersect with Levinson’s (2010) deficit or deliberative framework. I am not suggesting that mathematics and/or mathematical approaches be omitted from curriculum; however, I do think that prioritization of uses of equations and calculations may set up power dynamics in the classroom that could potentially silence some students (e.g., those that feel somewhat more intimidated by math). This notion and the ideas presented here by other scholars may also intersect with MacLure’s (2003) observation that, “...discourses are exclusionary: they rule out other ways of thinking, talking or acting” (p. 178).
Uncertainty in Science?

Some of the language and discourses associated with the curricular outcomes may suggest to the reader that there is uncertainty associated with climate change science. For example:

investigate and identify human actions affecting biomes that have a potential to change climate (e.g., emission of greenhouse gases, draining of wetlands, forest fires, deforestation) and critically examine the evidence that these factors play a role in climate change (e.g., global warming, rising sea level(s)). (p. 31)

The use of the phrase, “potential to change climate” suggests that human actions may or may not actually change or impact climate. Similarly, the use of “critically examine the evidence” may convey messages to the reader that somehow the science associated with climate change is still debatable and is uncertain. Having students take a critical stance and to question information may align more so with Levinson’s (2010) praxis or dissent and conflict framework of democratic participation in science as students are being asked to investigate and critically evaluate evidence that is presented to them. It is not clear if students would engage in activities aimed at engaging in conflict with people or groups responsible for climate change. Similarly, this outcome:

describe the limitations of scientific knowledge and technology in making predictions related to climate and weather (e.g., predicting the direct and indirect impacts on Canada’s agriculture, forestry and oceans of climate change, or from changes in energy transfer systems, such as ocean currents and global wind patterns). (p. 31)

challenges students to critically evaluate the science associated with climate and weather. Science has limitations and the critical evaluation of any topic may be beneficial for our students. Likewise, the following curriculum outcomes seem to imply to the reader that the science associated with climate change is perhaps more limited, insecure and

\[\text{\textsuperscript{19}}\] It is worth noting that limitations of data are explored in other curricular units such as Unit B: Energy Flow in Technological Systems as stated here:

identify limitations of data or measurement (e.g., recognize that the measure of the local value of gravity varies globally; use significant digits appropriately) (p. 20)
debateable compared with other scientific fields:

identify limitations of data, evidence or measurement (e.g., list the limitations of data and evidence of past climate changes, evaluate the validity of interpolations and extrapolations, use significant digits appropriately)

explain how data support or refute a hypothesis or a prediction (e.g., provide evidence for or against the hypothesis that human activity is responsible for climate change). (p. 33)

This phrasing in the curricular outcomes may be reflective of the timing of the curriculum as the science of climate change was less secure ten years ago (i.e., the minor curriculum revisions in 2014 do not address the climate change outcomes). These expectations may also reflect Pedretti and Nazir’s (2011) logical reasoning current where the emphasis appears to be placed on decision-making, critical evaluation of the information and debate. These outcomes may also be reflective of popular thought surrounding climate change and ‘global warming.’ Although, there may be consensus, even a high degree of consensus, in the scientific community regarding a particular topic, the translation of science and technology into the public sphere is often not a smooth transition. Oreskes and Conway (2010) highlight some of the challenges associated with scientific communication here regarding climate change,

In 2004, one of us showed that scientists had a consensus about the reality of global warming and its cause as a major debate. By coincidence, another study also published in 2004 analyzed media stories about global warming from 1988 to 2002. Max and Jules Boykoff found that “balanced” articles—ones that gave equal time to the majority view among climate scientists as well as to deniers of global warming—represented nearly 53 percent of media stories. Another 35 percent of articles presented the correct majority position among climate scientists, while still giving space to the deniers. The authors conclude that this “balanced” coverage is a form of “informational bias,” that the ideal of balance leads journalists to give minority views more credence than they deserve. (p. 215)

It is interesting that the media in these cases has chosen to present what they may feel is a more ‘balanced’ reporting of this topic whereas with other science issues they have not. For example, there is a high degree of consensus in the medical community that vaccination is beneficial and supports wellness, however, there are ‘deniers’ in this community that are usually not provided with the same degree of media attention or debate. Deniers in the climate change debate are given recognition and status whereas
with other science issues such as vaccination, those who question the use of these pharmaceutical drugs are typically portrayed by the media as irresponsible parents lacking educational resources.

It may be beneficial to use Gee’s (2011) discourse analysis tool, ‘this way and not that way’ to explore how we might re/imagine the curricular outcomes associated with climate change if this material was presented in a more deficit-style of delivery and the other curricular units were delivered using more praxis/dissent and conflict approaches. For example, if we were to re-write the curriculum expectations for Unit D in a more deficit-style and not leave as much room to question or critique the science of climate change; how might practitioners and learners perceive the information? Would they perhaps feel that the information is more credible and be more apt to take actions to mitigate climate change? A perspective to consider regarding the possible use of a deficit approach when exploring issues may be a ‘boomerang’ effect. Plutzer et al. (2016) discuss this possible impact in the context of teacher education about climate change, but aspects may be applicable to the K to 12 educational systems. They urge some caution in using a ‘hardline’ stance regarding various science and technology issues where they state,

College and university instructors will need help reaching teachers and teachers-in-training who bring diverse political and value commitments to the classroom—particularly in avoiding “boomerang effects,” in which attempts to promote a particular view can instead harden opposition. This may entail acknowledging and addressing conflicts that teachers (and their students) may feel between their values and the science. (p. 2)

Another consideration, perhaps in favour of presenting the science in this unit in more uncertain or critical terms may be the work of Bar-Ann, Wilson and Gilbert (2009). They studied participant responses and reactions to uncertainty which they define as, “Uncertainty refers to the state of an organism that lacks information about whether, where, when, how, or why an event has occurred or will occur (Knight, 1921)”. They also state that,
…uncertainty is generally viewed as an aversive state that organisms are motivated to reduce (e.g., Hogg, 2000; Weary & Edwards, 1996). The state of curiosity, for example, in which people desire more information about something in their environment, has been viewed as a negative drive state that produces pleasure only when it is satisfied (Harlow, Harlow, & Meyer, 1950; Loewenstein, 1994). (p. 123)

The findings of their work suggest that,

…uncertainty intensifies affective reactions. Participants in the uncertain phrases conditions rated the positive film clips more positively and the negative film clips more negatively, relative to participants in the certain phrases conditions. (p. 126)

What this may mean for students experiencing uncertainty coupled with unpleasant climate change discussions and/or activities is that they could perhaps experience them as even more negative. It is difficult to speculate whether this would serve as a possible ‘motivator’ or ‘paralyzer’ for students regarding taking actions to mitigate climate change.

Actions

The climate change curriculum has two outcomes perhaps associated with actions. These outcomes may possibly align with Levinson’s (2010) dissent and conflict framework category or Pedretti & Nazir’s (2011) socio-ecojustice current and may promote beneficial and positive citizenship objectives. It is also of note that both of these outcomes are listed under curricular categories that indicate, “Students will…” where this stronger connotation perhaps implying that greater emphasis will be placed on these outcomes (or that there may be ties with the assessment and evaluation of these outcomes) as listed here:

Analyzing and Interpreting (Students will…)

- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (e.g., design a home for a specific climate; analyze traditional Aboriginal home designs for their suitability in particular climates). (p. 33)
Communication and Teamwork (Students will…)

- develop, present and defend a position or course of action, based on findings (e.g., a strategy to reduce greenhouse gas emissions caused by the transportation of people and goods). (p. 33)

The first outcome above may reflect Pedretti and Nazir’s (2011) logical reasoning current as there is analysis of strengths and weaknesses and no specific mention of a plan of implementation; whereas, the second outcome cited could intersect with the socio-ecojustice current and/or a dissent and conflict (Levinson, 2010) approach as there is mention of “…developing action plans, changing their own habits, educating others, lobbying for change, raising funds, planting trees, and litter cleanups” (Pedretti & Nazir, 2011, p. 618). It is unclear if students would defend a course of action targeted at groups that hold power in society or if their plans would be more of an individualistic approach. This appears to be a more student-centred learning approach that could position the teacher in the role of facilitator. Also of interest is that the development and defense of a course of action is placed under the ‘Communication and Teamwork’ curricular segment perhaps implying that this is a collective construction and effort.

5.5 Some Factors that May Affect the ‘STS & Knowledge’ Curriculum

5.5.1 Curriculum Construction Processes Revisited

“…curriculum is the course of experience(s) that forms human beings into persons.” (Ball, p. 30)

The development of the 1990 Alberta Science 10 curriculum seemed to stem from a rather complex dialogue between various stakeholder groups such as professional scientists and technologists (e.g., engineers), parents and others (Panwar & Hoddinott, 1995). In 1985 a policy document was released which formed some of the prevailing thought about how the science and technology curriculum might shift to reflect stakeholder perspectives beyond the realm of scientists, technologists and high school science educators which stated that,
Senior high science programmes were to 'include an understanding of basic scientific concepts and their applications to our world'. An integrated science programme was to be developed (Science 10-20-30), consisting of a three-course sequence, as an alternative to the traditional specialized courses in biology, chemistry and physics after science in grade 9. (Panwar & Hoddinott, 1995, p. 507)

This stance which was inclusive of STS education was controversial and described here by Panwar and Hoddinott (1995):

...science faculty members at the University of Alberta described the integrated science programme as 'largely devoted to selective technological applications of science and current social issues of those technologies. The result is social science masquerading as science'. The report of the Faculty of Science ad hoc Committee on the proposed revision to the high school science programme stated: We believe that science curriculum development should be primarily the responsibility of professional scientists and teachers educated and trained in science and science education. It must not be unduly influenced by professional educators whose background and interests in science are frequently secondary. (p. 508)

Additionally, Panwar and Hoddinott (1995) assert that these controversies and rifts caused a hierarchy of status to emerge during the curriculum debate and construction process. This placed the academic scientists and high school science teachers ‘at the top’ and the Department of Education officials ‘at the bottom’ (p. 509). Blades (1997) corroborates these claims regarding the development of the Alberta science curriculum released in 1990 where he states,

...Over time the curriculum-discourse included the voices of academics and professional organizations. Representatives from groups claimed the right to also determine the direction and content of the new programs, shifting expertise from the original design team to the public forum. The consequence was an “academic influence” (Fensham, 1993) in the curriculum-discourse that catalyzed a shift towards emphasizing the expertise of non-education specialists in science education reform. (p. 86)

Fensham (2013) has this to add to this conversation about whose voice may prevail during curriculum discussions and decision-making:
The outcome of the power play is usually a compromise, weighted in favour of the dominant expert group, and this outcome is then confirmed as the curriculum for teaching and learning by the appropriate curriculum authority. From the later 1980s, the contest in a number of countries has, however, been characterized rather differently, with a much more commanding role being played by the curriculum bureaucrats in the government ministry responsible for school education. (p. 153)

An additional consideration when viewing the curriculum documents is that they arguably may be summative representations of the perspectives of the ‘winners’ of these stakeholder power struggles. Carr (1998) draws from the work of Fred Inglis (1985) where he likens the curriculum to a ‘battle’ in stating,

The curriculum is the battleground for an intellectual civil war and the battle for cultural authority…is a fervent one. Its different guerrillas include parents, pupils, teachers, bureaucrat, left, right, centre, nationalities and the compelling mercenaries of market forces. (p. 23 as cited in Carr, 1998, p. 326)

Although, these commentaries are based on the Alberta curriculum development process from documents prior to those used to explore the ‘STS & Knowledge’ outcomes in this case study, we may be able to glean some insights as to the processes and the content currently present in the Alberta Science 10 document (Revised 2014). It was puzzling to me why the term, ‘STS’ was used as opposed to ‘STSE’ which is commonly used across provincial and territorial jurisdictions (with the exception of the NWT as the Alberta science curriculum is used there). This may be an aspect of timing as Alberta integrated STS approaches in 1990 before the use of the acronym, STSE (i.e., although the minor updates to the 2005 curriculum in 2014 did not include an update to become STS[E]). Another consideration may be political intervention and possible controversy surrounding the word, ‘environment’. Bloche (2014) provides some insights here regarding her work in Ontario about a past PC government and political intervention:

…The third incident involved whether the term environment could be used in the curriculum. This incident was also raised by Xia who commented: I can remember them [politicos] blocking out the word environment. You know we’re not a company of tree-huggers. There were these things like the environmental focus that simply weren’t allowed. (Interview. 8 August 2007). (p. 262)

And also here,
When the representative of the Ontario Parent Council, another group sympathetic to the government’s reforms in education, expressed that their group had no concerns about the word environment being in the curriculum or even having expectations related to the environment, the issue was resolved and environment was acceptable to use. He did mention that the Parent Council expected a balanced approach in that students were learning the science related to environmental issues and that the curriculum did not have expectations presenting a negative view of business and industry on environmental issues. (p. 262)

Of course, these interviews and anecdotes were specific to Ontario and may not necessarily represent the complex factors involved in the curriculum development process in Alberta.

The fusion of the ‘STS and Knowledge’ categories was an interesting feature of the curriculum as well; however, after engaging in more research about some of the historical elements prior to this curriculum document; the role of scientists, technologists and science educators and their concern with providing what they viewed as a rigorous science education appeared to be a common theme in the literature. Perhaps the presentation of the STS curriculum with a ‘knowledge-backbone’ provided a compromise that appealed to the greatest number of stakeholders involved in the development process. This combination also speaks to the concerns raised by Roberts regarding the potential for STS[E] to become a ‘hidden’ aspect of the curriculum without a knowledge association.

5.5.2 Assessment Practices in Science

Alberta, as well as other Canadian provinces and territories, participates in standardized testing such as provincially administered tests in various subjects and global standardized testing such as the Programme for International Student Assessment (PISA) exam administered to 15-year old students. Provincial Achievement Tests (PAT) are administered to Grade 3, 6, and 9 students in “…English and French language arts, mathematics, science, and social studies” and “Grade 9 achievement tests based on the Knowledge and Employability program of study in English language arts, mathematics,
science and social studies are also administered. Grade 12 students additionally participate in Diploma Examinations where their final grade is an amalgamation of both their Diploma Examination result and teacher-determined course grade (i.e., this is weighted 70-30 split where 70% of their grade is based on the teacher-assigned course grade). Diploma Examinations occur in Francais, French Language Arts, English Language Arts, Social Studies, Mathematics, Chemistry, Physics, Biology and General Science (i.e., Science 30). These types of standardized tests would fall under the category of criterion-referenced tests (Graham & Neu, 2004).

I briefly explored some of the content present in the Grade 9 Provincial Achievement Test in science to gain some insights into assessment practices and perhaps curricular emphases that precede the Alberta Science 10 curriculum. The Grade 9 Provincial Achievement Test in science from 2012 was accessible on the Alberta Education Ministry website. The topics tested included: Biological Diversity (11 questions); Matter and Chemical Change (11 questions); Environmental Chemistry (11 questions); Electrical Principles and Technologies (11 questions); Space Exploration (11 questions). A total of 55 questions occurred on this PAT and are further sub-divided into knowledge and skills and are all multiple-choice responses (i.e., with four possible answers). I was curious about the STS[E] content of these questions as this association might provide some insights into perhaps what could be emphasized in the written curriculum documents.

The STS content appeared to be used to contextualize some of the more traditional products of science in the PAT. For example, one released PAT question about the oil spill spread from the Exxon Valdez disaster in 1989 could be used to discuss a number of STS[E] issues and actions; however, in this context, information is provided and the question is closed-ended and about the scientific vocabulary depicting the movement of one liquid through another. Aside from these contextualized STS[E] questions, the test seemed to emphasize more traditional approaches to science such as

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20 Please see the following website for more detail: https://education.alberta.ca/media/15273769/02-ach-gib-2015-16-introduction-revisions.pdf

21 Please see the following website for more detail: https://education.alberta.ca/media/15311125/05-science-9-released-2012_20150930.pdf
reading graphs, terminology and processes.

Graham and Neu (2004) conducted research on some of the standardized testing protocols in Alberta and assert that, “…although standardized testing may serve its ostensible purpose of measuring student performance, it also functions as a mode of government control by helping to construct governable subjects” (p. 295). In this sense, they are referring to the work of Foucault where they quote:

[T]he examination is at the centre of the procedures that constitute the individual as effect and object of power, as effect and object of knowledge. It is the examination which, by combining hierarchical surveillance and normalizing judgment, assures the great disciplinary functions of distribution and classification… (Foucault 1984, p. 204 in Graham & Neu, 2004, p. 295)

5.5.3 Explorations of Alberta’s Political Landscape

This case study section presents a selection of some facets of the political environment in Alberta at the time of the construction and implementation of the Science 10 Alberta curriculum document (minor revisions, 2014) which have been explored as some possible factors or influences regarding curriculum development processes (i.e., as the Minister of Education or other politically appointed representatives do hold the ‘final say’ regarding what is documented and released as discussed previously in my literature review). The documents analyzed in this exploration focused on the Progressive Conservative (PC) Party of Alberta’s election platform (2012), Speech from the Throne (November 17, 2014), website materials and Alberta’s 2008 Climate Change Strategy: Responsibility/Leadership/Action.

Political climates are evolving and non-static entities that are subject to change and challenging to grasp in their full complexity. This exploration is not meant to be in any sense exhaustive due to limitations in the number of documents explored; rather this section is intended to provide a provincial political ‘flavour’ to gain a limited

22 The wording, ‘some facets,’ has been selected as political environment is highly complex, evolving and challenging to explore or categorize entirely.
appreciation of some factors that may or may not influence STS (science-technology-society) curricular construction in science.

Alberta has been predominately governed by the Progressive Conservative (PC) party (i.e., the PC government had represented Alberta from 1971 to 2015). Khan and McNiven (1991) state that the PC perspective on some issues is similar to that of the Liberal Party of Canada in that, “…it supports the bilingual character of the country, the scope of the welfare state, and the existence of regional diversity” (p. 158). Additionally, they comment here that,

The differences between the two parties are not so much in substance but in style. Aside from their traditional support in certain parts of the country, both parties compete for the same voters with only slight variations in their message. Neither would, for instance, abandon the welfare state nor exhibit overt hostility towards the United States. For example, the PC government negotiated the Free Trade Agreement with the United States; the liberals opposed it. But the Liberals insist that they were not against free trade with the United States; they simply did not like the agreement the PC government had negotiated. (p. 159)

Political party platforms are documents that state agendas and issues of importance to a party presented to the public prior to or while running an election campaign. They are somewhat useful to glean insights regarding discourses and themes of import regarding the political party stance on a variety of issues and what the party perceives as important regarding winning a majority of seats to form a government (i.e., what their electorate or stakeholders regard as critical issues); however, what a political party places in their platform may or may not be representative of what actions they may actually take if they are elected to represent a municipality, province or country.

I selected the 2012 Alberta Progressive Conservative Party Platform entitled, “Alberta by Design: Reaching our full potential: Building on a legacy of real-life leadership & securing the promise of Alberta’s future” for this case study as it is relatively recent and was released prior to the minor revisions conducted on the Alberta Science 10 curriculum in 2014. I used a similar rationale for my selection of the Alberta Speech from the Throne and the selected climate change action plan as the dates reflect and fall into a timeframe that reasonably reflects the timing of the curriculum release and implementation (i.e., a completely synchronous timeframe may be unnecessary to explore
some aspects of general political culture). Both document analysis and discourse analysis were used to explore some interesting features of these documents.

Wordle™ was used to summarize and present a cursory overview of some emphasized words appearing in the Speech from the Throne and the PC platform (please see Figures 5.1 & 5.2 below).

![Image]

Figure 5.1. Wordle™ depiction of the Alberta Progressive Conservative Party Platform 2012.

In Figure 5.1 we can see that the following words occur most often throughout this document: Alberta, government, new, programs, school, services, support, communities, students, education, care, PC, program.

Another useful source of information to establish political landscape or climate are the aforementioned throne speeches read by the Governor General. The following Wordle™ (see Figure 5.2) was generated based on the first address to the house via the Speech from the Throne on November 17, 2014.

![Image]
The most frequently occurring words as indicated by their enlargement appear to be: Alberta, Albertans, government, province, work, care, and health. This speech typically sets the tone for the governmental year and while there are similarities between the platform and speech, there are some differences, such as the lack of emphasis on education or environment as depicted in terms of the number of times each word has been mentioned. The speech moves into a description of the beautiful natural landscapes present in Alberta and then into a description of what the party states they value most presented here:

But we value most what Albertans themselves bring to our province: entrepreneurial spirit, hard work and innovation, a commitment to excellence and ethics of compassion and service to others.

The following sections will explore three thematic categories that emerged from my analysis of some of the aforementioned political documents in Alberta: neoliberalism and sustainable development focusing on areas that may be more relevant to curriculum construction and specifically the science curriculum (i.e., there would be other emergent themes, but I chose to focus on these areas as they may intersect more so with curriculum).

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23 As the creation of a Wordle™ is somewhat reductionist, I am using this tool as an indicator of importance affixed to words, not as the sole interpretation of the relative importance of these words or topics.
Neoliberalism

The body of the Alberta PC platform (2012) focuses on three objectives that are described on the second page before the table of contents. These objectives are:

If you entrust us with a new mandate, we will:

1. **Secure Alberta’ Economic Future**: we will make strategic investments in education, human capital and infrastructure to strengthen Alberta, growing our knowledge-inspired economy, and improving Alberta’s competitiveness in the global marketplace.

2. **Advance World-leading Resource Stewardship**: we will develop our natural resources responsibly to protect our environment and grow our markets.

3. **Invest in Families and Communities**: we will support wellness, families and communities as an investment in Albertans and Alberta’s future.

The first mandate listed is to secure the economic situation of Alberta; this first objective has been emphasized as a priority item occurring first in this list and also numerically as it has a number ‘1’ associated with it and there is specific mention of ‘human capital.’ This may connect with some of the work of Bertrand and Valois (1992) where they comment here about ‘human capital’ in educational contexts, “…education is first and foremost perceived as a “central economic investment for the development of creativity, productivity, and competitiveness,” and as a transfer process where scientific and technical knowledge is favoured (UNESCO, 1992, p. 14 as cited in Sauvé, 1996, p. 21).

There is also mention of the focus on competition and the global economy that may be tied to more neoliberal and individualistic pursuits. Ball (2012) states that, “It [neoliberalism] is characterized by a strong commitment to methodological individualism and the principles of private property…” (p. 18). Resource stewardship is the second overall objective mentioned and uses the terminology ‘natural resources’ and ‘environment’ in the context of a financial goal or objective citing the growth of markets. This may be linked to a more sustainable development objective or perspective (Sauvé, 1996). The final overall objective stated is the investment in families and communities. This appears after securing economic objectives and resource management tied with the economy. Although community investment is highlighted in the top three overall priorities, it is in last place; the reader may register that it is not as much of a priority as the first two objectives listed. The term investment has been selected and again may be reflective of a more neoliberal prioritization and also implies that there may be some sort
of ‘return,’ although the building of communities could also be considered a collective resource and as such may not be as reflective of some principles that seem to govern neoliberal principles in general.

The Speech from the Throne (November 17, 2014) also appears to mirror some of these neoliberal aspects that may also be present in the aforementioned PC party platform. Some of the key priorities of the elected PC government as described in the speech are provided here:

This government is focused on the clear priorities of Albertans — reflecting Albertans' values and ambitions for today while ensuring a strong foundation is set for future generations. Five key principles underline our efforts:

- A focused commitment to sound, conservative fiscal principles;
- Ending entitlements and restoring public trust;
- Maximizing the value of our natural resources and respecting property rights;
- Establishing our province as an environmental leader; and
- Increasing Albertans' quality of life by being a leader in the areas of health, education, seniors' care and skills training.

It is of note that these principles seem to reflect the mandates of the election platform where fiscal responsibility is the priority (i.e., regarding document statement ordering); emphasis on natural resource management and becoming a provincial environmental leader and lastly a focus on the development of social programs and goods such as health care and education.

Neoliberalism: Transparency and Accountability. Throughout the body of the Progressive Conservative (PC) Party of Alberta’s election platform (2012), there were some additional patterns that may fall under the broader theme of neoliberalism. The first theme that emerged was one that focused on the use of efficiency, accountability and also a use of an intertextual discourse that might be associated with the business world. For example, on page 14 of the document using two colours to highlight an outcome was a focus on “transparency, clarity and accountability” using the phrasing, “A NEW ALISON REDFORD GOVERNMENT WILL: INCREASE the accountability of the education system providing better information to stakeholders” (p. 14). This might imply
surveillance. Ball (2012) draws from the work of Ozga (2008) to describe surveillance such as this which could also be tied to numerical references or statistics where they state,

More broadly, Ozga (2008) has been mapping and analyzing the increased use, across a variety of European states, of what she calls ‘governing knowledge’, that is knowledge of a new kind—a regime of numbers—that constitutes a ‘resource for comparison’ (p. 264), addressed to improvements in quality and efficiency, by making nations, schools and students ‘legible’ (p. 268) (p. 33).

And also here,

These numbers are increasingly important in the ways that states monitor, steer and reform their education systems by the use of targets, benchmarks, and performance-triggered interventions. That is, ‘the technology of statistics creates the capacity to relate to reality as a field of government’ (Hunter, 1996, p. 154). (p. 33)

Similarly, in terms of this continued business associations we see this theme continued where the document mentions curricular changes and modifications (i.e., bolding and italicization present in the original document):

**Update Alberta’s Curriculum**

- A new PC government will focus on updating Alberta’s curriculum. **Curriculum Redesign** is an opportunity to review today’s curriculum and the process by which it’s developed, to ensure that it remains relevant and forward-reaching. The redesigned curriculum will **respond to needs of today’s globally connected young minds**. Increasingly, sophisticated technologies must be part of our approach to support the kinds of learning experiences that challenge and engage today’s young learners – positioning them to reach their full potential.

The outcomes of Curriculum Redesign will be:
- **Efficiencies** in curriculum development;
- **Enhanced access** to curriculum, supported by technology;
- Supportive, flexible, paced and **student-centred learning**;
- **A balanced approach to assessment**; and
- **Inclusiveness** for all learners. (p. 17)

The first outcome mentioned regarding curriculum redesign is ‘efficiency’. This may connect with the notion of ‘performativity.’ Ball (2012) describes this concept here:

…performativity is the quintessential form of neo-liberal governmentality, which encompasses subjectivity, institutional practices, economy and government. It is both individualizing and totalizing. It produces both an active docility and depthless productivity. (p. 31)
It is unclear from this excerpt whether student-centred learning approaches cited would intersect with individualized learning promotion. Some forms of individualized pedagogies could be problematic if we consider them in relation to neoliberalism in the sense that they may emphasize individualistic competition and place limitations on the building of classroom community; however, this may or may not be the case. Carter (2010) offers a perspective here regarding this point:

There is no doubt that many of us would believe our promotion of learner-centered pedagogies as best practice within the humanist and progressive tradition of education rather than as culturally insensitive fodder for the global knowledge economy. But we need to recognize that there is more to it, and that neoliberal global discourses on education and knowledge economy/global information society have coopted humanist visions of active learning within democratic and collaborative environments to its own purposes of human capital development. (p. 230)

_Sustainable Development_

The ideas of sustainable development and the environment can be thought of as both a collective and individual good. The environment can become individualized and commodified when resources are harvested for economic gain. There is a great deal of debate in environmental fields regarding what ‘sustainable development’ is and if this is even an attainable goal. Sauvé (1996) presents different typologies of ‘sustainable development’ and their possible ties with educational paradigms from the Calgary Latin American Studies Group (1994) such as: “Continuous development owning to technological innovation and free trade”; “Development as dependent on a world order”; Alternative development”; “Autonomous development (Indigenous development)” (p. 27). Environmental goals and stewardship are framed within the context of economic objectives and increasing efficiency as illustrated here in the Progressive Conservative (PC) Party of Alberta’s election platform (2012):
Advance World-Leading Resource Stewardship
Create win-win solutions for developing Alberta’s resources while protecting Alberta’s environment for future generations

1. Introduce an initiative to make Alberta the national leader in energy efficiency and sustainability.
2. Work with the federal government to develop sensible and pro-consumer future coal-fired regulations that support the common goal of reducing carbon dioxide emissions.
3. Implement the Regulatory Enhancement Task Force recommendations, including the creation of a single regulator for upstream oil and gas, and coal.
4. Develop the appropriate partnerships, inside and outside of government, to deliver a credible and open-source information system on science-based environmental indicators. (p. 4)

There is mention of recommendations about the development of environmental indicators. It is stated on page 19 that, “A NEW ALISON REDFORD GOVERNMENT WILL: WORK to become a world-leader in sustainable development and environmental management and protection.” Also on page 19, a photograph is used to depict a potentially harmonious fusion of economy and environmental where semiotically, this image displays an aesthetically pleasing backdrop of the pristine snow-capped mountains with a river and forest scene in the front positioning of the photograph. In the middle of the photo is a grey-metal pipeline that is barely visible in the image perhaps conveying to the reader that the human constructed pipeline will not impact this beautiful and pristine natural environment.

If we consider actor network theory and attempt to perhaps ‘depunctualize’ aspects of this photograph, we might also ponder what may have been ‘lost in translation’ from reality to photograph (e.g., Pozzer-Ardenghi & Roth, 2010). For example, this photograph cannot capture mechanical sounds associated with these human-constructed pipelines nor can we the smell the emissions from the stacks. This image was perhaps selected as a segue where the PC government takes a clear stance in their support of the Keystone XL pipeline where they state on page 21, “A NEW ALISON REDFORD GOVERNMENT WILL: SUPPORT the Keystone XL and Northern Gateway pipelines and continue to work strategically to bring Alberta products to market.” These discourses may be associated with Sauvé’s (1996) conceptualization of, “Environment as a resource…to be managed” (p. 10). She describes this view of the environment as an entity that, “…should be managed according to the principles of sustainable development
and equitable sharing” (p. 10). These statements may also tie with sustainable development that focuses on “Continuous development owing to technological innovation and free trade” where the environment is regarded as, “…a resource to be developed and managed; rational use of resources for sustainable profit, and thus sustainable quality of life” (Calgary Latin American Studies Group, 1994 as quoted by Sauvé, 1996, p. 27).

The theme of sustainable development seems to appear throughout Alberta’s 2008 Climate Change Strategy: Responsibility/Leadership/Action. Again, human priorities appear to be at the forefront and there also is a focus on technological solutions such as illustrated here:

-Conserving and using energy efficiently. Goal: to reduce greenhouse gas emissions by transforming how we use energy, applying energy efficient solutions, and conserving energy.
-Implementing Carbon Capture and storage. Goal: to store quantities of CO₂ in Alberta’s geological formations rather than releasing it into the atmosphere.
-Greening energy production. Goal: to transform the way we produce energy and to introduce cleaner, more sustainable approaches to energy production. (p. 7)

These goals seem to emphasize efficiency, conserving energy, carbon capture techniques and focusing on more sustainable energy production. These strategies appear to align with the economic stance shared in Alberta’s 2008 Climate Change Strategy: Responsibility/Leadership/Action as illustrated here:

Governments around the world can choose from a variety of options to meet their obligations, including: carbon capture and storage and other transformational technologies, renewable energy, emissions offsets, energy efficiency programs, taxes, slowing down economic growth, or sweeping changes to the very structure of their economy. Alberta’s strong and vibrant economy is founded on resource extraction and value added upgrading, so our strategy ensures we build on this strength – we are not prepared to forgo the opportunities our strong and vibrant economy provides. Our greenhouse gas emissions profile is strongly linked to the production and use of fossil fuels. Our policy approach to climate change is mindful of this reality and in fact helps strengthen our current economic structure. (p. 13)

These discourses may be connected again with the conception of sustainable development as perhaps continuous development where, “…economic growth following neoliberal principles will solve social and environmental problems” (Calgary Latin
American Studies Group, 1994 as quoted in Sauvé, 1996, p. 27). On page nine of this document, there is a clear acknowledgement that climate change is a reality:

Climate change is real. Our planet is warming and it’s doing so at a faster pace than at any other time in our recorded history. (p. 9)

There is also clear acknowledgement in this document regarding the role that Alberta plays in the production of carbon dioxide emissions such as this statement,

As a leading energy producer for Canada and the world, Alberta is responsible for producing about a third of Canada’s total greenhouse gas emissions – the leading cause of climate change. Our emissions are expected to increase by another third over the next five to ten years. (p. 9)

Actions and Adaptation

Emphasis to be placed on the reduction of greenhouse emissions, efficient use of energy and greener technologies in the document, Alberta’s 2008 Climate Change Strategy: Responsibility/Leadership/Action. Both collective and individual responsibilities are perhaps acknowledged here:

Each of us has a responsibility to make better choices in our own homes, at work, and in the ways we choose to travel. Clearly, industry and business have key roles to play. (p. 9)

Another aspect raised in the document is the acknowledgement that youth be involved in terms of initiatives such as the statement expressed here:

… it provides an opportunity to engage Alberta’s youth in tackling an issue that will affect their futures and future generations of Albertans even more than it affects us today. (p. 15)

A sub-theme that seemed to emerge involving action regarding climate change appears to be adaptation to climate change. The document acknowledges that despite immediate actions taken that certain facets of climate change are a certainty as illustrated in this passage:
...scientists agree that climate change caused by human actions will continue for centuries to come. That means we need to anticipate and plan ahead to reduce our vulnerability to the impact of climate change. Strategies to adapt to climate change must go hand in hand with actions identified in this plan to reduce current and future greenhouse gas emissions. It’s not a question of doing one or the other – both approaches are necessary. (p. 21)

There appears to be acknowledgement that anthropogenic actions are responsible for environmental damages and that there is no easy fix.

5.6 Some Concluding Thoughts

The emphasis in the ‘STS & Knowledge’ outcomes appears to align with an application & design (knowledge) focus with some aspects highlighting socio-cultural and historical perspectives that might be more deficit/deliberate in focus overall (i.e., with the exception of Unit D which seems to have more possible connections to praxis). The actual curriculum document arguably represents the final compromise and the ‘winners’ of the stakeholder negotiations regardless of how the negotiations were conducted. After conducting both document and discourse analysis on a selection of political and curricular documents, there may be some overlapping themes or patterns which could indicate some general influence by the government formed during the construction and implementation of the ‘STS and Knowledge’ science curriculum, although, this is challenging to say with certainty due to the complex nature of these interactions. I will present my thoughts on where these potential overlaps may be occurring in the next few paragraphs, although overall, I feel that the influence from the larger political sphere appears to be limited regarding the STS content.

Neoliberalism

It appeared that aspects of neoliberal discourse were present in some of the political documents explored in this case study. It is unclear whether the fusion of the ‘STS & Knowledge’ outcomes present in the Alberta Science 10 curriculum are linked to this construct or not. The literature reviewed in the curriculum construction section appears to depict certain stakeholders as having more power during curriculum formulation (e.g. from Blades, 1997 descriptions); however, it is unclear the extent to
which stakeholders have influenced the development of this current curriculum or the revisions that occurred in 2014. The focus on the ‘products’ of science and the fusion of STS and knowledge may indicate an emphasis on academic and technological stakeholders.

The literature reviewed about standardized testing protocols in Alberta seems to suggest a linkage to Foucault’s notion of governmentality, neoliberalism and also “performativity” (Ball, 2012). It is important to note that standardized testing in science does not occur at the tenth-grade, however, it is implemented at the ninth-grade and in twelfth-grade science courses in the form of Diploma Examinations. The Science 10 course is somewhat ‘sandwiched’ between these standardized testing protocols. If teachers decided to ‘teach to the test’ it could result in an emphasis on more individualized educational pursuits that are focused on the ‘products’ of science as opposed to outcomes focused on more open-ended STS[E] explorations that could suggest a neoliberal influence.

*Sustainable Development*

Although the phrasing, sustainable development, is not explicitly used in the PC party platform or climate change action plan explored, there seems to be an emphasis placed on the management of resources for economic or human gains with the perspective to be cognizant that we must try to mitigate impact for future generations. There is also emphasis placed on what the individual might do to mitigate their personal impact on the environment (e.g., reducing time spent driving). There is also clear indication that climate change is a reality and must be addressed; however, the phrasing of some of the curricular outcomes might suggest that the science of climate change is still somewhat insecure. Despite attention paid to the environment in both of these political documents, the Alberta Science 10 science curriculum (revised in 2014) still uses the title, “Science, Technology and Society (STS)” versus, “Science, Technology, Society and the Environment” (STSE) used by the majority of provinces and territories. The other aspect present in the climate change action plan is a definitive stance that climate change is not a debatable topic. In several curricular outcomes, the curriculum
wording suggests that some of the associated science may be questionable whereas Alberta’s 2008 Climate Change Strategy: Responsibility/Leadership/Action suggests that that it is not.

Actions, both collective and individual, are highlighted in the various political documents explored in this study regarding climate change. There is also explicit mention of actions involving youth regarding climate change as previously mentioned. The science curriculum segment explored here also features actions regarding climate change in the development, presentation and defense of either a course of action or an opinion based on student findings that appears to align with more general political culture.
Chapter Six – Explorations of STS[E] Education in Ontario at the Tenth-Grade Level

I focused my explorations and efforts on both the academic and applied Ontario tenth-grade science curriculum (2008) to examine the STS[E] content and to analyze similar documents across my provincial case studies. I present some general curriculum document features; then focus on the STS[E] curriculum in both the academic and applied streams and follow this with a more in-depth exploration of the climate change units. In a sense, this case study focusing on Ontario could almost be considered a ‘two for one’ in that the academic and applied streams have been analyzed separately (i.e., although, there are overlapping areas). As mentioned in the Alberta case study, I used a combination of analytical tools including document analysis and discourse analysis as well as loosely applying Posner’s (2004) description of curriculum analysis to explore the STS[E] curriculum from multiple angles and perspectives. I also found the application and combination of Bloom’s revised taxonomy (Krathwohl, 2002); Levinson (2010) and Pedretti and Nazir’s (2011) frameworks to be useful to focus my exploration of the STS[E] curriculum. Various factors are presented following my STS[E] curriculum analysis work to explore some possible influences on the STS[E] curriculum content.

6.1 Some Organizational Features of the Ontario Curriculum

The Ontario Curriculum: Grades 9 and 10: Science (2008) is approximately 104 pages long and features font and descriptions in black, white and green throughout the document. The choice of the color, ‘green’, perhaps conjures images of the environment in the mind of the document reader.

The document presents an organizational schematic that explains features of the science curriculum. This diagrammatic representation appears to be hierarchical (Heimer, 1969 as cited by Posner, 2004, p. 133) and compartmentalized although there is equal representation regarding the overall expectations and the specific expectations. This might suggest to the reader of the document a reminder of the ‘top down’ and following direction in educational settings, inclusive of implementation of the science curriculum. The overall goals of the science curriculum are again, spatially equally represented,
however the presence of the numerical sequence appears to place both the goals and associated overall and specific expectations in relative order of import. The first goal of the curriculum is to focus instruction on STS[E] concepts followed by inquiry skill development and then focuses on basic information and concepts in science. These orderings may suggest to the reader the relative significance of the concepts via their placement in the curriculum document where STS[E] is number one.

The content of the Ontario Grade 9 and 10 Science curriculum is structured into the following content or strand areas:

A. Scientific Investigation Skills and Career Exploration
B. Biology
C. Chemistry
D. Earth and Space Science

Specifically, at the Grade 10 level the aforementioned curricular areas are tied to the following curricular units (please see Table 7.1 below):

| TABLE 6.1: Curricular strands and their specific focus at the Grade 10 level. |
|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| **B. Biology**                | **C. Chemistry**              | **D. Earth and Space Science**| **E. Physics**                |
| **Grade 10 Academic**         | Tissues, Organs, and Systems  | Climate Change                | Light and Geometric Optics    |
|                               | of Living Things              |                               |                               |
| **Grade 10 Applied**          | Tissues, Organs, and Systems  | Chemical Reactions and Their  | Earth’s Dynamic Climate       |
|                               |                               | Practical Applications        |                               |
|                               |                               |                               | Light and Application of Optics |

Each course at the Grade 9 and 10 level is offered in various streams such as ‘academic’ and ‘applied’ and the unit titles vary slightly across these categorizations. As depicted in Table 7.1 above, the Grade 10 applied stream appears to focus on ‘applications’ of knowledge where we see in the titles associated with chemistry and physics explicit use of this word. In Earth and Space Science we see a title in the academic stream appearing to focus on climate change whereas in the applied stream the emphasis appears be on a ‘dynamic climate.’ The choice of the word, dynamic, can perhaps suggest to the reader ‘change’ and also potentially ‘progress’ if we consider
dictionary type definitions of this term. Climate change sounds ominous where ‘dynamic climate’ possibly sounds positive and upbeat to the document reader. It is curious as to why these units differ in terms of their titles.

The appearance of two curricular streams, the academic and the applied, is an interesting feature of this document. The two curricular offerings are distinguished from one another as described here:

Academic courses develop students’ knowledge and skills through the study of theory and abstract problems. These courses focus on the essential concepts of a subject and explore related concepts as well. They incorporate practical applications as appropriate.

Applied courses focus on the essential concepts of a subject, and develop students’ knowledge and skills through practical applications and concrete examples. Familiar situations are used to illustrate ideas, and students are given more opportunities to experience hands-on applications of the concepts and theories they study. (p. 11)

It appears from the wording of these definitions that the academic curriculum tends to focus more so on abstractions involving science whereas the applied courses may place more emphasis on practical applications of science. This could convey a message of two ‘classes’ of science being offered to students; one that focuses on academic abstractions; perhaps a ‘white-collar science’ and the other focuses perhaps on more trade-related associations, perhaps a more ‘blue-collar science’.

These categories also draw to mind the work of Young (2009) and his distinctions between “procedural knowledge” which may align more so with an applied stream and “theoretical knowledge” perhaps aligning with the academic stream as he discusses here,
…One is the context-dependent knowledge that is developed in the course of solving specific problems in everyday life. It can be practical – like knowing how to repair a mechanical or electrical fault or how to find a route on a map. It can also be procedural, like a handbook or set of regulations for health and safety. Context-dependent knowledge tells the individual how to do specific things. It does not explain or generalize; it deals with particulars. The second type of knowledge is context-independent or theoretical knowledge. This is knowledge that is developed to provide generalizations and makes claims to universality; it provides a basis for making judgments and is usually, but not solely, associated with the sciences. It is context-independent knowledge that is at least potentially acquired in school, and is what I referred to earlier as powerful knowledge. (p. 15)

The ordering of the units may provide some insights into their relative importance. In the case of the Grade 10 curriculum, Strand A focusing on the development of inquiry skills appears first, however, it is unclear what classroom approaches might be taken regarding this unit. For example, some practitioners may decide to teach this unit separately from other units of study or they may decide to integrate various facets throughout their delivery of the other units to contextualize the material. The physics unit appears last in this organizational structure, however, in practice this may or may not be the case. For example, some teachers may decide to work in teams at schools to develop and implement units and may opt to change the order of unit delivery (i.e., I base this on my personal practitioner knowledge).

6.2 Explorations of STS[E] Content and Selected Framework Applications

An Exploration of Verbs Associated with STS[E] Expectations

All units of study at the tenth-grade academic and applied levels were analyzed for various themes and patterns. Wordle™ was used to help explore some general patterning of words throughout the curriculum and as a visual aid to examine verbs that may be emphasized in the wording of the expectations (please see Tables 6.2 & 6.3 below).
TABLE 6.2. Some exploration of the verbs in the Ontario Grade 10 Academic Science STS[E] curriculum expectations.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Wordle™ Depicting Verbs used in STS[E] Overall and Specific Expectations</th>
<th>Some Commonly Occurring Verbs Associated with STS[E] Overall and Specific Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology: Tissues, Organs, and Systems of Living Things</td>
<td><img src="image" alt="Wordle" /></td>
<td>Analyse; assess; describe; evaluate; use</td>
</tr>
<tr>
<td>Chemistry: Chemical Reactions</td>
<td><img src="image" alt="Wordle" /></td>
<td>Analyse; analyse; analyse;</td>
</tr>
<tr>
<td>Earth and Space Science: Climate Change</td>
<td><img src="image" alt="Wordle" /></td>
<td>Analyse; analyse; assess;</td>
</tr>
<tr>
<td>Physics: Light and Geometric Optics</td>
<td><img src="image" alt="Wordle" /></td>
<td>Evaluate; analyse; analyse</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit</th>
<th>Wordle™ Depicting Verbs used in STS[E] Overall and Specific Expectations</th>
<th>Some Commonly Occurring Verbs Associated with Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology: Tissues, Organs, and Systems</td>
<td>analyse</td>
<td>Analyse; analyse; evaluate</td>
</tr>
<tr>
<td>Chemistry: Chemical Reactions and Their Practical Applications</td>
<td>analyse</td>
<td>Analyse; analyse; identify</td>
</tr>
<tr>
<td>Earth and Space Science: Earth’s Dynamic Climate</td>
<td>analyse</td>
<td>Analyse; analyse; analyse</td>
</tr>
<tr>
<td>Physics: Light and Applications of Optics</td>
<td>analyse</td>
<td>Analyse; analyse; describe</td>
</tr>
</tbody>
</table>

A focus on the verb, ‘analyse’ appears to be prevalent in both the academic and applied STS[E] expectations and uses the British spelling of the word. There is also use of the word, ‘evaluate’ in the academic stream and ‘describe’ in the applied stream.

At the academic level, it appears that the use of the verb, ‘analyse’ from the curriculum document may intersect with Krathwohl’s (2002) framework category of ‘Analyze’ where the STS[E] expectations appear to be focusing on the “conceptual knowledge” domain with some emphasis on “procedural knowledge” (see Appendix B). There also appear to be some STS[E] expectations that focus on their categories of “evaluate” and “create” (see Appendix B). From my perspective, when exploring the applied STS[E] curriculum expectations, there tended to be a similar emphasis on the “analyze” category and focus on “conceptual knowledge” (see Appendix B). I noted a
difference between the STS[E] expectations in the “create” category as there appeared to be an expectation that focused on this area that was present in the academic STS[E] curriculum and absent from the applied STS[E] curriculum (see Appendix B).

Framework Applications and Explorations with the STS[E] Expectations

I found the applications of Levinson’s (2010) and Pedretti and Nazir’s (2011) frameworks to be useful regarding possible citizenship explorations and the STS[E] curriculum and to examine the ‘currents’ and themes that may be present. As previously mentioned, each curriculum expectation at the tenth-grade applied and academic level in the STS[E] segment was explored using these frameworks. These classifications proved to be challenging and complex for a number of reasons that are further explored in the discussions of these contexts below.

The following tables show the summations of those framework applications to the STSE curriculum expectations in both the applied and academic Grade 10 science contexts (please see Table 6.4 & 6.5 below).

TABLE 6.4: A summary of some possible areas of emphasis in the Grade 10 academic Ontario STS[E] science curriculum expectations using both Levinson (2010) and Pedretti and Nazir’s (2011) frameworks.

<table>
<thead>
<tr>
<th>Unit of Study</th>
<th>Approx. Number of STS[E] Outcomes</th>
<th>Deficit-Related Outcomes</th>
<th>Deliberate-Related Outcomes</th>
<th>Deliberate/Praxis-Related Outcomes</th>
<th>Praxis-Related Outcomes</th>
<th>Dissent &amp; Conflict-Related Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>B: Biology: Tissues, Organs, and Systems of Living Things</td>
<td>4</td>
<td>0</td>
<td>1 (Value-Centred)</td>
<td>3 (Value-Centred; Logical Reasoning; Logical Reasoning)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C: Chemistry: Chemical Reactions</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3 (Logical Reasoning; Logical Reasoning; Logical Reasoning)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D: Earth &amp; Space Science: Climate Change</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2 (Logical Reasoning; Socio-Cultural)</td>
<td>0</td>
<td>1 (Socio-Ecojustice)</td>
</tr>
<tr>
<td>E: Physics: Light &amp; Geometric Optics</td>
<td>3</td>
<td>0</td>
<td>1 (Application/Design)</td>
<td>2 (Socio-Cultural; Socio-Cultural)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
TABLE 6.5: A summary of some possible areas of emphasis in the Grade 10 applied Ontario STS[E] science curriculum expectations using both Levinson (2010) and Pedretti & Nazir’s (2011) frameworks.

<table>
<thead>
<tr>
<th>Unit of Study</th>
<th>Approx. Number of STS[E] Outcomes</th>
<th>Deficit-Related Outcomes</th>
<th>Deliberate-Related Outcomes</th>
<th>Deliberate/Praxis-Related Outcomes</th>
<th>Praxis-Related Outcomes</th>
<th>Dissent &amp; Conflict-Related Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>B: Biology: Tissues, Organs, and Systems</td>
<td>3</td>
<td>0</td>
<td>2 (Logical Reasoning; Logical Reasoning)</td>
<td>1 (Logical Reasoning)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C: Chemistry: Chemical Reactions and Their Practical Applications</td>
<td>3</td>
<td>0</td>
<td>3 (Application/Design; Application/Design; Application/Design)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D: Earth &amp; Space Science: Climate Change</td>
<td>3</td>
<td>0</td>
<td>1 (Logical Reasoning)</td>
<td>2 (Socio-Cultural; Logical Reasoning)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E: Physics: Light and Applications of Optics</td>
<td>3</td>
<td>0</td>
<td>2 (Socio-Cultural; Socio-Cultural)</td>
<td>1 (Socio-Cultural)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The associations between the frameworks as depicted above seem to show an emphasis on the deliberate category that overlaps with the logical reasoning, application and design and also socio-cultural STS[E] currents such as depicted in more detail here through the following examples from the curriculum (see Table 6.6):
TABLE 6.6: Examples of expectations from the Ontario Grade 10 science curriculum that may align with the deliberative and or deliberative/praxis framework category (Levinson, 2010) and overlap with the logical reasoning, application and design and socio-cultural currents (Pedretti & Nazir, 2011).

<table>
<thead>
<tr>
<th>Curricular Examples</th>
<th>Academic-Level</th>
<th>Applied-Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Possible ‘Logical Reasoning’ Association</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B1.2 assess the importance to human health and/or society of medical imaging technologies (e.g., ultrasound, X-rays, computerized axial tomography [CT or CAT] scan, magnetic resonance imaging [MRI], microscopy, biophotonics) used in Canada in diagnosing or treating abnormalities in tissues, organs, and/or systems [AI, C]</strong>&lt;br&gt;<em>Sample issue:</em> Ultrasound is routinely used during pregnancy to monitor the development of the fetus. It is also used to perform amniocentesis, which screens for genetic disorders, and allows doctors to perform surgery on the fetus before birth to correct some abnormalities. However, there have been few studies on the long-term effects of the use of ultrasound. (p. 74)</td>
<td><strong>B1.1 analyse, on the basis of research, medical imaging technologies (e.g., ultrasound, X-rays, computerized axial tomography [CT or CAT] scan, magnetic resonance imaging [MRI], microscopy, biophotonics) used in Canada to explore, diagnose, or treat the human body, and communicate their findings [PR, AI, C]</strong>&lt;br&gt;<em>Sample issue:</em> The diagnostic use of nuclear isotopes has saved lives by providing more reliable diagnoses of certain diseases. However, in the longer term, nuclear medicine could have harmful effects on the human body. (p. 86)</td>
<td></td>
</tr>
<tr>
<td><strong>Possible ‘Application &amp; Design’ Association</strong></td>
<td><strong>e1.1 analyse a technological device or procedure related to human perception of light (e.g., eye- glasses, contact lenses, infrared or low light vision sensors, laser surgery), and evaluate its effectiveness [AI, C]</strong>&lt;br&gt;<em>Sample issue:</em> Laser surgery corrects vision by surgically reshaping the cornea to correct refractive defects in the eye. While the procedure is effective in most cases, it poses risks and can in some cases lead to poor night vision. (p. 80)</td>
<td><strong>C1.2 identify practical applications of chemical reactions in a particular profession (e.g., ceramics, cosmetology, firefighting, heating and cooling system technology, food preparation, plumbing, custodial services), and assess the associated hazards, including hazards associated with the handling and disposal of chemicals [PR, AI, C]</strong>&lt;br&gt;<em>Sample issue:</em> Class B fire extinguishers containing ammonium phosphate, sodium bicarbonate, or potassium bicarbonate are effective in smothering fires involving flammable liquids. However, some of these chemicals are corrosive and can cause damage if introduced to an ecosystem. (p. 88)</td>
</tr>
</tbody>
</table>
Possible ‘Socio-cultural’ Association

d1.1 analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems (e.g., loss of habitat for Arctic mammals such as polar bears and loss of traditional lifestyles for Inuit as Arctic ice shrinks; famine as arable land is lost to desertification; an increase in water-borne disease and human resettlement as coastal lands are flooded; expansion of the growing season in some regions). (p. 78)

d1.1 analyse, on the basis of research, various ways in which living things and natural systems have been affected by climate change (e.g., the effect of loss of permafrost on northern roads and housing; the effect of longer growing seasons in some regions on farmers; the effect of warming oceans on coral reefs), and communicate their findings [IP, PR, AI, C]

Sample issue: Some areas of Canada have been experiencing hotter and drier summers, resulting in poor harvests, loss of wetland habitat, and increased incidence of forest fires. However, in other areas, an increase in the number of frost-free days has extended the agricultural growing season. (p. 90)

One sample issue from the academic level curriculum exploration depicted here that I found curious was this:

**Sample issue:** Ultrasound is routinely used during pregnancy to monitor the development of the fetus. It is also used to perform amniocentesis, which screens for genetic disorders, and allows doctors to perform surgery on the fetus before birth to correct some abnormalities. However, there have been few studies on the long-term effects of the use of ultrasound. (Ontario. Ministry of Education, 2008, p. 74)

I find it interesting that the emphasis here on monitoring the fetus and the potential uses for amniocentesis as a genetic screening device but no discourse of choice or informed consent. The discourse and language usage here may imply that the woman’s body is a docile recipient of said tests as her body is not even mentioned. This omission of the woman’s body is similar to descriptions presented by Lane and Lawlor (2007) when exploring the discourse of medical depictions of Papanicolaou (PAP) screening. For example, we might consider the discourses and possible connotations if we re-wrote this text to factor in the woman’s body and the use of language to support the idea of informed consent (i.e., modeled after Lane and Lawlor’s (2007) revised PAP testing pamphlets):
Ultrasound can be used during a woman’s pregnancy to monitor the development of the fetus growing inside her body with her consent. It is also used to perform amniocentesis on the woman’s body with her consent, which tests for genetic disorders (e.g., trisomy 21 or Down Syndrome), and may allow doctors, with the woman’s consent, to perform surgery on the fetus and the woman’s body before birth to correct some abnormalities. However, there have been few studies on the long-term effects of the use of ultrasound on either the woman’s body or the fetus growing inside.

A value-centred current possibly aligned with the deliberate and/or potentially a praxis-based approach appeared to be present in the academic stream and absent from the applied stream where the emphasis may be focused on understanding of issues and an awareness or the exploration of associated ethics or morals surrounding some of these socio-scientific issues. An example of an expectation that may align with a value-centred approach is depicted here (e.g., mention of ‘ethical issues’ in this curricular context is highlighted):

B1.1 analyse, on the basis of research, ethical issues related to a technological development in the field of systems biology (e.g., cloning, stem-cell research, live organ transplants, transgenic transplants), and communicate their findings [IP, PR, AI, C]

Sample issue: DNA screening is a valuable tool for determining whether a person is genetically predisposed to certain diseases. However, it raises ethical issues related to privacy, choice, access, treatment, and discrimination. It also raises questions about how far society should go in using available technologies, who funds research, and who owns or manages the resulting product or technology. (p. 74)

An argument may also be made that depending upon how a practitioner might interpret this expectation that it could also possibly align with a socio-ecojustice approach that may move into a praxis/dissent citizenship alliance. For example, if students explored an issue such as genetic or DNA screening and then decided to develop action plans or actions based on their research such as broader community educational initiatives about making such choices this expectation may possibly have a different sort of classification.
(i.e., also of note here is that the sample issue depicted is not technically part of the curriculum and educators may or may not use this issue in their practices).

6.3 Discussions and Theoretical Perspectives

The explorations of these frameworks at both the academic and applied level may indicate an association with Levinson’s (2010) deliberate or perhaps a ‘deliberative/praxis’ focus with certain expectations. This may in part be illustrative of the complexity of categorizing curricular data into distinctive areas and could suggest a transition from a Vision I to a Vision II alignment (Roberts, 2007) where a more contextualized approach to STS[E] is envisioned and possibly enacted from the curriculum expectations.

I found in some cases that the expectations may have had some characteristics of both a deliberative or praxis approach, but did not exactly fit in either of these contexts ‘neatly’. After much contemplation, I decided to embrace this complexity and created a separate category that features some ideas associated with each characterization for Ontario. An example of these expectations that I felt could indicate a transition from deliberate to a more praxis-based approach may be:

B1.3 describe public health strategies related to systems biology (e.g., cancer screening and prevention programs; vaccines against the human papillomavirus [HPV] and measles, mumps, and rubella [MMR]; AIDS education), and assess their impact on society [AI, C]

Sample issue: Early-childhood vaccination programs have greatly reduced the incidence of certain diseases and the social and medical costs associated with them. Influenced by controversial studies arguing that there may be health risks associated with such vaccines, some parents have chosen not to vaccinate their children, which could lead to a resurgence of these potentially deadly diseases. (p. 74)

Or

C1. analyse a variety of safety and environmental issues associated with chemical reactions, including the ways in which chemical reactions can be applied to address environmental challenges. (p. 76)

The other aspect tied with the categorization of these curriculum expectations and others and determining which framework categories seemed to align best was my uncertainty
regarding how practitioners might choose to interpret these STS[E] expectations. These expectations could align with either a deliberate or praxis based approach in a more decisive manner if additional data were explored regarding the context of how educators may interpret these learning outcomes (i.e., although, this may also add an additional layer of complexity as practitioners are individuals and will interpret the expectations as such). For example, in the second curricular example highlighted above, an educator might decide to address this overall expectation through the use of a mind-map to explore safety and environmental considerations of various chemical reactions, perhaps as a consolidation activity. Another practitioner may decide to have their students conduct research projects and then take research-informed and negotiated actions to address problematic STS[E] issues as aligned with the STEPWISE approach. Another educator could interpret the expectation and decide to hold a ‘town hall debate.’ The use of the mind map could be more closely aligned with a deliberate-style of involvement whereas the town hall debate or the presentation of research projects or possible construction and/or actions surrounding these topics could be more fitting with a praxis-based approach.

I classified the following expectation occurring in Unit D of the academic curriculum as an outcome that may align with a praxis or dissent and conflict style of approach and also a socio-ecojustice current:

d1.2 assess, on the basis of research, the effectiveness of some current individual, regional, national, or international initiatives that address the issue of climate change (e.g., Drive Clean, ENERGY STAR, federal and provincial government rebates for retrofitting older buildings to be more energy efficient, carbon offset programs, community tree-planting programs, municipal recycling programs, Intergovernmental Panel on Climate Change [IPCC]), and propose a further course of action related to one of these initiatives [PR, AI, C] (p. 78)

This expectation where students must explore the effectiveness of initiatives to address climate change based on their own research and then propose a course of action was quite different from the other types of learning outcomes found throughout the Ontario STS[E] curriculum. A course of action may imply a type of political literacy and introduce a political intersection in the science classroom; yet it is uncertain whether this might take

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25 See Dr. Larry Bencze’s STEPWISE framework found here for more details:
http://webspace.oise.utoronto.ca/~benczela/STEPWISE_Framework.html
the form of individualized actions or perhaps a collective type of action (i.e., also perhaps
dependent upon practitioner interpretation of the curriculum); also, it is uncertain whether
students would also perhaps enact their courses of action. This outcome is not found in
the STS[E] expectations of the applied curriculum (i.e., although, a similar expectation
does occur in the applied curriculum in a section separate from the STSE expectations—
D2.5 in the Developing Skills of Investigation and Communication).

This difference in curricular expectation location from academic where a potential
linkage to participatory citizenship is at the forefront in the STS[E] expectations and
appears ‘further’ down in the curriculum at the applied level is problematic. The work of
Sears (n.d.) on distinctions between the Ontario applied and academic curriculum may
speak to this observation:

I am struck by the much more critical and potentially political nature of the
questions raised for academic students [versus] applied students. The implication
is that academic students are much more ready for critical citizenship than applied
students. In citizenship, I don’t know why you would have different content.
There seems to be an assumption that applied students wouldn’t be able to handle
the bigger issues. In my own experience as a teacher, students in applied are, in
many cases, much more ready to engage in critical questions than academic
students are. (Alan Sears as quoted in Hamlin & Cameron, 2015, p. 4)

I have had many years of experience teaching students at the applied level and have
found my classes to be more than capable of rising to the challenge of critically analyzing
issues and concur with Sears.

6.4 Additional Analysis of Unit D: Climate Change

As explored above, I noted some interesting patterns and associations connected
with Unit D that focuses on the science of climate change at the tenth-grade level. This
was the only unit that featured an expectation from the academic level curriculum that
may align with a dissent and conflict/socio-ecojustice orientation. I found this interesting
and decided to conduct additional analysis on Unit D to explore patterns and emergent
themes based on my introductory analysis work with the application of the
aforementioned frameworks.
Global Perspectives

A theme emphasizing a more global perspective or a broader systems type of approach seemed to emerge from the climate change unit in the Ontario academic stream. This theme may be illustrated here through the following curriculum expectations:

- Analyse some of the effects of climate change around the world, and assess the effectiveness of initiatives that attempt to address the issue of climate change. (p. 78)

- Investigate, through research or simulations, the influence of ocean currents on local and global heat transfer and precipitation patterns. (p. 79)

- Classify the climate of their local region using various tools or systems (e.g., Ecoregions of Canada, bioclimatic profiles), and compare their region to other regions in Ontario, Canada, and the world. (p. 79)

This emphasis and connection to both the local community and a more global perspective on STS issues may intersect with Sauvé’s (2005) systems current where there could be more emphasis placed on the analysis of issues within a system context. This may enhance critical thinking skills as students are possibly challenged to view issues that occur locally or within other locations in Canada as global concerns. The Grade 10 applied curriculum does not appear to highlight this globalized context to the extent to which it appears to be present in the academic curriculum.

Logical Reasoning

An analytical emphasis seems to be another theme throughout the climate change curriculum that may connect with the work of Pedretti and Nazir (2011) and their logical reasoning STSE current such as illustrated here:

- Analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems (e.g., loss of habitat for Arctic mammals such as polar bears and loss of traditional lifestyles for Inuit as Arctic ice shrinks; famine as arable land is lost to desertification; an increase in waterborne disease and human resettlement as coastal lands are flooded; expansion of the growing season in some regions) [AI, C]

**Sample issue:** Scientists are researching changes in climate patterns as possible contributing factors to an increase in the number of smog days in Ontario and elsewhere in Canada. As the air quality worsens, people may curtail their outdoor activities, and those with respiratory problems may require medical attention, increasing health care costs.
Sample questions: How have recent extreme weather events such as heat waves in Europe or drought in southern Africa affected habitats in these regions? How might predicted changes to global temperature and precipitation affect agriculture in Ontario, Canada, or different areas around the world? How might the continuing reduction of the polar ice cap influence domestic and international transportation and shipping. (p. 78)

Within this context, there also appears to be connections and overlap with Sauvé’s (2005) systems current as perhaps demonstrated through the references to global weather events in Europe and Africa and also perhaps a socio-economic introduction through reference to transportation and shipping. Also of note in this expectation is the acknowledgment of the Inuit and their traditional lifestyle that could overlap with Pedretti and Nazir’s (2011) sociocultural current as First Nations, Metis and Inuit perspectives are mentioned. Of note also is that the Inuit considerations in this unit mentioned focus on ‘traditional lifestyles’ and not perhaps traditional environment knowledge (TEK) related to climate change. This theme may also be demonstrated here:

investigate a popular hypothesis on a cause- and-effect relationship having to do with climate change (e.g., the combustion of fossil fuels is responsible for rising global temperatures; the concentration of atmospheric CO₂ is responsible for rising global temperatures; global temperatures have been on the increase since the industrial revolution; the severity of cyclones, hurricanes, and tornadoes increases as atmospheric temperatures increase), using simulations and/or time-trend data that model climate pro-files (e.g., data from Statistics Canada and Environment Canada) [PR, AI, C]. (p. 79)

Critical Thinking & Climate Change

Another theme that emerged was a focus on thinking critically regarding climate change. Many of the expectations clearly highlight anthropogenic origins to some of the curricular perspectives in this unit such as:

investigate various natural and human factors that influence Earth’s climate and climate change;

and
demonstrate an understanding of natural and human factors, including the greenhouse effect, that influence Earth’s climate and contribute to climate change. (p. 78)

Human factors are clearly mentioned in both overall unit expectations. Also of note is that ‘natural’ climate change factors are prioritized in both sentence structures.

A more critical thinking approach to analyzing climate change may also be evident in the following expectation:

analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems (e.g., loss of habitat for Arctic mammals such as polar bears and loss of traditional lifestyles for Inuit as Arctic ice shrinks; famine as arable land is lost to desertification; an increase in water-borne disease and human resettlement as coastal lands are flooded; expansion of the growing season in some regions). (p. 78)

Current effects are prioritized and the potential is also mentioned. Both pros and cons about the effects of climate change are mentioned in this expectation with the example of potential for expansions of growing seasons in some regions. The applied curriculum expectation similar to this one additionally indicates an example of a potential ‘positive’ associated with climate change as demonstrated here:

analyse, on the basis of research, various ways in which living things and natural systems have been affected by climate change (e.g., the effect of loss of permafrost on northern roads and housing; the effect of longer growing seasons in some regions on farmers; the effect of warming oceans on coral reefs), and communicate their findings [IP, PR, AI, C]

Sample issue: Some areas of Canada have been experiencing hotter and drier summers, resulting in poor harvests, loss of wetland habitat, and increased incidence of forest fires. However, in other areas, an increase in the number of frost-free days has extended the agricultural growing season. (p. 90)

These expectations suggesting that there are both pros and cons regarding climate change are unusual and may intersect with the work of Oreskes and Conway (2010) where they have explored the phenomenon regarding the denial of global warming as primarily a political issue (i.e., as there is currently such as high degree of consensus in the scientific community regarding the anthropogenic causes of climate change). For example, they describe this connection here:
This divergence between the state of the science and how it was presented in the major media helped make it easy for our government to do nothing about global warming. Gus Spieth had thought in 1988 that there was real momentum toward taking action. By the mid-1990s, that policy momentum had not just fizzled; it had evaporated. In July 1997, three months before the Kyoto Protocol was finalized, U.S. senators Robert Byrd and Charles Hagel introduced a resolution blocking its adoption. Byrd-Hagel passed the Senate by a vote of 97-0. Scientifically, global warming was an established fact. Politically, global warming was dead. (p. 215)

This style of expectation wording as to be inclusive of a potential positive association might indicate compromises between stakeholders involved in the curriculum construction process. Expansion of growing seasons in relationship to climate change is contentious—others would argue that potential seasonal extensions could be off-set by crop damage from for example hail storms. Bloch (2014) describes an example of compromise regarding the use of the word, ‘environment’ in the curriculum as reported here that may aid in the explanation of why a more seemingly balanced perspective is offered regarding climate change:

…the Parent Council expected a balanced approach in that students were learning the science related to environmental issues and that the curriculum did not have expectations presenting a negative view of business and industry on environmental issues. (p. 262)

*Actions*

The climate change unit focuses on the development of a proposed course of action (i.e., that may or may not be actually implemented by the student(s)) that relates to initiatives presented in the Grade 10 academic curriculum such as indicated here:

assess, on the basis of research, the effectiveness of some current individual, regional, national, or international initiatives that address the issue of climate change (e.g., Drive Clean, ENERGY STAR, federal and provincial government rebates for retrofitting older buildings to be more energy efficient, carbon offset programs, community tree-planting programs, municipal recycling programs, Intergovernmental Panel on Climate Change [IPCC]), and propose a further course of action related to one of these initiatives. (p. 78)

This expectation also relates to the systems focus previously explored where there is exploration of various initiatives at the local level up to and inclusive of the international. There are initiatives discusses that might be congruent with a sustainable development focus such as Drive Clean, ENERGY STAR, retrofitting older buildings for efficiency,
recycling and carbon credit programs and one initiative mentioned that would be perhaps more conservation-minded such as tree planting. The focus appears to be more so on mitigation of impacts.

The development of a course of action related to an initiative may overlap with Levinson’s (2010) praxis/dissent frameworks as students potentially conduct their own research regarding these programs and then formulate a related action plan; however, it is unclear if these actions are implemented by students. There may also be connections with Pedretti and Nazir’s (2011) socio-ecojustice current where they state that learning opportunities often take the form of

…developing action plans, changing their own habits, educating others, lobbying for change, raising funds, planting trees, and litter cleanups. (Pedretti & Nazir, 2011, p. 618)

This expectation also may intersect with Sauvé’s (2005) praxis current where students are reflecting on various initiatives and then considering how to implement actions in their own lives. This expectation of the development of a plan differs slightly in the applied curriculum such as demonstrated here:

investigate their personal carbon footprint, using a computer simulation or numerical data (e.g., determine carbon emissions that result from their travelling to school, work, and recreation venues; from vacation travelling; from buying products imported from distant countries), and plan a course of action to reduce their footprint (e.g., a plan to increase their use of bicycles or public transit; to eat more local foods). (p. 91)

Instead of focusing on various initiatives, both local and global, this expectation has the students explore their personal carbon footprint and plan a course of action to reduce their carbon footprint. This approach may speak to the students more so than the focus outlined in the academic curriculum as the personal carbon footprint is personal. The examination of various initiatives certainly can be beneficial, however, the students may not be able to relate to this information. In both the applied and academic stream there is no curricular indication that the action plan will actually be carried out.
6.5 Some Factors that May Influence the STS[E] Curriculum

6.5.1 The Curriculum Development & Revision Process in Ontario

As briefly explored in the introductory literature review, there are many facets and complicated aspects of the curriculum development process across all provinces including Ontario. The actual stakeholder interactions, power-relations and other conversations and consultations that occur to construct a curriculum remain rather obscure and quite challenging to access information about. Fensham (2013) offers the following perspective commenting on these somewhat closed proceedings here,

Jenkins (2012), in reviewing the role of public policy in k-12 science education (edited by De Boer 2010) points out that significant parts of policy formulation for science education are usually closed to contemporary public or scholarly scrutiny until opened later by historians... (p. 154)

I found the work of Bloch (2014) to be very illuminating regarding some of these stakeholder proceedings in Ontario. She traced education and science education policy formation and stakeholder interactions over the course of three different provincial Ontario governments (i.e., PC, NDP and Liberal) through document analysis and interviews with various people involved in curriculum development processes. For example, in Ontario the curriculum documents use the term ‘expectation’ versus ‘outcome’ (i.e., ‘outcome’ is used in both Alberta and Manitoba). She reports that this originated from the PC time in office where the Minister of Education, John Snobelen, disliked the word, ‘outcome.’ Political interactions may also help to explain why Ontario has different ‘levels’ or educational streaming which appears to be distinct from either Alberta or Manitoba (i.e., at least how the outcomes/expectations appear to be constructed as per the curriculum documents). Bloch (2014) comments here on the streaming practices present in Ontario:

…The Ontario Curriculum for Grades 9 and 10 discontinued the policy of a de-streamed Grade 9 that had been introduced by the NDP government. The new PC curriculum had two streamed courses for both Grades 9 and 10. One course was designated as academic -with a focus on theory, and the other course was designated as applied-with a focus on applications. The Ontario Curriculum for Grades 11 and 12 discontinued the OS:IS curriculum organisation around three streams of advanced, general and basic and were instead organised around post-secondary destinations of university, college, workplace and university/college
Bloche (2014) found that there were a number of educational stakeholder opinions (e.g., universities, colleges, parent organizations) that were collected and assembled during curriculum construction processes. Bloche (2014) states that despite this consultation among many stakeholders that,

...power and control of information remained with Ministry staff. They synthesized the documentation from the input stage into a recommendations report. This report required approval by senior administration before any writing proceeded. (p. 30)

6.5.2 STS[E] and The Achievement Chart

Assessment and assessment practices are of critical importance regarding student learning across all subject areas. Race et al. (2005) succinctly summarize the importance of these practices in stating, “Nothing we do to, or for our students is more important than our assessment of their work and the feedback we give them on it. The results of our assessment influence students for the rest of their lives…”

The Achievement Chart is a schematic developed by the Ministry of Education to provide guidelines regarding assessment practices which I have read and used many times as a practitioner. As I looked more closely and critically at this representation from my lens using discourse analysis, I made note of some interesting observations that Bloche (2014) had also explored in her work.

The Achievement Chart consists of four overarching areas found in the science curriculum which are: Knowledge and Understanding; Thinking and Investigation; Communication and Application. These segments are aligned with the overall and specific curriculum expectations found in each unit of study (i.e., and also in different grade levels). The Application segment of this chart is tied with STS[E] assessment practices as depicted though the final two points under this heading which are:
-Making connections between science, technology, society, and the environment (e.g., assessing the impact of science on technology, people and other living things, and the environment)
-Proposing courses of practical action to deal with problems relating to science, technology, society, and the environment (The Ontario Curriculum, Grades 9 and 10, p. 27)

Although the STS[E] curricular expectations are at the forefront of each unit, the Application segment and the STS[E] portions appear at the end of the Achievement Chart. Bloche (2014) comments here regarding the Achievement Chart and this STS[E] ‘undermining effect’ when discussing the curriculum changes from the Making Connections category to Applications where she states,

The revised McGuinty Liberal achievement chart has reduced making connections to a criterion within the new category called Applications. The significance of this is that the revised Achievement Chart undermines the emphasis of STSE in the curriculum text. (p. 309)

Assessment practices are very important as noted in the literature and this placement on the Achievement Chart regarding STS[E] may be significant. If readers of this document are reading the Achievement Chart and see that STS[E] is not prioritized, why teach it as such (i.e., although, it should be noted that assessment weighting for final grades may also factor into perceptions of prioritization)?

6.5.3 Explorations of Ontario’s Political Landscape

This case study segment explores some facets of the general political context present in Ontario at the time of the construction and implementation of the Grade 9 and 10 Ontario science curriculum (2008) that may be helpful in understanding some of the political climate that perhaps surrounds/surrounded the development of the STS[E] curriculum. The following documents have been used to help explore some political perspectives such as: the Liberal Party of Ontario Election Platform entitled: Moving Forward, Together: The Ontario Liberal Plan Highlights (2007), Speech from the Throne (November 29, 2007), Ministry of Education webpages and the Go Green: Ontario’s Action Plan on Climate Change (2007).
Currently, the Liberal Party of Ontario has formed the Government of Ontario since 2003. Khan and McNiven (1999) quote Lester Pearson as epitomizing Liberal perspectives in Canada here,

Liberalism stands for the middle way: the way of progress. It stands for moderation, tolerance, and the rejection of extreme courses, whether they express themselves in demands that the state should do everything for the individual…or in demands that the state should do nothing except hold the ring so that the fittest survive under the law of the jungle. (p. 363)

They also assert that, despite our close geographic location to the United States, where classical liberalism is more prominent, Canada, “…reflects more the reform liberal tradition” (p. 363). The following quote from Khan and McNiven (1999) may also help to provide some general characteristics associated with the Liberal party:

In general, they accept active participation of government as a means for the solution of social problems. The liberal economic and political elite prefers to use the power of government to develop and regulate the economy, rather than give in to unfettered private enterprise and a competitive market economy, as classical liberals advocated. Canadian liberals find this a safe middle ground in the face of challenges from the conservative right and the social left. Instead of individualism, free competition, and laissez faire, they have adopted the principles of social reform, public ownership of certain sectors of the economy, and the welfare state. (pp. 367-368)

The following Wordles™ (please see Figures 6.1 & 6.2 below) have been created to aid in the presentation of some general aspects of the political climate presented throughout this section. These Wordles™ may present an interesting overview of some of the words that have been highlighted in the election platform and also the Speech from the Throne which sets the tone for the government delivered by the Honourable David C. Onley, Lieutenant Governor of Ontario on November 29, 2007 (i.e., just after the Liberal party formed the government of Ontario) entitled, “Moving Forward the Ontario Way.”

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27 According to Khan and McNiven (1999), “Reform liberals stressed the need for positive government intervention to create conditions which would enable individuals to use their abilities effectively” (p. 360).
Figure 6.1: Wordle™ depiction of the Ontario election platform, Moving Forward Together (2007) where the larger wording indicates a more frequently appearing word in the document.

Figure 6.2: Wordle™ depiction of the Ontario November 29, 2007 Speech from the Throne where the larger the word appears, the greater the number of times the word appears in the document.

Figures 6.1 and 6.2 show some overlap in terms of words emphasized such as: government, Ontario, Ontarians, help and some differences such as the emphasis placed on people, work, care and jobs in the throne speech versus more emphasis placed on energy and school in the platform.
Neoliberalism

The economy and economic considerations such as job creation are listed after educational priorities in the Ontario Liberal Platform (2012) perhaps indicating that economic factors may rank slightly behind educational issues. The first few focal areas appear to prioritize job creation that may align with some tenets of neoliberalism such as illustrated here:

Expand our Next Generation Jobs Fund to $1.15 billion to support job creation in areas of great potential for Ontario. (p. 3)

And here,

Add a new Second Career strategy to our Rapid Re-Employment and Training Service, to help Ontarians who have suffered job loss build new skills and find new employment. (p. 3)

There is also specific mention of programs to support more affordable housing, poverty reduction strategies, full-day pre-school and tax reductions for businesses in Ontario. I do not think that strategies to reduce poverty and provide affordable housing is necessarily aligned with neoliberalism, however, as Bencze (2010) reminds us, tax breaks for businesses could be indicative of these possible relationships.28

These points mentioned regarding neoliberalism may also connect with the work of Bloche (2014) where she draws from the work of several scholars and states that:

The McGuinty Liberals, like the PCs that preceded them adopted neoliberal principles in their social and economic policies (Fanelli & Thomas, 2011). When first elected McGuinty positioned himself as a moderate but Fanelli and Thomas (2011, p. 151) stated that he is ‘a much more sophisticated and nuanced neoliberal than his predecessor’. As examples they cited his introduction of new public management techniques and the privatization of services formerly covered under Ontario’s health insurance plan. Coulter (2009) suggested that the McGuinty Liberals represent a form of Third Way neoliberalism drawing from both the left and right to pursue their political agenda. (p. 281)

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28 This possible association between provincial taxation and neoliberalism is explored more thoroughly in the Manitoba case study.
Neoliberalism: Student Achievement. Education and educational initiatives are both highlighted and mentioned specifically in terms of action items such as presented here in the Ontario Liberal Platform (2012):

In the next four years, our goal is to reach every child. We want all our students to do better in school. We will provide them with the individual attention they need in a quality setting, measure their progress to ensure we’re getting results, and ensure we take positive action if a student, or school, is struggling. (p. 2)

Although education may be thought of as a collective goal; this objective uses the terminology, ‘individual attention’ perhaps implying that the individual may be prioritized in the classroom setting and could be linked with some neoliberal constructs (Carter, 2010); however, this may also be thought of as a measure of inclusivity to provide supports to all students where needed. Measurement of the result perhaps implies a more reductionist approach to education and may raise the following questions: How and what will be measured? Why does this matter? This may be associated with Ball’s (2012) linkages to performativity and an education results orientation. What are positive actions taken if a student or school falls short of the expectation or goal? My findings intersect with Bloche’s (2014) discussions of the McGuinty government as presented here:

By setting targets for literacy, numeracy and high school graduation, and the surveillance and accountability mechanisms to measure their success, Ontario education became an auditable commodity. (p. 286)

And here:

The McGuinty Liberals had a focused agenda on accountability, surveillance and regulation to prepare students for a global marketplace (Ontario. Ministry of Education, 2004). (pp. 290-291)

Some of these items were also discussed in the Ontario Hansard (i.e., the transcript of discussion in the legislature) (please see Appendix C). Science or science education does not appear to be an emphasized item of discussion. This finding echo’s the work of Bloche (2014) where she discusses how subjects like science were seemingly not a

29 Ball (2012) states, “Performativity is enacted through measures and targets against which we are expected to position ourselves but often in ways that also produce uncertainties bout how we should organize ourselves within our work (p. 31)”
priority of this government (i.e., she also asserts that this may not have been the intent, however, that it appears to be a consequence of their focus on other areas such as numeracy and literacy). Her findings may provide some context and explanation as to why discussions regarding achievement and funding occurred so often in the Hansard (see Appendix C).

**Sustainable Development**

The phrase, ‘sustainable development’ does not appear explicitly in this platform, however, many of the more action-oriented items appear to reflect a focus on sustainable development where there is prioritization placed on human-needs and sustaining the economy in the context of environmental protections and conservation perhaps as illustrated here:

Make our energy greener and cleaner, with the province’s first long-term energy plan in a generation. Our plan will replace coal by doubling renewables and doubling conservation.

Build more rapid transit, with Move Ontario 2020, the largest transit expansion in Canadian history.

Reduce emissions that cause climate change by 6% below 1990 levels by 2014, 15% below by 2020 and 80% by 2050.

Provide rebates and tax incentives for Ontarians to buy energy efficient appliances and make energy saving investments in their home.

Eliminate inefficient, old light bulbs

Provide financial assistance to communities to help save energy and reduce emissions that cause climate change.

Create a tough new toxic reduction law that requires companies that emit toxic pollution to reduce their emissions over time

Work with Cancer Care Ontario and the Ontario Medical Association to identify, target and reduce the number of cancer-causing agents released into our environment. (p. 5)
And also present in Go Green: Ontario’s Action Plan on Climate Change (2007) document as depicted here:

*Climate change is the defining issue of our generation—we’ve come a long way, but we have more to do, together. By putting Ontario at the forefront of green innovation, we can meet our responsibility to the generations to come and create jobs and new opportunities for people today.* Premier Dalton McGuinty. (p. 7)

And here:

We must also act, because this environmental crisis is also an economic opportunity. As a province with a strong manufacturing sector, plenty of natural resources, and a smart, educated, skilled workforce, there are opportunities for Ontario.

We don’t have to choose between a strong economy and a healthy environment. Faced with the challenge of climate change, the only way to have a strong economy is to go green. And the only way to go green is to have a strong economy. (p. 3)

Associations between a ‘greener’ economy and climate change are clearly indicated. This may convey messages to a more business oriented readership that ‘going green’ is not going to significantly impact the economy and that the two are simpatico through the introduction of ‘greener’ technologies and less reliance on petroleum-based products.

These goals do not seem to suggest that production is associated with economic slow-down, but rather appear to indicate that greener approaches such as reduction of emissions, use of ‘cleaner’ technologies and the reduction of chemicals will be released into the environment. There is no explicit mention of alternative energy creation here such as wind or the use of solar or nuclear energy (i.e., not to say that this is not occurring). This discourse may be related to Sauvé’s (1996) presentation of the Calgary Latin American Studies Group (1994) conceptualizations of varying classifications of sustainable development. In this case, the discourse might suggest an alliance with the following perspective:

Development as dependent on a world order CREDO: economic growth will solve social and environmental problems if a world order (from top organizations) regulates consumption, pollution and mechanism of distribution of wealth (Calgary Latin American Studies Group, 1994). (Sauvé, 1996, p. 27)
And may also align with this description provided of the “Principle Characteristics” as stated here:

Free trade on a world scale; scientific and technological innovations for economic growth; restructuring of political, economic and social organizations: world or regional-wide pacts, agreements, legislation, etc. (Calgary Latin American Studies Group, 1994). (Sauvé, 1996, p. 27)

*Environmental Conservation.* There also appears to be a theme that might be aligned with an environmental conservation approach separate from a focus on the aforementioned sustainable development. These initiatives outlined in the platform aimed at a conservation approach in an environmental context may be associated with the following initiatives and ideas:

Implement our nation-leading Endangered Species Act, beginning with a plan to protect large-scale areas for caribou habitat in the Boreal Forest.

Consider applications by regional and county governments to grow the Greenbelt.

Create stronger protections for threatened lakes like Lake Simcoe and provide funding to clean up hot spots in the Great Lakes, like Randle Reef in Hamilton. (p. 5)

These priorities differ from the sustainable development discourses as outlined above, which place the economy before the environment; whereas, here, the environment is emphasized. The verbs, ‘protect’ and associations with ‘growth’ are specifically tied in with environmental considerations. This theme also occurs in Go Green: Ontario’s Action Plan on Climate Change (2007) such as illustrated here:

*What’s next – 50 million trees*
Ontarians have said they want their province to do more to protect — even expand — our forests.

Together, we’re going to take a historic step — we’re going to plant 50 million trees across southern Ontario by 2020.

In northern Ontario’s managed forests the government will also continue our efforts to replant trees. Together we’ll continue to manage this sustainable resource sustainably to ensure the maximum potential of Ontario’s forests to store carbon. (p. 24)
The first two objectives prioritize protection and expansion of natural areas through tree planting. The third objective is a bit misleading as typically the intent of tree planting in a ‘managed’ forest is to restore the resource for a harvesting event at some point in the future. While this does temporarily sequester carbon, when the trees are harvested the carbon is again released to the environment.

**Actions**

The collective acknowledgement of climate change and associated actions was an emergent theme. This acknowledgement may be associated with this statement,

> Climate change is a crisis we caused together, and a responsibility we all share, together. So it’s important we act, not only because we can’t ignore the science, not only because we bear the responsibility, and not only because we have an obligation to our children. (Go Green: Ontario’s Action Plan on Climate Change 2007, p. 3)

The word, *together*, is highlighted in the first passage. Is this a collective crisis or perhaps an example of an externality that has been transferred to society by industry creating pollution? There is also reference to the obligations we have to our children. The framing of climate change as an issue that could impact our children is conveying a powerful and personal message to the readership of this document.

There are also connections made regarding global responsibilities and actions regarding climate change. This following passage may illustrate this association here:

> Climate change is a global issue that requires global solutions. While we know we can count on Ontarians’ innovation and ingenuity to provide opportunities and solutions here at home, Ontario must continue working with other places in the world to share information, solutions and ideas that will benefit all of us. (Go Green: Ontario’s Action Plan on Climate Change, 2007, p. 33)

Collective actions to mitigate climate change with an Ontario focus may be exhibited in this quotation from Go Green: Ontario’s Action Plan on Climate Change (2007):

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30 Externality is an economic term referring to a benefit or cost that impacts another party who did not choose to acquire the benefit or cost ([https://en.wikipedia.org/wiki/Externality](https://en.wikipedia.org/wiki/Externality) Accessed July 25, 2015).
In addition to building our homes more efficiently and sustainably, we have to build our communities more efficiently – preserving green space, building near transit, increasing density and reducing the distance people have to commute to work. We are one of the leading jurisdictions in North America for planning for sustainable growth through innovative land-use planning legislation and policy such as the reformed Planning Act, the new Provincial Policy Statement, the Places to Grow Act and the Greenbelt Act. (p. 17)

Adaptation to climate change is also mentioned. This could be viewed as both a collective response and also having individualized implications. This perspective seems to be acknowledged here in Go Green: Ontario’s Action Plan on Climate Change (2007):

Scientists, most notably the IPCC, tell us that, while we can prevent the worst effects of global climate change if we act now, the volume of greenhouse gases already in the atmosphere means that Ontario will still experience some of these effects, no matter what. (p. 34)

And possibly here,

Climate change will impact on public and private infrastructure, the natural environment, people and other species.

That’s why we need to take steps to adapt to the changes that will occur. (p. 34)

There is also mention of consultation with First Nations, Metis and Inuit groups and representatives from northern Ontario.

6.6 Some Concluding Thoughts

Political Climate and the STS[E] Curriculum

It is challenging to gauge the extent to which political landscape may influence curriculum due to many factors and stakeholders that shape the curriculum in Ontario. In the following concluding remarks, I discuss a few areas that I feel demonstrate overlapping connections and themes that may indicate some influence from the political sphere on the STS[E] curriculum that has been explored in this case study. However, there are also some gaps such as the prominence of environmental discourse present throughout much of the political literature and then expectations that have students explore both positive and negative attributes of climate change. The other misalignment appears to be with inconsistencies between STS[E] curricular importance and then what
is assessed based on the structure and placement of the Application category. It would appear that influence from the Political on the STS[E] curriculum at the Grade 10 level is limited. There may be some associations or connections in the following areas linked with general political culture, however, it would appear that some of these connections might come into play in parts of the science curriculum that are not technically parts of the curriculum such as the front matter or the examples or issues that follow the expectations.

*Sustainable Development and Environmental Focus*

The environment is featured prominently in the front matter of the curriculum document and also in the curriculum outcomes featured throughout this case study. This was also a political theme that was present across the various documents explored. Bloch (2014) states,

> Political interest in environmental education led to a stronger emphasis regarding environmental stewardship across all subject areas. This is an example of government influence being itself influenced by the public and the media. In spite of the lessened role of curriculum policy with the McGuinty Liberal government, when there was media interest, like other governments, they took action. (p. 305)

The political documents explored in this study seem to indicate the perspective of both natural and human responsibility for climate change. They acknowledge that Ontario and Ontarians are both part of the cause and potential mitigation of climate change through both collective and individualized initiatives. This shared responsibility stance may surface through the references in the curriculum to the word, anthropogenic, which primarily relates to human influence on the environment. This word, or its associations are featured in many curriculum expectations that have been previously explored.

*Actions*

There appears to be a focus on the proposal of collective and individual actions associated with climate change mitigation from the exploration of the selected political documents (i.e., which may or may not actually be implemented by students). This seems to be a focus in the curriculum expectations where students prepare action plans based on
either their analysis of a climate change policy (i.e., academic stream) or on the analysis of their carbon footprint (i.e., applied stream). The focus in the academic stream examines broad types of policy (e.g., carbon credits, recycling programs) to base action plans on whereas the applied curriculum has students base their action plans on their personal carbon footprints. This could indicate that action plans in the academic stream may focus more so on collective actions whereas the applied action plans may focus more on individualized plans. There is no curricular indication that students would be encouraged to actually implement either type of plan.
Chapter Seven - Explorations of STS[E] Education in Manitoba at the Tenth-Grade Level

This section of the case study about Manitoba focuses on an exploration of the STS[E] segments of the Senior 2 Science: Manitoba Curriculum Framework of Outcomes (2001) and the Senior 2 Science: A Foundation for Implementation (2003) documents. I begin this section with a brief overview of some of the more general document features and then focus specifically on the STS[E] curriculum in Strand 0 of the curriculum and also the more contextualized outcomes located in various units. As with the previous two case studies, I have used various tools to aid in these explorations such as document analysis, some tools associated with discourse analysis and Posner’s (2004) overview of curriculum analysis. As previously mentioned, I have applied various theoretical frameworks such as Bloom’s revised taxonomy (Krathwohl, 2002); Levinson (2010) and Pedretti and Nazir (2011) to provide a diversity of theoretical lenses to support and strengthen my analysis of this portion of the curriculum.


Two documents were utilized for analyzing the tenth-grade level science curriculum in Manitoba: the Senior 2 Science: Manitoba Curriculum Framework of Outcomes (2001) (i.e., 13 pages in length including Senior 2, Cluster 0) and the Senior 2 Science: A Foundation for Implementation (2003) (i.e., 631 pages in length). The first of these two sets of curricular documents is a more ‘bare-bones’ depiction of the specific learning outcomes present in each of the units of study whereas the Foundation for Implementation is a very comprehensive ‘guidebook’ of the curriculum including sample ideas for implementation, detailed appendices including many resources and an extensive front matter section. The Foundation for Implementation might be characterized as almost a type of ‘textbook’ due to the depth, length and level of detail presented in the document. The front matter in the Foundation for Implementation (2003) provides an

31 The Manitoba Senior 2 Science Curriculum is equivalent to a Grade-10 level curriculum.
overview of the priorities of Canadian science programs as aligned with the Pan-
Canadian Science Framework (1997) (i.e., an intertextual reference) such as:

A. Nature of Science and Technology
B. Science, Technology, Society, and the Environment (STSE)
C. Scientific and Technological Skills and Attitudes
D. Essential Science Knowledge
E. Unifying Concepts. (p. 5)

Also emphasized in the curriculum front matter is range of pedagogical styles and inquiry approaches where there is increased emphasis placed on:

Understanding scientific concepts and developing abilities of inquiry; Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science; Integrating all aspects of science content; Studying a few fundamental science concepts; Implementing inquiry as instructional strategies, abilities, and ideas to be learned. (p. 3 from Reproduced from National Research Council, National Science Education Standards Washington, DC: National Academy Press, 1996) 113. Reproduced by permission (as noted in the document))

and also,

Activities that investigate and analyze science questions; Investigations over extended periods of time; Process skills in context; Using multiple process skills—manipulation, cognitive, procedural; Using evidence and strategies for developing or revising an explanation; Science as argument and explanation; Communicating science explanations; Groups of students often analyzing and synthesizing data after defending conclusions; Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content; Applying the results of experiments to scientific arguments and explanations; Management of ideas and information; Public communication of student ideas and to classmates. (p. 3 from Reproduced from National Research Council, National Science Education Standards Washington, DC: National Academy Press, 1996) 113. Reproduced by permission (as noted in the document))

The document contains many conceptual and graphic organizers to depict information such as the associations between science and technology, sustainable development, STS[E] decision-making processes, literacy and also the general organization of the curriculum outcomes.
The use of the circle to represent science literacy may imply the use of a schematic that is less hierarchical, however the bottom portion of their curriculum organizational schematic still appears somewhat hierarchical (Heimer, 1969 as cited by Posner, 2004, p. 133). This conception ties together the Manitoba vision for scientific literacy to the specific learning clusters organized by grade level. As indicated in this organizer, the Manitoba Senior 2 Science curriculum is organized into the following five content areas:

Cluster 0: Overall Skills and Attitudes (i.e., this includes STS[E] content)
Cluster 1: Dynamics of Ecosystems
Cluster 2: Chemistry in Action
Cluster 3: In Motion
Cluster 4: Weather Dynamics

The relative positioning and flow of these curricular units of study may indicate increased importance placed on the Overall Skills and Attitudes outcomes which contain the STS[E] content and context, although, the use of the number zero might imply less of a prioritization. Weather Dynamics (i.e., contains the content related to climate change) is positioned as a final outcome that may indicate to the reader decreased significance and could, depending upon unit delivery, leave less time toward the end of a course for inclusion of content. If we consider Gee’s (2011) tool, ‘why this way and not that way’ and apply this construct to the organizational structure, we might consider how the significance to the reader regarding the semiotic display of this structure changes if we were to perhaps re-image it as:
Figure 7.1. Re-envisioning the organizational presentation of units of study in the Manitoba tenth-grade science curriculum.

or even this visual ‘flipped’ a quarter turn to the right so that the Overall Skills and Attitudes visually appear as an over-arching feature. A small change in structural organization can have implications to the reader such as moving the Overall Skills and Attitudes to a placement that emphasizes a more equitable distribution as perhaps opposed to the structure above that may suggest that the Strand 0 outcomes remain removed from the other outcomes. The General Learning Outcomes\(^\text{32}\) mentioned in the curriculum front matter are also associated with STS[E] which are intertwined with the specific outcomes associated with clusters 1 – 4 as listed here:

B1. describe scientific and technological developments past and present and appreciate their impact on individuals, societies, and the environment, both locally and globally

B2. recognize that scientific and technological endeavours have been and continue to be influenced by human needs and the societal context of the time

B3. identify the factors that affect health, and explain the relationships among personal habits, lifestyle choices, and human health, both individual and social

B4. demonstrate a knowledge of and personal consideration for a range of possible science- and technology-related interests, hobbies, and careers

\(^{32}\) General Learning Outcomes are also associated with the following curricular areas: Nature of Science; Scientific and Technical Knowledge Skills and Attitudes General Learning Outcomes; Essential Science Knowledge General Learning Outcomes and Unifying Concepts General Learning Outcomes.
B5. identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally. (p. 20)

In addition to these General Learning Outcomes associated with STS[E], there is specific and detailed reference to the decision-making processes that might be associated with the explorations of STS[E] using a flow chart. An interesting feature of this schematic is the visually equivalent representations of the decision-making process regarding STS[E] and the decision-making and implementation process. The *implementation* of STS[E] decisions is an interesting and highlighted feature. While ‘reflection’ may imply deeper thought or even emotional exploration.

### 7.2 Explorations of STS[E] Content and Selected Framework Applications

*An Exploration of Verbs Associated with STS[E] and Unit Outcomes*

The central focus of my analysis is the content found in the Overall Skills and Attitudes (i.e., Strand 0) as it reflects the location of most of the STS[E] content, however, all units of study were read and analyzed. The following Wordle™ depicts some of the verbs that appeared to be emphasized in the curriculum outcomes across all clusters (please see Tables 7.1 & 7.2 below) occurring in the Senior 2 Science: Manitoba Curriculum Framework of Outcomes (2001):

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33 Please see the following Manitoba Ministry of Education website for a full description of schematics found here: [http://www.edu.gov.mb.ca/k12/cur/science/found/s2/s2_fulldoc.pdf](http://www.edu.gov.mb.ca/k12/cur/science/found/s2/s2_fulldoc.pdf)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Wordle™ to Illustrate Outcome Verbs Appearing Most Frequently in STSE Outcomes (i.e., verbs associated with the other skills &amp; attitudes were omitted)</th>
<th>Commonly Occurring Verbs Associated with Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior 2, Cluster 0: Overall Skills and Attitudes (STSE-related outcomes)</td>
<td><img src="image" alt="Wordle" /></td>
<td>Demonstrate; describe; discuss; identify</td>
</tr>
</tbody>
</table>
In the Senior 2 Science: Manitoba Curriculum Framework of Outcomes (2001), most of the STSE content is located in a separate cluster (i.e., Strand 0 as mentioned previously) that is to be integrated throughout the curriculum (as well as some outcomes in the contextualized units and also in the General Learning Outcomes). To accommodate for this difference in curricular delivery, I decided to present these findings as two separate tables (i.e., although in the delivery of these outcomes, they may be merged). The verbs highlighted in Table 7.1 via the use of the Wordle™ tool may indicate that

### TABLE 7.2. Wordle™ depiction of verb stems used in Strands 1 – 4 of the Senior 2 Science curriculum outcomes.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Wordle™ Depicting Verbs used in Unit Curricular Outcomes</th>
<th>Commonly Occurring Verbs Associated with Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior 2, Cluster 1: Dynamics of Ecosystems</td>
<td>explain; discuss; interpret; construct; observe; document; illustrate</td>
<td>Explain; investigate; discuss; describe</td>
</tr>
<tr>
<td>Senior 2, Cluster 2: Chemistry in Action</td>
<td>investigate; describe; experiment; classify; write; relate; balance</td>
<td>Investigate; explain; write</td>
</tr>
<tr>
<td>Senior 2, Cluster 3: In Motion</td>
<td>experiment; gather; analyze; collect; calculate; calculate; describe; define</td>
<td>Investigate; calculate; describe</td>
</tr>
<tr>
<td>Senior 2, Cluster 4: Weather Dynamics</td>
<td>Investigate; explain; analyze; illustrate; outline; discuss; collect; evaluate; outline</td>
<td>Investigate; explain; analyze; illustrate; outline; discuss; collect; evaluate; outline</td>
</tr>
</tbody>
</table>
there is more emphasis placed on: demonstrating; describing; discussing and identifying, however, of note is that there is not as clear a demarcation between these words and other verbs that are also highlighted. The ‘demonstration’ of STS[E] may connect with Levinson’s (2010) praxis/dissent framework where there appears to be more of an ‘action’ element tied with this content area. Investigation and explanation are also common to most of the curricular content areas which again may indicate more connection to the praxis/dissent categories where the teacher may be acting as more of a knowledge facilitator versus a dispenser of information. This style of verb usage associated with the curriculum outcomes may communicate messages to the educator using the document and perhaps also to students that science is an action-oriented process not simply a collection of facts to be memorized and perhaps an alliance more tied with Roberts (2007) Vision II style of science literacy where the context of science is a key feature.

In addition to the use of the Wordles\textsuperscript{TM}, Bloom’s revised taxonomy (Krathwohl, 2002) was used to further explore the verbs appearing in the STS[E] curriculum (please see Appendix D). The outcomes from Strand 0 appeared to span many cognitive process domains including: understanding; apply; analyze; evaluate and create where the greatest emphasis appeared to focus on the ‘analyze’ and ‘evaluate’ dimensions and intersected with the conceptual knowledge (i.e., a focus on theoretical knowledge) domain (see Appendix D).

Both Levinson’s (2010) and Pedretti and Nazir’s (2011) frameworks were used to explore the STS[E] curriculum outcomes in Senior 2 Science (2001) to analyze ontologically similar documents across the provinces and were useful to guide my exploration of the potential degree of politicization of this segment of the curriculum. It is worth noting that the application of Pedretti and Nazir’s (2011) framework was more challenging with these outcomes as they are separate, decontextualized and presented as outcomes to be applied to all other strand areas in the Science 2 Science (2001) curriculum\textsuperscript{34}. Therefore, in some cases no current could be assigned as it was not clear

\textsuperscript{34} It is worth noting that the Manitoba Senior Science 2 Framework for Implementation (2003) does offer detailed and contextualized suggestions and approaches for many curriculum outcomes, however, it is still beyond the scope of this thesis as to how practitioners actually use this document and the more ‘bare-bones’ curriculum outcomes.
what the context would be without the collection of additional practitioner data as to how they might frame the outcome. As a result, I present the findings of the application of the Pedretti and Nazir (2011) framework slightly differently from the other case study representations to accommodate for these variations in provincial curriculum constructions. An interesting Strand 0 outcome that I did not classify using Levinson’s (2010) framework, but that I felt warranted mention as it seemed aligned with Pedretti and Nazir’s (2011) socio-cultural current was this:

Appreciate and respect that science and technology have evolved from different views held by women and men from a variety of societies and cultural backgrounds. (p. 3.14)

There are some unique features about the phrasing of this outcome. The prefacing of ‘women’ before ‘men’ I feel is done with intent because it is out of alignment with alphabetization (i.e., documents might simply list ‘men’ before ‘women’ in this type of sentence structure as ‘m’ comes before ‘w.’). It is emphasizing that women’s contributions as well as various societies and cultures are to be appreciated and respected when studying science and technology. Another useful inclusion in this outcome may be to perhaps consider phrasing to be inclusive of a variety of multi-gendered representations as not everyone would fall into either of these categorizations.

Most of the curricular outcomes associated with STS[E] from Strand 0 in the Senior 2 Science (2001) curriculum were coded using Levinson’s (2010) framework categories of deficit; deliberate; praxis and dissent and conflict. Some STS[E] outcomes could not be coded using this framework because they did not appear to align with any of these areas (e.g., the STSE Strand 0 section: Demonstrating Scientific and Technological Attitudes and Habits of Mind). I felt that some of the outcomes associated with either deliberate or praxis could fall into either category depending upon the practitioner interpretation of the outcome, so I decided to classify some outcomes twice in multiple categories to accommodate for this complexity (i.e., as noted in Table 7.1). For example, the outcome, “Formulate and develop options which could lead to an STSE decision” might be a discussion or negotiation (i.e., perhaps more so aligned with a deliberate perspective) between students or student and teacher or perhaps involve a much more open-ended and participatory dialogue (i.e., more aligned with a praxis-based approach).
that leads to the enactment of a decision related to STS[E] (Pedretti & Navis, 2015) depending upon how the educator might choose to contextualize and deliver this outcome.

I felt that the majority of Strand 0 outcomes would most closely align with Levinson’s (2010) deliberate or praxis framework categories (see Table 7.3 below) as most of the emphasis appeared to engage learners in discussion and exploration of STS[E] topics and could lead to more praxis-related pedagogical deliveries such as student-led inquiry depending upon practitioner interpretation.
TABLE 7.3: A summary of some possible areas of emphasis in the Manitoba tenth-grade Strand 0 STS[E] and contextualized STS[E] outcomes using Levinson’s (2010) and Pedretti and Nazir’s (2011) frameworks (i.e., where applicable).

<table>
<thead>
<tr>
<th>Selected Strand 0 STS[E] Outcomes (i.e., some outcomes in this strand are inquiry and attitude-based outcomes, not applicable to Levinson’s framework and some outcomes have been classified in more than one category)</th>
<th>Approx. Number of STS[E] Outcomes</th>
<th>Deficit-Related Outcomes</th>
<th>Deliberative-Related Outcomes</th>
<th>Praxis-Related Outcomes</th>
<th>Dissent &amp; Conflict-Related Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior 2, Cluster 1: Dynamics of Ecosystems</td>
<td>5</td>
<td>1(Logical Reasoning)</td>
<td>4(Logical Reasoning)</td>
<td>1(Socio-ecojustice)</td>
<td>0 <strong>This outcome may also be associated with a dissent &amp; conflict approach</strong></td>
</tr>
<tr>
<td>Senior 2, Cluster 2: Chemistry in Action</td>
<td>3</td>
<td>0</td>
<td>1 (Historical or Socio-cultural)</td>
<td>1(Application &amp; Design)</td>
<td>0</td>
</tr>
<tr>
<td>Senior 2, Cluster 3: In Motion</td>
<td>4</td>
<td>0</td>
<td>3 (Del or Praxis); (All may be Application &amp; Design or Logical Reasoning)</td>
<td>1 (Praxis); Logical Reasoning)</td>
<td>0</td>
</tr>
<tr>
<td>Senior 2, Cluster 4: Weather Dynamics</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3 (Logical Reasoning)</td>
<td>0</td>
</tr>
</tbody>
</table>

If we explore the contextualized outcomes that seem to be associated with STS[E] in the units of study, there seems to be a slightly more prevalent emphasis on a deliberative style with some outcomes that seem to be associated with either the deliberative or praxis framework categories. There are also some outcomes that seem to be aligned with a
praxis outlook as indicated above in Table 7.3. I did not find that the more contextualized outcomes aligned clearly with a dissent and conflict framework category based on the written curricular descriptions with the exception of one outcome in the ecology-based unit.

I found the STS[E] outcomes associated with Levinson’s (2010) framework category of dissent and conflict mainly found in Strand 0 to be quite interesting and to represent a different emphasis from the STS[E] outcomes found in the other provinces explored in this thesis such as depicted here:

Select the best option and determine a course of action to implement an STSE decision. (p. 3.13)

Implement an STSE decision and evaluate its effects. (p. 3.13)

The use of words such as ‘implement’ constitute perhaps a different or somewhat alternate construction of STS[E] education; as it may denote action. A reflective element was also present in the outcomes that may suggest an alliance with a praxis-based approach such as illustrated here:

Reflect on the process used to arrive at or to implement an STSE decision, and suggest improvements.

Reflect on prior knowledge and experiences to develop new understandings. (p. 3.13)

As mentioned above, it was somewhat more challenging to streamline a process to code the Strand 0 STS[E] outcomes using Pedretti and Nazir’s (2011) STS[E] currents as they are decontextualized. I was able to code some of these outcomes using their currents and also coded the contextualized outcomes associated with STS[E] throughout the other units of study in the Grade 10 level curriculum (see Table 7.3 above). I noted overlaps with the dissent and conflict aligned outcomes and the socio-ecojustice current perhaps as illustrated here in the unit associated with ecosystems:

Investigate how human activities affect an ecosystem and use the decision-making process to propose a course of action to enhance its sustainability.

Include: impact on biogeochemical cycling, population dynamics, and biodiversity. (p. 3.17)
And also overlaps between the dissent and conflict category and the logical reasoning current such as illustrated here in the unit associated with physics (i.e., motion):

Use the decision-making process to address an STSE issue related to safe driving conditions.

Examples: adverse driving conditions; reaction time and narcotic influences such as blood alcohol level; excessive vehicle speed…(p. 3.21)

Table 7.4 below displays additional areas of potential overlap between Levinson’s (2010) framework and Pedretti and Nazir’s (2011) STS[E] currents when additional curriculum outcomes were considered from the contextualized units (i.e., beyond Strand 0).
TABLE 7.4. The explorations of some selected curriculum outcomes to show the possible hybrid associations and connections with both Levinson’s (2010) and Pedretti and Nazir’s (2011) framework categories.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Selected STS[E] Curriculum Outcomes from Strands 1 - 4</th>
<th>Possible Associations with Levinson’s (2010) Framework Categories</th>
<th>Possible Associations with Pedretti &amp; Nazir’s (2011) STSE currents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamics of Ecosystems</td>
<td>Investigate how human activities affect an ecosystem and use the decision-making process to propose a course of action to enhance its sustainability. (p. 3.17)</td>
<td>Dissent &amp; Conflict</td>
<td>Socio-ecojustice</td>
</tr>
<tr>
<td>Chemistry in Action</td>
<td>Describe the formation and the environmental impact of various types of air pollution. (p. 3.19)</td>
<td>Deliberative</td>
<td>Logical Reasoning</td>
</tr>
<tr>
<td>Chemistry in Action</td>
<td>Investigate technologies that are used to reduce emissions of potential air pollutants. (p. 3.19)</td>
<td>Deliberative</td>
<td>Application &amp; Design</td>
</tr>
<tr>
<td>In Motion</td>
<td>Use the decision-making process to address an STSE issue related to safe driving conditions. (p. 3.21)</td>
<td>Praxis or Dissent &amp; Conflict</td>
<td>Logical Reasoning</td>
</tr>
<tr>
<td>Weather Dynamics</td>
<td>Investigate and evaluate evidence that climate change occurs naturally and can be influenced by human activities. (p. 3.22)</td>
<td>Praxis</td>
<td>Logical Reasoning</td>
</tr>
</tbody>
</table>

7.3 Theoretical Discussions and Perspectives

I found it interesting that there appeared to be intersections between Levinson’s (2010) praxis and dissent and conflict framework categories and Pedretti and Nazir’s (2011) socio-ecojustice and also their logical reasoning current. I would not necessarily have considered overlaps between action-oriented outcomes and a logical reasoning type of perspective, perhaps tied to the students’ sources of data and possible claims. However, despite apparent associations between framework depictions, caution must be
exercised regarding possible interpretations as this may or may not be representative of different curriculum constructions outside of this provincial context.

The STS[E] curriculum in Manitoba appears to emphasize a range of Levinson’s (2010) framework categories including: deliberative, praxis and dissent and conflict; however, most of the outcomes seem to align with a deliberative stance. This shift seemingly toward inclusivity of a wider range of approaches to citizenship might suggest somewhat more of an alliance with a Vision II perspective (Roberts, 2007) on science literacy where the context and citizen participation is highlighted. But is this a more democratic and inclusive approach to science education? On the surface, it would seem that the Strand 0 STS[E] outcomes appear to embrace a philosophy that might be more oriented toward a Vision II perspective, however, Strand 0 is a unit which is separate from the others. The intent is that the STS[E] content will be integrated, however, the reality of what practitioners decide to do may be quite different. I know, for example, from my personal practitioner experiences that it is quite easy to overlook the integration of various topics, especially so when the content is challenging to navigate such as in the case of STS[E] outcomes. Pedretti and Bellomo’s (2013) work with teachers of varying experience levels in the context of a professional learning network may offer insights as to what might be implemented in the science classroom regarding STS[E] educational initiatives. They found that,

…the majority of participants did not demonstrate a comprehensive understanding of STSE education—responses were generally vague and lacking in detail. Few participants wrote or talked about STSE and its relationship to agency or politicization at the beginning of the PLC. However, analyses of data from the latter part of the project revealed some shifting views and perceptions of STSE education that went beyond simple connections and interfaces across science and society. Latter views began to acknowledge values, advocacy, and/or change as part of STSE education. (p. 424)

It seems that some educators may lack a clear understanding of what STS[E] looks like in action or what the end result of this type of education could/should be used for. If this is also the case in Manitoba, it is somewhat problematic that the STS[E] curriculum is separated from the rest of the science content (i.e., although, examples and materials are provided in the Foundation for Implementation, 2003).
It is interesting to note how with additional professional development, that Pedretti and Bellomo (2013) affirm that advocacy and agency were included as part of the teachers’ conceptions of STSE education. They state that, “Furthermore, STSE orientations need to be *explicitly* explored, which means that teachers need time, resources, critical readings, and support” (p. 432). Pedretti and Bellomo (2013) also reported that although there is a large body of literature which promotes activism and agency in science that they found that, “there was some resistance to the notion of action and even more so to the idea of politicization within the science classroom setting” (p. 432). I wonder if this would be the case in a jurisdiction such as Manitoba that appears to emphasize a more politicized STS[E] written curriculum. Also, I wonder about the types of professional development opportunities that would be provided to support science teachers in enacting the STS[E] curriculum.

### 7.4 Some Additional Analysis of the Unit Associated with Climate Change: Weather Dynamics

The Weather Dynamics cluster was selected for more detailed analysis as it contains content most similar to other provincial curricula depicting climate change. I am presenting findings from both the abbreviated specific outcomes found in the Senior 2 Science: Manitoba Curriculum Framework of Outcomes (2001) document and the Senior 2 Science: A Foundation for Implementation (2003) document. This unit begins with a very short introduction in the Foundation for Implementation (2003) document as presented here:

This cluster develops an understanding of the sometimes complex relationships that influence weather and climate. An examination of the global energy budget of Earth, through water and heat transfer, provides the basis for discussion of global winds, ocean currents, and ultimately severe weather phenomena. Students gain understanding of sophisticated meteorological information, gather and analyze meteorological data related to a severe weather event, and explore the social, economic, and environmental impact of the event. Evidence that climate change occurs due to natural events and human activities is investigated and evaluated. Students apply their understanding of weather and climate in a discussion of the potential consequences of climate change. (p. 179)
There are no big ideas or leading questions present in this text. There is a focus on weather and the STS[E] impact of weather-related events. Climate change is presented in the context of both natural and human-related activities where natural activities are prioritized before anthropogenic contexts for climate change perhaps. The phrasing, ‘potential consequences of climate change’ is used which may convey the message that the science associated with climate change remains uncertain due to the use of the modifier, ‘potential.’

There are eight curriculum outcomes listed in the Weather Dynamics cluster. The outcomes are not subdivided into categories and are presented together on one page. All outcomes occur under the subheading, “students will…” indicating to the reader that all expectations are of equal importance.

**Sustainable Development**

Sustainable development is mentioned in many parts of the text inclusive of the front matter of the Foundation for Implementation\(^{35}\) (2003). There is a clear perspective provided regarding the decision-making aspects of sustainable development in the document where it states, “…balances the impact of economic activities, the environment, and the health and well-being of the community” (p. 19). The Manitoba curriculum presents a diagrammatic representation\(^{36}\) of their perspectives on sustainable development using three interlinked circles labeled ‘economy’, ‘human health and well-being’ and ‘environment’ in the front matter of the Senior 2 Science: A Foundation for Implementation (2003). The ‘heart’ of the triad where the three circles intersect is labeled, ‘quality of life.’

The economy is prioritized in both the wording of the description (i.e., economic factors are mentioned first) and by the visual placement of the ‘economy’ at the top of their diagram. There is also explicit mention in the front matter regarding the

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\(^{35}\) Also of note is that there have been resources such as ESD in Manitoba Curriculum developed to highlight specific outcomes and associations in curricular documents that tie to Education for Sustainable Development.

\(^{36}\) Please see the Manitoba Ministry of Education website for a complete description and schematics found here: [http://www.edu.gov.mb.ca/k12/cur/science/found/s2/s2_fulldoc.pdf](http://www.edu.gov.mb.ca/k12/cur/science/found/s2/s2_fulldoc.pdf). This particular schematic was on page 8.
intersections between social responsibilities and sustainable development such as here, “Sustainable development supports principles of social responsibility and equity” (Senior 2 Science: A Foundation for Implementation, 2003, p. 19). This concept of ‘equity’ is extended to support and include, “…equity among nations, within nations, between humans and other species, as well as between present and future generations” (p. 19). This statement reminds me of Pierce’s (2013) argument regarding the extension of actor network theory to include both human and non-human actants as equity is promoted amongst both humans and other species. This series of statements may reflect Sauvé’s (2005) sustainability/sustainable development current where she summarizes this approach here as, “Promote economic development that takes care of social equity and ecological sustainability; Contribute to such development” (p. 34). This sustainable development theme may also align with the curricular outcome presented here,

Investigate the social, economic, and environmental impacts of a recent severe weather event. Include: related consequences of personal and societal decision-making. (Senior 2 Science: Manitoba Curriculum Framework of Outcomes, 2001, p. 3.22)

Both social and economic factors are considered when evaluating the impact on the environment related to a severe weather event that may align with a sustainable development focus. Also of note is the emphasis placed on both individualized and collective decision-making.

The Foundation for Implementation (2003) document uses a series of circles to depict a conception of sustainable development that may suggest an Indigenous association. The ‘quality of life’ in the centre of their Venn diagram has many possible interpretations. Some indicators for quality of life are perhaps tied with economic factors such as, “…GDP; Distribution of Income in Society; Employment/Unemployment” (Pettinger, 2010) or with other considerations such as, “Life Expectancy; Educational Standards; Housing; Air Pollution; Levels of Congestion and Transport; Environmental Standards; Wildlife Diversity; Access to Clean Drinking Water; Climate…” (Pettinger, 2010). Also when exploring quality of life, some might argue that happiness assessments

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37 Please see the following Manitoba Ministry of Education website for a full description of the curriculum and various schematics discussed here: [http://www.edu.gov.mb.ca/k12/cur/science/found/s2/s2_fulldoc.pdf](http://www.edu.gov.mb.ca/k12/cur/science/found/s2/s2_fulldoc.pdf)

This particular schematic was on page 8.
should factor in such as the Happy Planet Index (Marks, 2015), which bases relative happiness on the individual’s perceived well-being, their predicted life expectancy and ecological footprint perhaps as depicted here:

\[
\text{Happy Planet Index} \approx \frac{\text{Experienced well-being} \times \text{Life expectancy}}{\text{Ecological footprint}}
\]

**Critical Thinking & Climate Change**

Some of the curricular outcomes associated with climate change in the Weather Dynamics Cluster could convey a more uncertain and perhaps critical approach to climate change science. This might be illustrated here in the following curriculum outcomes:

Investigate and evaluate evidence that climate change occurs naturally and can be influenced by human activities.

Include: the use of technology in gathering and interpreting current and historical data. (Senior 2 Science: Manitoba Curriculum Framework of Outcomes, 2001, p. 3.22)

And perhaps here:

Discuss potential consequences of climate change.

*Examples: changes in ocean temperature may affect aquatic populations, higher frequency of severe weather events influencing social and economic activities, scientific debate over nature and degree of change.* (Senior 2 Science: Manitoba Curriculum Framework of Outcomes, 2001, p. 3.22)

The wording of the first outcome may suggest that climate change is primarily a naturally-occurring event being impacted by human factors as the ‘natural’ is prioritized in the sentence structure. Climate change does of course occur naturally and is documented in science literature; however, the Manitoba Climate Change Action Plan (2008) and its citation of science literature indicates that anthropogenic factors are responsible for the most recent climate change. The wording of the second outcome may imply to the reader that the projected consequences of climate change may or may not actually impact climate or may not impact climate to the extent of scientific projections due to the use of the modifier, ‘potential.’ This may appear insignificant, however, if we
were to remove it and re-phrase the sentence to state: Discuss consequences of climate change; it may carry a different connotation. This might imply the presentation of a more balanced approach to the science of climate change, such as discussed in Oreskes and Conway (2010) that is not currently aligned with the majority of thought from the science community on the anthropogenic factors associated with climate change.

Some of the suggestions for instruction aligned with the above outcomes highlight research and choice for students. The use of wordings such as “student or student groups…” is used as well as choice regarding presentation of findings (e.g., oral presentation, written reports, dramatic presentation, etc.). Some suggested student research activities from the Senior 2 Science: A Foundation for Implementation (2003) that could be conducted surrounding the above outcomes include:

… discuss El Nino’s or La Nina’s effects on air and water currents and their impact on Canada’s economy, society, and environment; assess evidence that civilizations have vanished due to climate change (e.g., Vikings in Greenland); investigate how ice core sampling is used to determine the climate of the past; explore the evidence for the “Snowball Earth” hypothesis, which claims that our planet has completely frozen over as much as four times in Earth’s past, followed by rapid warming to tropical extremes; describe how Manitoba’s landscape provides evidence of glaciation; discuss how microclimates can be modified by humans; compare Manitoba’s current climate with the climate of the past. (p. 208)

Of note in this list of potential interpretations of this outcome is the first activity which has students research and comment on human activities that may influence greenhouse gases whereas the suggested activities that follow seem to reflect more natural associations with climate change. This appears to be a different emphasis from the earlier Senior 2 Science: Manitoba Framework of Outcomes (2001) curriculum document that may suggest a more ‘balanced’ perspective on the science of climate change. What is not clear is the extent to which educators use each document for classroom instruction.

*Actions*

The emphasis in the STS[E] outcomes appears to focus on the identification of STS[E] issues, exploration of possible stakeholders and the evaluation of information regarding decision making as exhibited in the following outcomes:
S2-0-1c Identify STSE issues that could be addressed.

S2-0-1d Identify stakeholders and initiate research related to an STSE issue.
(Senior 2 Science: A Foundation for Implementation, 2003, p. 67)

And also here,

S2-0-3d Summarize relevant data and consolidate existing arguments and positions related to an STSE issue.

S2-0-3e Determine criteria for the evaluation of an STSE decision.

Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability... (Senior 2 Science: A Foundation for Implementation, 2003, p. 68)

And here,

S2-0-5d Evaluate, using predetermined criteria, different STSE options leading to a possible decision.

Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability. (Senior 2 Science: A Foundation for Implementation, 2003, p. 70)

And also here in the General Learning Outcomes associated with STS[E]:

B5. identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally. (Senior 2 Science: A Foundation for Implementation, 2003, p. 20)

The Senior 2 Science: A Foundation for Implementation (2003) also states,

…suggest ways in which they can be personally involved and proactive with respect to STSE issues. (p. 99)

Outcome S2-0-3 cites examples for inclusion versus the wording of outcome S2-0-5 where the term, ‘include’ occurs. Examples may or may not be used, however, the term, ‘include’ implies usage of the perspectives mentioned above. These focal areas within the STS[E] curriculum may reflect Pedretti and Nazir’s (2011) value-centred current as there is a focus on decision-making that could be based on social, moral or philosophical stances or perhaps a logical reasoning alliance as there appears to also be emphasis placed on evaluation and criteria. This focus on the evaluation of decisions related to STS[E] outcomes may reflect Levinson’s (2010) deficit/deliberative framework as there
is a focus on analysis of issues; however, the use of the phrase, possible decision, may imply an action which could indicate a more praxis/dissent and conflict perspective. It is not clear from Senior 2 Science: A Foundation for Implementation (2003) quotation appearing above if student engagement with STS[E] issues would be primarily a personal decision or would involve perhaps more collective actions.

Other outcomes present in the STS[E] outcomes of Cluster 0 appear to be focused on actions associated with STS[E]. The following curriculum outcomes focus on the selection, implementation, evaluation and reflection on actions associated with STS[E] such as (i.e., bolded emphasis added):

S2-0-7c Select the best option and **determine a course of action to implement an STSE decision.**

S2-0-7d **Implement** an STSE decision and evaluate its effects.

S2-0-7e Reflect on the process used to arrive at or to implement an STSE decision, and suggest improvements. (Senior 2 Science: A Foundation for Implementation, 2003, p. 71)

The implementation and thoughtful reflection of an action associated with an STS[E] issue may be aligned with Levinson’s praxis/dissent frameworks (2010) where teachers may potentially shift more so into the role of facilitator to guide students regarding their decision-making. This association also seems to reflect Pedretti and Nazir’s (2011) socio-ecojustice current where students are involved in both the generation and implementation of action plans that may be associated with environmental considerations (i.e., most likely in this Weather Dynamics unit).

*Cross-Disciplinary Approaches*

This theme of a cross-curricular approach may be demonstrated through the use of both suggested teaching approaches and also cross-referencing/intertextual linkages of various outcomes in the Weather Dynamics cluster. The use of creative strategies such as the use of drama or poetry such as this teaching suggestion surrounding severe weather may demonstrate this:
Student groups create severe weather haiku poetry, such as

Snowflakes fall and drift

as the north wind howls blizzard

No school tomorrow!

Haiku poems typically contain 17 syllables in a 5-7-5 arrangement and a seasonal reference. (Senior 2 Science: A Foundation for Implementation, 2003, p. 204)

This cross-disciplinary connection to poetry and English in science may convey that science can be a creative enterprise and help to reinforce that science is not a subject area studied in isolation from other scholarly fields. There are also many references occurring throughout the curriculum outcomes that link to mathematics, language arts and various General Learning Outcomes. These cross-references may link to Orr’s (2004) perspective that subject disciplines are somewhat an illusion. He argues that institutions are the only places that enforce rigid lines of demarcation between subject areas and how we learn and use information does not contain these forms of compartmentalization, but rather is much more fluid and holistic. This presentation and incorporation of different disciplines may also facilitate border-crossing in students such as described by Calabrese Barton (1998):

If the boarders of science are expanded or made fuzzy, then there will be more room to fit children’s experiences that cannot be neatly labeled as science. Valuing these experiences shifts the dynamics of what counts as science and who can do science because children would not have to silence certain experiences of feelings traditionally labeled outside of science. (p. 386 as cited in Pedretti & Bellomo, 2015)

7.5 Some Factors that May Influence the STS[E] Curriculum

7.5.1 The Curriculum Construction Process in Manitoba

As explored briefly in my literature review, there are many aspects of the curriculum construction process that may shape the science curriculum including the STS[E] curriculum. As mentioned earlier in this case, it is interesting that the Manitoba Senior 2 Science: A Foundation for Implementation (2003) clearly acknowledges authorship of the contributing authors. There is a blend of scholars, consultants and
educators from both the elementary and secondary panels. The principle writer (i.e., seemingly a self-identified woman) named was affiliated with the University of Winnipeg and the two contributing writers were an educator at the secondary level and a science consultant respectively (i.e., seemingly two self-identified males). There is a wide range of educational representation from both the elementary and secondary panels from various schools and school boards; inclusive of multi-gendered representations.

As depicted on the Manitoba Education website, teachers, scholars and others are appointed to be members of these development teams as stated here:

Curriculum development team members are selected through a nomination process. At the outset of a new curriculum project, the Program Development Branch sends letters to Superintendents of Education of provincial school divisions/districts, to Principals of Independent schools, and to Directors of Education and Principals of First Nations schools, requesting nominations of teachers to serve on the development team. The nomination forms identify criteria on which selection is based, including knowledge of curriculum planning and design, knowledge of the discipline, exemplary classroom practice, ability to work collaboratively, and team diversity (e.g., geographical representation, gender balance, multicultural and Aboriginal representation).


Young and Graham (2011) comment about the origins of this curriculum development approach and comments on the associations with the “Western Canadian Protocol: Collaboration in Basic Education,” that describes the processes for selecting curriculum writers. Young and Graham (2011) note that the document, “A Foundation for Excellence” (1995), and provides the following ten considerations for all curricula developed:

Foundation skill areas (literacy and communication; problem-solving; human relations, and technology): resource based learning; differentiated instruction; curriculum integration; Aboriginal perspectives; gender fairness; appropriate age portrayals; human diversity; anti-racist/anti-bias education; and sustainable development. (p. 416)

This nomination process and areas of emphasis are important as these teams of people have the power to shape the discourses present in the assembled curriculum documents and in turn may influence educators, students/citizens and shape the content and contexts found in the science, technology, society and the environment (STSE) curriculum. It may be worth noting that I found it quite challenging to locate specific and
scholarly literature depicting more about the curriculum development processes occurring in Manitoba external to the information on their Education Ministry website.

7.5.2 Some General Facets of Manitoba’s Political Landscape

The New Democratic Party (NDP) of Manitoba has been in power consistently since 1999 (i.e., until quite recently in 2016). This political party was established during the 1930s and had the name, the Cooperative Commonwealth Federation (CCF) (Khan & McNiven, 1999). The New Democratic Party (NDP) was formed in 1966 from an alliance between the CCF and the Canadian Labour Congress (CLC). Khan and McNiven (1999) assert that this alliance “stereotyped the NDP as a labour party in a country where labour unions enroll fewer than one third of the workers, and as a class party in a country not greatly class conscious” (p. 159). Political ideology largely separates the NDP from the PC or Liberal parties of Canada as demonstrated here:

…favours increased government involvement in economic planning and public ownership of key industrial and service enterprises. It is very sensitive to the growth of American economic and cultural influence and staunchly opposes the Canada-U.S. Free Trade Agreement. Unlike the major parties, which are only peripherally concerned with ideology, the NDP has a definitive democratic socialist orientation. (Khan & McNiven, 1999, p. 160)

The more socialist orientation also differentiates the NDP from either the PC or Liberal parties. Khan and McNiven (1999) state here that,

Loosely defined, socialism perceives people as basically sociable and cooperative beings, whose interests are best served when political and economic systems operate to reinforce these instincts. (p. 386)

Also noted by Khan and McNiven (1999) is the diverse array of socialisms including: communist socialism (e.g., practiced in China); democratic socialism (e.g., practiced in Scandinavian countries, NDP, British Labour Party); utopian socialism (i.e., the Judeo-Christian conception of social welfare); Marxist socialism and others. Canadian socialism has an interesting history and diffuse origins, however, many Canadians associate cooperative movements with socialism (Khan & McNiven, 1999). For example, the Antigonish Movement, a socialist movement founded by Fr. James Tompkins and Fr. Moses Cody where the extension services provided by St. Francis Xavier University were
used to form community cooperatives are well known in the Maritimes and globally (Khan & McNiven, 1999).

7.5.3 Some Facets of the General Political Environment at the time of Curriculum Construction

This portion of case study based on Manitoba explores some aspects of the political landscape that were present at the time of the construction and implementation of the Grade 10 science curriculum. The following documents were used to help explore some facets of the general political cultures: the New Democratic Party (NDP) of Manitoba’s election platform (2011); the Speech from the Throne (1999) and Next Steps: 2008 Action on Climate Change. I selected the 1999 Speech from the Throne as it represented a time frame close to the release of the Manitoba tenth-grade level science curriculum documents. The 2011 election platform was selected as it may provide some insights into the general issues of importance to the current government.

Manitoba was selected as the third provincial case study as it seemingly represents a different political context from the political landscape present in either of the other two provincial case studies at the time of curriculum construction and implementation. This segment of the Manitoba case study focuses on the NDP Election Platform from 2011 to provide some political context and what this party perhaps prioritizes. I begin by exploring this document using some of the tools of discourse analysis (i.e., both finer and coarser tools of analysis as proposed by Gee, 2011) and will then proceed to some thematic organization that emerged through the analysis of other aforementioned political documents using both discourse and document analysis.

The Manitoba NDP Speech from the Throne (1999) and the NDP Election Platform (2011) were explored for various patterns and emphasized issues through the creation of the following Wordles™ (see Figures 7.2 & 7.3 below).

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38 This throne speech was selected as it would, in part, perhaps represent the governmental priorities of a newly elected party just prior to the release of the Manitoba science curriculum in 2001.
As with the other case studies presented, these Wordles™ are meant to convey words that have been stated or used frequently in both the election platform and the Speech from the Throne. Despite the time lapse between the documents used to create these Wordles™, there remain consistencies in emphasized words such as: Manitoba, Manitobans, community or communities, education, health and care.
Neoliberalism

The 2011 NDP election platform is entitled, “Our vision for the next four years: Let’s keep building. Don’t turn back” and is 16 pages in length. The use of contractions throughout this document may imply a lack of formality and increased accessibility in terms of the readership as more ‘everyday’ Germanic English is utilized (i.e., as opposed to more Latin-derived ‘jargons’) (Gee, 2011).

The central tenets of the NDP platform are listed on page two of this document and comprise the following under the context of, “Keep Building: Our vision of a future that puts Manitoba families first” which are:

- Jobs and Training Opportunities: Building the economy of tomorrow
- Keeping Life Affordable: Money in your wallet
- Health: National leaders in health by putting patients first
- Excellence in Education: Ensuring every child has every opportunity to succeed
- Manitoba Hydro: Building prosperity for everyone
- Safe Communities: Fighting crime
- Water and the Environment: Preserving and protecting our natural heritage. (p. 2)

The prioritization of jobs and training for employment opportunities via document positioning appears here where as concerns associated with the water and environment appear last. Also of note is that three of the seven central mandates listed focus on economic factors.

The first pattern that emerged from my analysis was a focus on issues that would be tied with economic concerns. The economy would have characteristics of both collective goals as monies are required to implement and support various social goods and provincially administered programs such as health care and education and also individual needs as employment can and is used to secure personal wealth. There seems to be emphasis on some goals which may be associated with neoliberalism such as ‘Money in your wallet’ and ‘Excellence in Education’ where there appears to be an emphasis on the individual. This passage may illustrate this theme and the discourse associated with its presentation may suggest connections to both collective and individual interests:
We are going to keep building a strong economy, to keep people working and ensure prosperity is shared by all. We already have among the lowest unemployment rates in Canada. This allows us now to emphasize the creation of well-paying jobs that young families can build their futures around. Our vision for the Manitoba economy is one where entrepreneurs turn good ideas into good jobs. Where well-funded universities and colleges serve the needs of students and of our economy. Where any student willing to work hard can get high-quality education and training. And where our hydro-electric resources – “Manitoba’s oil” – benefit everyone. (Manitoba NDP Election Platform, 2011, p. 4)

Wording associated with sharing benefits such as, “…prosperity is shared by all” and, “…good ideas into good jobs” as well as, “…benefit everyone” demonstrate collective interests while at the same time ensuring that individuals are suitably employed (i.e., not under-employed) which I feel may indicate an economic theme that seems to include collective goals perhaps moving beyond exclusively neoliberal ten such as those summarized here by Thomas Friedman in ‘The Lexus and the Olive Tree’:

…a country must either adopt, or be seen as moving toward the following golden rules: making the private sector the primary engine of its economic growth, maintaining a low rate of inflation and price stability, shrinking the size of its state bureaucracy, maintaining as close to a balanced budget as possible, if not a surplus, eliminating and lowering tariffs on imported goods, removing restrictions on foreign investment, getting rid of quotas and domestic monopolies, increasing exports, privatizing state-owned industries and utilities, deregulating capital markets, making its currency convertible, opening its industries, stock and bond markets to direct foreign ownership and investment, deregulating its economy to promote as much domestic competition as possible… (pp. 86-76 as cited in Albo, 2002, pp. 46-47)

However, despite these differences that may be present in the discourse of more seemingly left-aligned political documents, scholars such as Albo (2002) comment that, “…We get neoliberalism even when we elect social democratic governments” (p. 47) as many elected governments, inclusive of the NDP, still emphasize some of the policies highlighted by the above passage by Friedman in Albo (2002).

Another interesting facet of economy is the political intersections with taxation rates. For example, in Canada, there are two taxation structures that apply to personal income tax; federal structures (i.e., which are consistent across the country) and provincial structures that vary from province to province. According to the Canadian Revenue Agency (CRA), the current Alberta personal provincial income taxation
structure reflects a ‘flat rate’ of 10% of total taxable income whereas other provinces such as Manitoba or Ontario and the federal income taxation structure use a stratified system where tax rates are incrementally higher as income increases. This means that typically as household gross taxable income increases, a larger amount of personal income goes toward the Manitoba government whereas relatively smaller amounts of personal income goes to provincial government revenue in Alberta (please see Table 7.5). This may be related to Bencze’s (2010) assertion that there could be associations between tax structures and forms of neoliberalism where he states that, “…under neoliberalism, profit-oriented government intervention has been encouraged—often in the form of tax reductions” (p. 294). As personal income tax rates are higher in Manitoba, it may suggest a government perhaps less aligned with some neoliberal economic policies as discussed by Bencze (2010) above. An alternative perspective to consider with this type of analysis is that Manitoba also represents the smallest population base of the three provinces selected in this study. This factor may also impact relative personal taxation rates as it could be costlier to the tax-payer to offer social programs and thus these rates may need to be relatively higher.

TABLE 7.5: Amount of personal income tax paid to various provincial governments based on a gross taxable income of $30,000 (i.e., a relatively low-income household) versus $1,000,000 (i.e., a relatively high-income household).

<table>
<thead>
<tr>
<th>Province</th>
<th>Amount of Money Paid to Provincial Government based on total Taxable Income of $30,000 (using the current provincial income tax structures)</th>
<th>Amount of Money Paid to Provincial Government based on Total Taxable Income of $1,000,000 (using the current provincial income tax structures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>$3000</td>
<td>$100,000</td>
</tr>
<tr>
<td>Manitoba</td>
<td>$3240</td>
<td>$286,959.31</td>
</tr>
<tr>
<td>Ontario</td>
<td>$1515</td>
<td>$211,200.38</td>
</tr>
</tbody>
</table>

Climate Change and Sustainable Development

The Manitoba NDP government appears to take a strong position regarding climate change from their prioritization of various issues as highlighted in their document, Next Steps: 2008 Action on Climate Change. There appears to be very clear
wording indicating that climate change is inevitable and is not subject to debate such as illustrated here:

We are increasingly witnessing the consequences of a warming world: less predictable weather patterns; more frequent and intense extreme weather; and the arrival of new plants and animals in the province. These are all hallmarks of what are expected to be among the most significant economic and environmental challenges of the 21st century: climate change. (p. 11)

And also here,

The process of climate change has begun. The average temperature of the Earth has increased over the past 50 years and ecosystems have begun to change. In turn, they are affecting the economies and societies they sustain. Early impacts of climate change are already being witnessed in Manitoba. (p. 46)

There are also specific and detailed examples provided of the impacts of climate change on the sensitive Prairie regions of Canada such as,

The diversity and abundance of the province’s plant and animal species will also change. While some species might thrive, others, such as white spruce, polar bears and woodland caribou, could become endangered or extinct. (p. 46)

Again, the wording and use of phrases such as, “…will also change” may convey the urgency and certainty of climate change in this context.

A focus on sustainable development appeared to be highlighted regarding environmental issues and concerns. Many of the environmental issues highlighted in the NDP Election Platform (2011) focused on the balance between the environment and meeting human needs and concerns. Farming was highlighted such as presented here: “Help farmers adopt more environmentally friendly approaches” and “help farmers do their part to protect the environment by reducing regulatory red tape” (p. 10). These focal areas do not necessarily speak to conservation or reducing but rather may indicate approaches that facilitate agricultural production by mitigating the impact on the environment. This theme of sustainable development may also be highlighted in the Climate Change Action Plan (2008) where the framing of climate change as an economic issue is highlighted such as illustrated here:
There will be significant economic costs if nothing is done about the impacts of climate change. We’ve already felt these economic upsets close to home in recent years. The 1997 Flood of the Century, for example, cost the province $380 million. In 2003, the costs from forest fires across Manitoba totaled $64,837,155, and the Canadian economy lost $5 billion due to drought on the Prairies between 2000 and 2003. According to the United Nations Environment Program’s Finance Initiative: “Unless action is taken now to set in motion a worldwide transition to a low-carbon economy, some scenarios suggest that by 2040, the world could experience annual economic losses as high as USD $1 trillion. (p. 11)

And also here,

An increasing number of studies (ex: Dow Jones Sustainability Index, Social Investment Forum Foundation) show there is a significant correlation between positive financial performance and corporate social and environmental policies and practices. In fact, recent studies (ex: Stern Review on the Economics of Climate Change (UK)) show it is significantly costlier to do nothing. Using the results of formal economic models, the review estimates that if we don’t act, the overall costs and risks of climate change will be equivalent to losing at least five per cent of global GDP each year. If a wider range of risks and impacts is taken into account, the estimated losses could rise to 20 per cent of GDP per year, or more. (p. 41)

The use of numbers appears to be a reductionist approach to framing such potentially devastating climatic impacts on a region, however, the positioning of this issue in this manner (i.e., considering Gee’s (2011) ‘why this way not that way’ and ‘Germanic’ versus ‘Latinate’ tool), may provide insights into the possible audience and readership potentially associated with this document. Numerical and economic references such as the GDP may appeal to businesses and corporate stakeholders. Also of note in these passages is the reference to many other forms of documentation and potential influence such as the UNEP Finance Initiative, Dow Jones Financial Index or the Stern Review on the Economics of Climate Change (UK). These documents would have their own distinctive discourses that introduce different intertextual ‘flavours’ to this document again perhaps appealing to a business-class readership.

Alternative energies are highlighted in the 2011 NDP election platform though the use of the phrasing, “Manitoba’s oil” which refers to hydroelectric energy creation. Hydroelectric energy creation is arguably a ‘greener’ form of energy than coal-fired electrical generation, and has environmental and social considerations such as the impact of damming various bodies of water. Wind energy is explicitly mentioned here, “Develop
alternative energy such as wind power to create jobs in rural communities” (p. 10).

Alternative energies are again phrased in the context of connection to the economy such as through job creation that appears to be aligned with a sustainable development approach and may reflect a shift toward an “Alternative development” focus where it can be described as:

CREDO: only a complete global shift in social values and choices will permit the development of sustainable communities. (Calgary Latin American Studies, 1994 as cited in Sauvé, 1996, p. 27)

The focus on this type of sustainable development approach is based on the:

Development of bioregional economy: distinguishing real needs from desires, reducing dependency, increasing autonomy, favouring renewable resources, stimulating democratic process, participation and solidarity, etc. (Calgary Latin American Studies, 1994 as cited in Sauvé, 1996, p. 27)

Actions and Environmental Conservation

Conservation may be considered a collective goal that benefits all. Conservation and the preservation of watersheds and riparian zones, forests, air and water bodies provide essential environmental services that all life needs to survive (e.g., clean air and water). There is specific mention of conservation goals and objectives in the election platform such as stated here, “Designate new protected areas”; “Preserve the east-side boreal forest instead of cutting it in half” and “New amenities in provincial parks” (p. 10). The use of the words ‘protect’ and ‘preserve’ indicate that these areas potentially would not be harvested or used for monetary gain. It should also be noted that the Boreal forest present in Manitoba is just one part of a global circumpolar forested region. It is also significant to keep this forested region intact as it represents one of the few remaining forests left undisturbed by roads or other human impacts.

This theme of action in the context of conservation is continued throughout the Climate Change Action Plan (2008) where collective goals are outlined such as illustrated here:
Integrated watershed management plans are being developed to address water budgeting and water conservation.

Flood protection is being improved throughout the province, including upgrading the Red River Floodway from protection against a 1-in-90-year spring flood to a 1-in-700 year spring flood.

Manitoba’s hydrometric network is being expanded. Incentives such as the Riparian Tax Credit and a Nutrient Management Regulation to protect lakes and rivers are being introduced.

A land planning initiative will combine traditional and western scientific knowledge to inform future decision-making.

Support is being provided for the nomination of a combined 12,000 square kilometres of boreal forestland for a UNESCO World Heritage Site in Manitoba and Ontario.

Capacity to protect forests and northern communities from fires is being enhanced.

The polar bear has been listed as a threatened species and is being monitored. Manitoba will be the location for the world headquarters of Polar Bears International. (p. 48)

Individualized actions also are featured and include measures such as, personal energy conservation, the reduction of vehicular emissions, recycling and composting. This orientation toward the collective with of course some emphasis on the individual may be reflective of Levinson’s (2012) insights (as well as the other scholars he cites) regarding the environment as a collective issue. This focus on conservation and the collective present in this document may also represent a stance that does not have as strong an alliance with neoliberal approaches. Levinson (2012) refers to Bauman (2000) and his discussion regarding the collective as a potential source of power as stated here:

... the falling apart of agencies of collective action is often noted with a good deal of anxiety... But social disintegration is as much a condition as it is the outcome of the new technique of power, using disengagement and the art of escape as its major tools. For power to be free to flow, the world must be free of fences, barriers, fortified borders and checkpoints. Any dense and tight network of social bonds... is an obstacle to be cleared out of the way. Global powers are bent on dismantling such networks for the sake of their continuous and growing fluidity, that principal source of their strength and warrant of their invincibility. (p. 14 as cited in Levinson, 2012, p. 694)
There may be many factors that could potentially impact the framing of the STS[E] curriculum and its delivery to students. One consideration already mentioned, is the placement of most of the STS[E] outcomes in Strand 0. It is challenging to speculate on how this physical placement might impact the delivery of the STS[E] outcomes without additional practitioner data. Another consideration regarding the STS[E] outcomes and the curriculum in general is how the province constructs the curriculum. While the actual document may be considered the summation of various power exchanges and discourses, the process and how and who is involved is also worth considering.

The Manitoba Senior 2 Science: A Foundation for Implementation (2003) contains specific names of authors that have contributed to the development and writing (i.e., primarily teacher contributions are acknowledged in the document front matter). This appears to be a more transparent acknowledgment of the contributions and authorship of the documents and is not indicated in either of the other two curriculum documents explored in this study. The authors are named and their institutional affiliations are clearly referenced and indicate a wide representation of people from the following areas of expertise: elementary and secondary teaching panels featuring both English and Francophone school and school board representations, government representations, independent consultants, academic representations (i.e., both in fields of education, science and the skilled trades), parent council and various teacher societies such as the Manitoba Science Teachers’ Association. This diverse team of educational representatives engaged in curriculum development suggests inclusion of many perspectives, not simply those with either a professional science or technology background. This may mirror Schwab’s (1971) areas of representation in the curriculum where “the teachers, subject matter and milieu” (p. 34 as cited in Posner, 2004) appear to be well represented. The one area of under-representation that may be present based on the listed authorship could be that of the students or learners. Indirectly, their perspectives and viewpoints may be conveyed through their teachers, however, a beneficial inclusion may be to involve students more directly and ask for them to sit on various curriculum construction committees.
7.6 Some Concluding Thoughts

As previously stated and in alignment with the other case studies presented, it is difficult to say with certainty how complex and changing factors such as the political landscape in a region may or may not influence curricular documents or facets of those documents that have been explored here as it is not a simplistic relationship (i.e., also acknowledging that the exploration of political themes is limited to a selection that may be more tied with aspects of the curriculum and is not exhaustive of all possible political themes). There may be some associations or influence from various political factors, as explored above, but as stated, it is challenging to state whether these influences are in fact political or due to other factors or influences on the curriculum.

Sustainable Development

The Senior 2 Science: A Foundation for Implementation (2003) clearly indicates in their front matter that they take a sustainable development perspective regarding the environment as previously explored. Humans and the needs of humans tend to be prioritized while balanced with concern for the environment and future generations. What is not clear is the relative attentions paid by practitioners to this lengthy document (i.e., 631 pages) and the extent to which they and others are informed of the content present. Many educators are extremely busy and while they may have opportunities to glance at the curricular front matter, they may not have time to spend pondering the details or discourses present in those materials as the majority of their time would in many cases revolve around how to address and present the curriculum outcomes.

Actions

Actions regarding climate change in the Weather Dynamics unit and also throughout Strand 0 (i.e., the STS[E]-related outcomes) are presented with detail and focus upon both collective and individualized actions to possibly mitigate climate change. The Weather Dynamics and STS[E] outcomes in Senior 2 Science: Manitoba Curriculum Framework of Outcomes (2001) focus on the development and implementation of student actions based on a STSE decision that they have made with teacher guidance. Actions are highlighted in the documents explored regarding climate change.
In summary, there may be some associations between facets of the political documents explored here and among the curriculum outcomes and materials explored here such as in the presentation of a sustainable development focus and through the actions of students regarding climate change. However, as explored in the previous case studies, I do not feel that there is a strong association or influence from the larger political context on the explored STS[E] curricular segments.
Chapter Eight: Cross-Case Analysis

8.1 Introduction

Several findings emerged after much reflection, contemplation and analysis of the three provincial cases based on my efforts focusing on explorations of the STS[E] curriculum at the tenth-grade level. The first finding related to my work with the STS[E] curriculum is the complexity of undertaking such a research initiative. Although the theoretical frameworks that I have selected to aid in my explorations of different facets of the science curriculum were helpful in supporting my efforts to sift through the outcomes or expectations, the application of other scholar’s conceptualizations proved to be challenging. Part of the challenge is of course my interpretation of other’s interpretations of a concept, category or depiction and the realities of ‘getting one’s hands dirty’ with these framework explorations. Our perceptions and constructions of reality or in this case, curriculum outcomes or expectations, sometimes do not fit neatly into framework categories. A wise colleague pointed out to me at NARST that, “life is messy” and this research certainly seemed to be representative of life’s uncertainty and general ‘messiness.’ Adding to this real-life complexity is that the science curriculum at the tenth-grade level across these provinces does not have the same format, but more about that a bit further along in this chapter.

As I continue to explore post-structuralism, I find this ‘messiness’ both freeing and sometimes uncomfortable. I like the way that Arvast (2006) captures some of these uncertainties here:

…In my understanding of post-structuralism, we fashion truth; fashions in truth – those discourses or paradigms which guide the way we see the world – in turn determine the very fabrics we have to make truth. Sometimes, that fabric is scant. Fabrication is also a component; meaning in language is a product of, and the illusion of, a structure which is stabilized by a centre, which limits play and which subjects all language users to its rules. The fabric itself is fabricated; “truth”, as it turns out, is neither stable nor eternal, but is provisional and socially constructed. (p. 2)

A second key finding that I will explore though this chapter is that my explorations of the political discourses studied here seem to have limited influences on the STS[E] curriculum. This interpretation is limited to the data sources that I have explored and with
the qualification that no study can ever fully capture all aspects of these complex and changing contexts.

Initially, I had thought that there might be some possible associations among aspects of general political culture found in the various provinces that may be possibly connected to how the STS[E] curriculum might differ across these regions, given that the STS[E] curriculum appears (i.e., at least superficially) to be a more ‘politicalized’ portion of the tenth-grade science curriculum. Many scholars affirm these more politicized linkages to the STS[E] curriculum such as Waks and Prakash (1985) and their discussions of STS and science as, “…Social action – students participate in responsible political action” (p. 108-114 as cited by Aikenhead, 1994) or Yager (1990) where they state,

Basic to STS efforts is the production of an informed citizenry capable of making crucial decisions and taking actions. STS means focusing upon current issues and attempts at their resolution as the best way of preparing people for current and future citizenship roles. (p. 199)

I will elaborate and explore these findings through my presentation of selected data from across my three provincial representatives. Cross-case analysis can be beneficial source of information and is also cited as an under-developed resource (Khan & VanWynsberghe, 2008), but it is not without critique. For example, Peattie (2001) reminds us about proceeding carefully regarding making large summaries such as here,

…It is simply that the very value of the case study, the contextual and interpenetrating nature of forces, is lost when one tries to sum up in large and mutually exclusive concepts. (p. 260 in Flyvbjerg, 2011, p. 311)

Flyvbjerg (2011) also cautions us about generalizations and summaries where he quotes Nietzsche (1974) and states, “…Above all we should not wish to divest existence of its rich ambiguity” (p. 335).

With these complexities in mind, I present an overview of some organizational features pertaining to STS[E] across the provinces of study and will then journey into an exploration of STS[E] discourses and some possible associations between the selected political discourses presented and some STS[E] discourses. As mentioned previously, I found this association to be limited. The following segment of this chapter will focus on some thematic explorations across the provinces including explorations of the following
categories: STS[E] Ontology and STS[E] and Citizenship. My last chapter following this exploration will describe some additional factors that may work in conjunction with the political climate to perhaps influence and shape the STS[E] curriculum at the tenth-grade level in these selected provincial regions. I should note here that this last concluding chapter is speculative and largely based on theoretical discussions as I was not intending to investigate these factors; rather these additional thoughts emerged as I progressed through my study.

8.2 STS[E] Ontology

Ontology is the study of the nature of reality. Some view science firmly on the realism end such as illustrated through Richard Dawkins famous perspective where he feels that at 30,000 feet there is no such thing as relativism (i.e., meaning that to fly in a plane the pilot and those who engineered the plane are applying universal science knowledge and constructs which do not change with location or culture). This is a pretty hardline stance on science where as STS[E] educational content is a segment of the science curriculum that may represent a more post-positivist (Pedretti & Nazir, 2011) perspective perhaps associated with the relativist end of the ontological spectrum as some STS[E] outcomes/expectations may more explicitly explore science as socially-constructed knowledge.

We might also consider ontological linkages to the analysis work previously presented using Levinson’s (2010) framework categories regarding democratic participation in science education. His framework categories could intersect with various ontological perspectives where deficit and deliberative associations may be more aligned with realist perspectives and the praxis and dissent frameworks perhaps emphasizing more social constructions in science and thus more relativist stances.

In this thematic category, I explore some of the provincial STS[E] characteristics, properties and types which might be deemed an ontological exploration in the sense that the provincial content and organizational representations of their STS[E] curricula may be indicative of the ‘provincial perception’ of the nature of reality about STS[E] education (i.e., what they have documented in this curricular section may represent a ‘snapshot’ of what is viewed as ‘reality’ regarding STS[E] education). We might think of
this as asking the ‘province’ if they are more of a relativist or realist when it comes to science. This discussion will begin with an exploration of some features of STS[E] curricular organization which may shed some light on this question (i.e., realist or relativist?) and I will then move into discussions about some of the interesting and unique features of the curriculum from these regions and present some previous analysis work with Levinson’s (2010) framework and ontological considerations.

Perhaps not surprisingly, the STS[E] curriculum organization differs across Alberta, Ontario and Manitoba because each region has jurisdiction over education inclusive of their science curricula. For example, consider the following summary table depicting some of these distinctive organizational features of the STS[E] curriculum across my provinces of study here:

<table>
<thead>
<tr>
<th>Canadian Province</th>
<th>Some STS/STSE Organizational Features &amp; Presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>- Blends STS &amp; Knowledge outcomes into one curriculum section that occurs first in each unit of study</td>
</tr>
<tr>
<td>Ontario</td>
<td>- STSE is a separate category of curriculum expectations and occurs first in each unit of study in both the academic and applied streams</td>
</tr>
</tbody>
</table>
| Manitoba          | - STSE is primarily located in a separate Strand 0 (with the intent of practitioners applying these outcomes across the units of study), i.e., appears decontextualized  
|                    | - STSE outcomes also appear in the General Learning Outcomes described in the curriculum front matter  
|                    | - A few outcomes in each contextualized unit of study are also connected with STSE |

These provincial differences were interesting to me when viewed through the lens of discourse analysis if we take the perspective discussed by MacLure (2003) that certain discourses that become institutionalized, such as exhibited by what is included in a curriculum document, may serve as agents that are exclusionary in the sense of what is selected or presented for inclusion versus what may be left out of the STS[E] curriculum content or context.

MacLure’s (2003) perspectives may be helpful in considering additional viewpoints regarding curriculum organization. The Manitoba STS[E] curriculum outcomes occur primarily in a separate Strand 0 (i.e., there are also some contextualized STS[E] outcomes in the units and in the General Learning Outcomes noted in the curriculum front matter). The discourses that may arguably become ‘institutionalized’ could be those outcomes that are contextualized within the curricular areas as depicted in
Table 8.1. Strand 0 isolation may be problematic from that perspective that portions of the science curriculum might be considered an ‘outsider’ relative to the rest. From an ontological perspective, it is interesting as this might be suggestive to the reader that there is potentially more socially-constructed or relativist positions taken on science knowledge as the STS[E] content and perspectives are prefaced and to be applied to all other parts of the science curriculum. Levinson’s (2010) deliberative framework category is emphasized, but there are also potential linkages to both the praxis and dissent categories (see Table 8.2) which again may indicate some realist and some relativist perspectives regarding the STS[E] content. Manitoba’s STS[E] curriculum seems to be a ‘quilt’ of various patches woven together that reflect realism and relativism.

Ontario’s STS[E] placement appears in both the overall expectations and the primary positions for the specific expectations in each unit. However, if we again consider MacLure (2003) and explore what might become ‘institutionalized’ regarding curriculum and even perhaps classroom practice, STS[E] expectations occupy the two last segments of the Achievement Chart (Bloche, 2014) that governs assessment and evaluation practices in Ontario. This placement could again position even the first place STS[E] expectations in the role of an ‘outsider’ relative to the other expectations taking priority regarding their status on the Achievement Chart. If we view this from an ontological perspective, it may be that the general positioning at the forefront of the expectations implies a more relativist ‘umbrella’ regarding the science content (i.e., of course also dependent upon how practitioners might interpret these expectations).

If Levinson’s (2010) categories are considered, there is an emphasis that appears to be focused on the deliberative and perhaps in some cases a deliberative/praxis association regarding the curriculum expectations (see Table 8.2). As written, this may point to a more relativist ontological perspective in the context of STS[E] education, however, as pointed out earlier by Bloche (2014), the relative placement of STS[E] at the bottom of the Achievement Chart may indicate that other more realist perspectives are in fact being emphasized in practice. I would perhaps liken this STS[E] curriculum as wearing a relativist ‘cloak’ over a more realist ensemble.

Alberta blends their Knowledge and STS outcomes. Although they title this section, ‘STS & Knowledge’, a case may be made that it should be re-written as
‘Knowledge & STS’ due to the placement of most STS outcomes (i.e., they tend to appear after the knowledge-related outcomes). This appears to ‘institutionalize’ and prioritize knowledge before connections among science, technology and society. Again, STS might be considered an outsider living inside? Ontologically, although these areas are blended, the prioritization of knowledge content before STS content (i.e., in most units, but not all), might suggest a perspective more aligned with realist ontology. The earlier explorations with Levinson’s (2010) framework also suggest that there may be associations with the deficit/deliberative if STS and Knowledge are considered together or a deliberative affiliation if STS is considered separate from the knowledge outcomes (see Table 8.2). This analysis may point to again a more realist ontological perspective regarding the STS[E] content. This STS[E] curriculum might resemble a realist outfit with perhaps a relativist collar or trim.

To summarize this segment and move forward into my next thematic exploration, I have constructed a summary matrix to depict some additional findings from each provincial case study (see Table 8.2). Again, my intent is not to be too reductionist regarding any of the meaning-making from the individual cases, since these cases speak to interesting points and perspectives in and of themselves, but to present an overview of some of those findings as the basis for additional descriptions and conversations about themes that emerged across the provinces of study.
TABLE 8.2: Cross Case Summary Matrix Depicting Some Provincial Explorations and Findings.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate Number of STS[E] Outcomes/ Expectations Explored in this study</td>
<td>20 (i.e., approximate number focusing on the isolated STS outcomes)</td>
<td>13</td>
<td>12</td>
<td>37 (i.e., this is approximate and encompasses selected Strand 0 STSE and contextualized STSE outcomes)</td>
</tr>
<tr>
<td>Grade 10 Science Units/Strands</td>
<td>Energy from the sun; Matter and energy in living systems; Matter and energy in chemical change; Energy and change</td>
<td>Scientific Investigation Skills and Career Exploration; Tissues, Organs, and Systems of Living Things; Chemical Reactions; Earth and Space Science: Climate Change; Physics: Light and Geometric Optics</td>
<td>Scientific Investigation Skills and Career Exploration; Tissues, Organs, and Systems; Chemistry: Chemical Reactions and Their Practical Applications; Earth and Space Science: Earth’s Dynamic Climate; Physics: Light and Applications of Optics</td>
<td>Strand 0: Overall Skills and Attitudes; Dynamics of Ecosystems; Chemistry in Action; In Motion; Weather Dynamics</td>
</tr>
<tr>
<td>STS[E] Curricular Title</td>
<td>STS &amp; Knowledge</td>
<td>STSE</td>
<td>STSE</td>
<td>STSE</td>
</tr>
<tr>
<td>Curriculum Document Authorship Clearly Indicated</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Provincially Mandated Standardized Testing in Science</td>
<td>Yes-Grade 9 Level and also via Grade 12 Level Diploma Examinations</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>PISA Participation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Some Outcomes of Applying Bloom’s Revised Taxonomy (2001) to STS[E] outcomes</td>
<td>Following categories appear to be emphasized: Understanding; Analysis; Evaluation (STS &amp; Knowledge)</td>
<td>Following categories appear to be emphasized: Analyze; Evaluate; Create (i.e., majority seemed to emphasize Analyze)</td>
<td>Following categories appear to be emphasized: Analyze; Apply; Evaluate (majority seemed to emphasize Analyze)</td>
<td>Many categories appear to be emphasized: Understand; Apply; Analyze; Evaluate; Create</td>
</tr>
</tbody>
</table>

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Deliberative if the STS and Knowledge outcomes are analyzed separately</td>
<td>Deliberative and Deliberative/Praxis</td>
</tr>
<tr>
<td>If STS is isolated from Knowledge: Application &amp; Design (lowest emphasis here); Historical; Logical Reasoning; Socio-cultural (highest emphasis here)</td>
<td>Logical Reasoning; Socio-cultural</td>
</tr>
<tr>
<td>Deliberative and some Deliberative/Praxis/</td>
<td>Logical Reasoning, Application &amp; Design, some Socio-cultural</td>
</tr>
<tr>
<td>Deliberative emphasis as well as Praxis and some possible linkages to Dissent &amp; Conflict</td>
<td>Logical Reasoning, Application &amp; Design, Socio-cultural, Socio-ecojustice</td>
</tr>
</tbody>
</table>

Some Themes that Emerged in Unit Related to Climate Change

<table>
<thead>
<tr>
<th>Some Themes that Emerged in Unit Related to Climate Change</th>
<th>Analyze)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropocentrism; Quantification; Uncertainty in Science; Actions</td>
<td>Critical Thinking &amp; Climate Change; Actions; Global Perspectives</td>
</tr>
<tr>
<td>Critical Thinking &amp; Climate Change; Actions &amp; Emphasis on Agency; Cross-Disciplinary Approaches</td>
<td></td>
</tr>
</tbody>
</table>

8.3 STS[E] and Citizenship

As mentioned above, the STS[E] curriculum appears on the surface to be perhaps the most politicized portion of the science curriculum as it involves choices, decisions and potential action implementations (i.e., perhaps in the case of Manitoba). If we consider democracy, citizenship and how a more political element might be enacted in a science classroom, it would probably make sense that there may be a range of how socio-political literacy might be enacted as demonstrated through the work of Bencze (i.e., the STEPWISE approach), Hodson (2003), Levinson (2010), or Pedretti and Nazir’s (2011) socio-ecojustice current.

From my explorations and framework applications across the provinces, Bloom’s revised framework applications (i.e., Krathwohl, 2002) seem to suggest that primarily the categories of ‘analyze’ and ‘evaluate’ are emphasized and some outcomes/expectations that might align with the ‘create’ dimension (see Table 8.2). If we think about possible implications of curriculum documents that seem to emphasize ‘analyze’ and ‘evaluate’ in the context of some of MacLure’s (2003) work such as:
-Language is not ‘transparent’: that is, it is not a neutral medium or vehicle for providing access to the world, or to thought.
-People are ‘made subjects’ through their involvement as speaking subjects within discourses. (p. 180-181)

If science is potentially making subjects of its students through uses of curriculum outcomes/expectations that emphasize analysis and evaluation, it might be argued that some critical thought is being promoted regarding issue analysis in STS[E]. However, it does not seem to make subjects who might be apt to ‘create’ knowledge or act in the interest of their perspectives, perhaps leaning toward a more representative versus participatory style of citizenship regarding issues associated with science and technology.

Interestingly, all three provincial curricula appear to emphasize Levinson’s (2010) deliberative framework category with some caveats (see Tables 5.2, 5.4, 6.4, 6.5 & 7.3). This emphasis and similarity among the provinces becomes more apparent if we consider the STS content separately from the knowledge-based outcomes found in Alberta.39 Ontario seems to emphasize the deliberative category in both the applied and academic streams; with some expectations that could align with a more praxis-orientation depending perhaps upon practitioner interpretation. Manitoba also tends to emphasize the deliberative framework category and also appears to have outcomes that would align with a praxis-based approach and even arguably dissent and conflict in a few outcomes (see Table 7.3). Although the primary emphasis appears to be similar, we do see a slight shifting of these results based on the province (see Tables 5.2, 5.4, 6.4, 6.5 & 7.3).

Similarities seem to exist among the provinces regarding Pedretti and Nazir’s (2011) STS[E] currents. All provinces seem to emphasize the logical reasoning and socio-cultural currents (see Tables 5.3, 5.5 6.4, 6.5 & 7.3); which supports their assertion that the logical reasoning current tends to be quite widely used. Manitoba additionally appears to have some outcomes that might be aligned with Pedretti and Nazir’s (2011) socio-ecojustice current such as illustrated here:

39 If the STS & Knowledge science curriculum category is analyzed as presented in Alberta, it appears to shift toward a deficit/deliberative focus, which would make sense if we consider more seemingly ‘objective’ types of knowledge associated with science and technology such as heat of formation equations how to balance a chemical equation. There would be little debate about these types of information or associated procedures.
Select the best option and determine a course of action to implement an STSE decision. (Senior 2 Science: Manitoba Curriculum Framework of Outcomes, 2001, p. 3.13)

Implement an STSE decision and evaluate its effects. (Senior 2 Science: Manitoba Curriculum Framework of Outcomes, 2001, p. 3.13)

Or here:

Investigate how human activities affect an ecosystem and use the decision-making process to propose a course of action to enhance its sustainability.

Include: impact on biogeochemical cycling, population dynamics, and biodiversity. (Senior 2 Science: Manitoba Curriculum Framework of Outcomes, 2001, p. 3.17)

The Senior 2 Science: A Foundation for Implementation (2003) also states that,

…suggest ways in which they can be personally involved and proactive with respect to STSE issues. (p. 99)

S2-0-7c Select the best option and determine a course of action to implement an STSE decision.

S2-0-7d Implement an STSE decision and evaluate its effects.

S2-0-7e Reflect on the process used to arrive at or to implement an STSE decision, and suggest improvements. (p. 71)

I do not think a simplistic relationship exists between Levinson’s (2010) framework categories and Pedretti and Nazir’s (2011) STS[E] currents, although there seem to be overlaps, as depicted through my analysis work. Interestingly, Levinson’s (2010) deliberative category can seemingly encompass a wide variety of Pedretti and Nazir’s (2011) STS[E] currents such as application and design, logical reasoning and the socio-cultural. There may also be associations between the frameworks in the sense that as the STS[E] curriculum moves toward a higher degree of potential politicization as indicated through my explorations with Levinson’s (2010) framework and Pedretti and Nazir’s (2011) socio-ecojustice current. For example, consider the following outcomes from the Manitoba curriculum from the ‘In Motion’ unit:
S2-3-13 Use the decision-making process to address an STSE issue related to safe driving conditions.

*Examples: adverse driving conditions, reaction time, narcotic influences such as blood alcohol level, excessive vehicle speed...* (Senior 2 Science: A Foundation for Implementation, 2003, p. 174)

Student Learning Activities

Student Research/Collaborative Teamwork

S2-0-1c, 3e, 3f, 4e

Student groups develop public awareness campaigns to address STSE issues related to safe driving conditions. Topics can include: drinking and driving; speeding; adjusting to icy road conditions; driver fatigue; cellphone use; defensive driving. Case studies, newspaper articles, and Internet sources can be used. (Senior 2 Science: A Foundation for Implementation, 2003, p. 174)

And here:

Research Report/Presentation S2-0-6d, 9c, 9e, 9f (see linkages below)

Student groups present their public awareness campaigns using:

- television/radio commercials; cartoons; posters; pamphlets, brochures, bulletin board displays; newspaper/magazine advertisements. (Senior 2 Science: A Foundation for Implementation, 2003, p. 175)

[S2-0-6d Adjust STSE options as required once their potential effects become evident.  
S2-0-9c Demonstrate confidence in their ability to carry out investigations in science and to address STSE issues.  
S2-0-9e Be sensitive and responsible in maintaining a balance between the needs of humans and a sustainable environment.  
S2-0-9f Demonstrate personal involvement and be proactive with respect to STSE issues]

I think that these curriculum outcomes demonstrate these potential overlaps among Levinson’s (2010) praxis or possibly even dissent and conflict categories and Pedretti and Nazir’s (2011) socio-ecojustice current given that there is an emphasis on a social issue and what can be done to address the socio-scientific issue; inclusive of the potential to address power structures in society (e.g., through a public awareness campaign approach). The enactment of a decision and the suggestion of the use of a public awareness campaign may also imply socio-political awareness and navigation that may
be consistent with a socio-ecojustice current (Pedretti & Nazir, 2011) or praxis and/or dissent and conflict framework (Levinson, 2010).

So what does this mean regarding citizenship? The apparent emphasis on Levinson’s (2010) deliberative framework category (i.e., with some qualifications) as well as Bloomian emphasis (i.e., using Krathwohl, 2002) on ‘analyze’ and ‘evaluate’ and a lack of emphasis on Pedretti and Nazir’s (2011) socio-ecojustice (i.e., with some exceptions) might suggest an allegiance to a more representative versus participatory style of democratic participation and citizenship across the provinces as depicted in the STS[E] curricular content. Interestingly, it would seem that despite some differences regarding geography and political climate at the provincial level that the provinces share similarities in their STS[E] content, of course with some caveats that have been discussed.

These explorations may also intersect with Robert’s (2007) Vision I and Vision II depictions of science literacy, where Vision I tends to represent a knowledge of science more so from within science where as a Vision II perspective aligns more with a science literacy focus and issues-based awareness. It might seem that based upon the written outcomes/expectations in the STS[E] curriculum that Alberta may have more of an alliance toward a Vision I with some characteristics of Vision II (i.e., when considering their blend of both STS and knowledge-based outcomes). Ontario appears to perhaps have some characteristics of a Vision II outlook where some of Ontario’s expectations seem to share some facets of both deliberative and praxis-based approaches. Manitoba also appears to emphasize a deliberative approach but also includes praxis-associated outcomes and perhaps a few outcomes that may even be associated with a dissent and conflict approach perhaps indicating again an outlook that includes both Vision I and Vision II perspectives.

8.4 Explorations of Selected Aspects of Political Culture and Some Possible Intersections with STS[E] Curricula

Some facets of general political culture have been explored across the provinces of Alberta, Ontario and Manitoba as one possible factor that might influence aspects of the STS[E] curriculum content in these regions. These discussions and explorations focus
on the various party platforms from each political party released at about the time of the science curriculum document release or construction, a selected Speech from the Throne and the provincial climate change action plans. As mentioned at the beginning of this chapter, although there may be some areas of possible intersection, it seems that these influences may be limited or perhaps work alongside other possible factors to perhaps shape and possibly influence STS[E] curricula that is explored in my last chapter. As depicted in the individual cases, I have focused my efforts on selected themes from the political sphere that I see as possibly influential regarding STS[E] curricula. These thematic explorations are broadly categorized under the broad heading of socio-economic factors where neoliberalism and sustainable development are explored. In each segment, I will discuss some aspects of the political discourse and then showcase where I possibly see this theme carried into facets of the STS[E] curriculum or in other segments of the tenth-grade science curriculum. As noted previously, I found this association to be complex, unclear and limited based on the explorations presented here and of course, and subject to change.

8.5 Socio-Economic Thematic Explorations

8.5.1 Neoliberalism and STS[E] Curricula

As previously explored in my theoretical background and in my individual cases, the term ‘neoliberalism’ is quite challenging to define as many scholars have different perspectives regarding what this ideology means and what it might look like in practice. Harvey (2005) provides us with the perspective that it is a combination of economic and political practices that prioritize individual pursuits, laissez-faire practices regarding the economy and trade and emphasize the accumulation of private property. Harvey (2005) states that since the 1970s that, “…Deregulation, privatization, and withdrawal of the state from many areas of social provision have been all too common.”

Discourses associated with neoliberalism seem to be present in the political discourses of all provinces to varying degrees. For example, all provinces prioritize fiscal policy, job creation and seem to make linkages between education and the economy and

40 Accessed from: https://books.google.ca/books?id=F5DZvEVt890C&printsec=frontcover&source=gbs_atb#v=onepage&q&f=false
educational ‘excellence’ (see Table 8.3 below). All provinces also highlight health care objectives, education and communities and families that may be goals that are not as aligned generally with neoliberalism (see Table 9.3 below).

TABLE 8.3: Summary of some political document explorations across the provinces (note that dates differ due to different time periods of the release of the science curriculum documents in each province).

<table>
<thead>
<tr>
<th>Province</th>
<th>Alberta</th>
<th>Ontario</th>
<th>Manitoba</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some Selected Quotations from the Speech from the Throne</td>
<td>“A good education is the first step to a productive, fulfilling life. Albertans rightly expect excellence in education. Government must focus on providing students with the quality education they will need to thrive in the future.” “This government will work to ensure that the basics of literacy and numeracy are the foundation for all student learning, from Kindergarten through Grade 12. We will also work to ensure students have opportunities to acquire 21st century competencies such as innovation, communication and collaboration.” (Alberta Speech from the Throne, November 17, 2014)</td>
<td>“When we improve the quality of public education, when we provide our young people in particular with the skills they need to succeed, we get the best workers, who land the best jobs, who in turn build the strongest economy, which funds everything we want to do together. But this virtuous circle encompasses far more than material gain. At its very best, education instills in our children the understanding that we are in this together, that they must take responsibility for themselves, their families and their communities, that we are all connected, and that we share a responsibility to look out for one another, to help one another and to build something greater than ourselves.” (Ontario Speech from the Throne, November 29, 2007)</td>
<td>“Constraints on public finances have forced us to carefully consider and focus the public investments we make. In meeting the challenges of the next century, however, we are still guided by the example of foresight and co-operative effort set by those who went before us. We share their commitment to increasing the prosperity of our province and to steadily expanding the circle of those who look to the future with hope and anticipation.” “Another priority for Manitoba is to build a modern, responsive education system that will prepare our youth for the challenges of the new economy.”</td>
</tr>
</tbody>
</table>
The language used in both the Liberal platform in Ontario and the NDP platform in Manitoba seem to use more Germanic or everyday language discourses such as their use of the terms: ‘smarter’ versus ‘educated; ‘greener’ versus ‘environmental’; ‘money in your wallet’ versus ‘conservative fiscal policy’ (see Table 8.3 above). The terms ‘economic’ and ‘invest’ as well as ‘advance’ all appear in the Alberta PC platform which might suggest a difference regarding potential readership and the use of more Latinate-sounding terms which might be associated with jargons and in this case perhaps a type of business jargon (see Table 8.3 above). If we explore the selections of text presented from each Speech from the Throne, again, we can see some consistencies aligned with the selections from the party platforms and also a distinctive tie between education and the economic considerations across all provinces.

If we consider the selected Speeches from the Throne and the provincial party platform summary Wordles™ as depicted below in Table 8.4 all provinces regardless of political orientation appear to emphasize the following words: province name, provincial residents and government. Where they tend to differ is that both Alberta and Ontario seem to emphasize the word ‘work’ (see Table 8.4) and Manitoba seems to have emphasized the word, ‘health’ (this is of course not to say that the other provinces do not mention these terms, but as looking at the Wordle™ as a tool to explore words emphasized).
Some of these similarities and differences in emphasis may speak to the assertion by Khan and McIvor (1991) that the Liberal and Progressive Conservative parties tend to be fundamentally quite similar yet differ in their ‘styles’ whereas the New Democrat party tends to differ in terms of its more socialist ideology. This difference in ideology regarding the NDP might be demonstrated here in the following quote from their Speech from the Throne (Thursday, November 25, 1999):

…The health of our democracy depends on continual efforts to expand participation in decision-making and build trust among citizens. In particular, citizens need to participate in the decisions that affect them directly, or that affect the communities in which they live. They need to feel that their voice and their role are respected.

The Manitoba government has committed: to give Manitobans a direct say in any proposed sale of our Crown Corporations; to increase citizens' input into regional health authority decisions and environmental licensing; and to eliminate corporate and union contributions to political parties.
These statements may suggest a different type of discourse inviting increased citizen participation and say in decision-making. However, the mention of the proposed sale of Crown Corporations may be aligned with some neoliberal tendencies and may intersect with Albo’s (2002) claim that neoliberalism can be associated with social democrat governments. Additionally, the claims of Khan and McNivon (1991) about similarities between the Liberal and PC parties and the differences in discourse and ideologies aligned with the NDP party may be mirrored through the Political Compass website (please see: http://www.politicalcompass.org/canada2005). Some caution must be exercised in the interpretation of their depictions as a detailed analysis of these categorizations is not presented here, but it does seem to intersect with some of the discourses explored in the political documents and also with some of the scholarly descriptions provided here and in the individual cases.

All provinces through their political discourse seem to highlight linkages between education and the economy (see Table 8.3) and all of course want ‘excellence’ in their educational systems. The term, ‘excellence,’ can mean different things to different people, not unlike the word, ‘success’ and can be associated with neoliberalism in that it may conjure images of competition, scarcity or perhaps individualism. Provincial interpretations of what constitutes excellence and how it might be measured and accounted for could have some influence on the style and delivery of the science curriculum and the STS[E] outcomes or expectations. Taubman (2009) comments here about these types of discourses in education:

…The transformation that has proceeded under the twin banners of “standards” and “accountability,” has over the last decade profoundly affected all aspects of teaching, schooling, and teacher education in the United States, and now threatens public educations itself. (p. 12)

and also here,

…the discourses and assemblages of business practices associated with neoliberal economic politics and what British anthropologists call audit culture, discourses and practices that have accelerated the standardization and quantification of educational experience and turned it into an education market worth billions of dollars…. (p.13)
‘Excellence’ in the STS[E] curriculum may take the form of number of outcomes or expectations that are presented and perhaps the extent to which standardized testing is used (i.e., a more individualized pursuit that may be associated with neoliberalism).

Neoliberalism: Does curriculum size matter? All provinces appear to share similarities in their emphasis on units or strands of study at the tenth-grade level where biology, chemistry, physics and earth and space science are all present. The provinces differ regarding how they demarcate this information into the relative number of STS[E] curriculum outcomes/expectations and through the titles that they use such as: Alberta: STS & Knowledge Outcomes; Manitoba: STSE Outcomes; Ontario: STSE Expectations.

The greatest number of curricular outcomes overall are found in Alberta (see Table 8.5); whereas the smallest number of outcomes are found in Manitoba. Interestingly, if we explore the relative and approximate number of STS[E] outcomes to total outcomes, we can see that Manitoba has a higher overall emphasis on STS[E] when compared with Alberta or Ontario (i.e., which are about the same). Both Ontario and Alberta embed their STS[E] outcomes/expectations into the various contextualized units of study whereas Manitoba primarily (i.e., as STS[E] is embedded in some additional curriculum outcomes and is also found in the General Learning Outcomes) presents many STS[E] outcomes in a separate strand where the expectation is to embed these outcomes across the other science strands (i.e., in addition to the STS[E]-related outcomes that are already present in the contextualized science units).
TABLE 8.5: Some approximations of STS[E]-related outcomes or expectations relative to the approximate total number of curriculum outcomes/expectations found in each province of study.

<table>
<thead>
<tr>
<th>Approximate Number of STS[E] Outcomes/Expectations Across all Units in Grade 10-Level Curriculum</th>
<th>Alberta</th>
<th>Ontario (Applied-level curriculum)</th>
<th>Ontario (Academic-level curriculum)</th>
<th>Manitoba</th>
</tr>
</thead>
<tbody>
<tr>
<td>20$^{41}$ (i.e., if the STS-related outcomes are considered separately from the knowledge-based outcomes)</td>
<td>12</td>
<td>13</td>
<td>37 (i.e., this is approximate and encompasses some Strand 0 STS[E] outcomes and contextualized STS[E] outcomes)</td>
<td></td>
</tr>
<tr>
<td>Approximate Number of Outcomes/Expectations in Tenth-Grade Level Science Curriculum</td>
<td>183$^{42}$</td>
<td>89</td>
<td>95</td>
<td>87</td>
</tr>
<tr>
<td>Approx. % of Curriculum Associated with STS[E]</td>
<td>11%</td>
<td>13%</td>
<td>14%</td>
<td>43%</td>
</tr>
</tbody>
</table>

The relative total number of outcomes/expectations could suggest relationships associated neoliberalism such as ‘control’ or ‘efficiency.’ For example, a relative higher number of outcomes/expectations present in a curriculum document may suggest a more stringent following of the outcomes as there would be much more practitioner time spent trying to ‘cover the curriculum’ and perhaps less time that could be devoted to slowing down and more deeply considering issues pertaining to the STS[E] topic at hand. A relatively smaller number of outcomes/expectations could suggest perhaps less emphasis on ‘covering the content’ and perhaps more freedom allocated to practitioners engaged in curriculum delivery. What remains unclear about this relationship is how much practitioner time would be spent on each outcome or expectation. Simply by having more or less of a topic in the curriculum does not necessarily translate to time allocations for those topics in the classroom.

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$^{41}$ Please note that this number is derived from counting the larger ‘overall’ outcome and the ‘sub-outcomes’ that follow the main outcome as bulleted points.

$^{42}$ Please note that this number is an approximation of the total number of outcomes as this number omits the outcomes designated, ‘students will be encouraged to…’ and focuses on the outcomes, ‘students will…’
Another perspective regarding STS[E] outcomes or expectations is that it is a very complex part of the curriculum and is also a part of the science curriculum that many teachers feel somewhat uncomfortable delivering due to myriad reasons (Pedretti et al., 2008). The presentation of a higher number of STS[E] outcomes/expectations may not necessarily represent a ‘controlling’ type of relationship; in this light it could also be viewed as a potentially more detailed ‘road-map’ for a highly complex set of outcomes/expectations.

So what could this mean for our students if neoliberalism might be expressed in our curriculum documents via larger number of outcomes or expectations? Bencze, Alsop and Bowen (2009) offer us a perspective here regarding how large volumes of information presented in a science curriculum may impact the learners:

…Confusion: Often, being a student of school science is like trying to take a sip from a fire hose! All too frequently, teachers feel compelled to ‘cover’ curriculum content (i.e., for learning science) so rapidly, and with few opportunities for application in personally meaningful contexts that many students are left confused or only capable of rote learning (which often is forgotten after tests) (Jenkins, 2000). (p. 91)

So to answer this sub-heading’s question, I do think curriculum size matters and smaller may be arguably better regarding the number of overall outcomes or expectations. We want our students to be science literate and hopefully not confused about science and technology and having more outcomes or expectations does not necessarily equal ‘excellence’. Science illiteracy has problematic implications for our societies in light of how many decisions utilize science and technology such as reproductive decisions, various food choices, pharmaceuticals, whether to engage in various types of medical screenings or testing protocols, allocation of protected green-spaces and forests, among many others.

**Neoliberalism: Performativity and Standardized Testing.** Another perspective to consider regarding the relative number of outcomes or expectations in light of possible ties to neoliberalism may be standardized testing. Kempf (2015) states that, “Standardized tests are a quick and dirty measure of our competitive rankings—particularly in mathematics and sciences” (p. 43). All provinces participate in standardized testing in science such as the PISA exam, but Alberta is the only province
that has a standardized test in science at the Grade-9 level and also diploma examinations
at the Grade 12-level in science (i.e., it should be noted that Ontario and Manitoba both
engage in various standardized tests in other subject areas and at various grade levels).
Taubman (2009) offers some interesting perspectives here about some general
possibilities regarding intersections among neoliberalism and standardized testing in
stating that,

…. Tests are the cattle prods, the surgical strikes, the electrical probes that
administer the first shocks. They extract the information, the data that will be used
to initially hold the system accountable, and in the name of standards, they “level”
the ground or playing field. Then they open it up to the market. (p. 16)

Kempf (2015) discusses this possible marketization of education via standardized testing
here where he states that,

In the United States in particular, increased standardization has intensified the role
of private companies in public education. Standardized measurement constitutes
the key private to public access point, both currently and historically within
education. (p. 45)

Graham and Neu (2004) conducted research on some of the standardized testing
protocols in Alberta and claim that,

…although standardized testing may serve its ostensible purpose of measuring
student performance, it also functions as a mode of government control by
helping to construct governable subjects. (p. 295)

Standardized testing can potentially be used to compare schools, districts and teachers
(Graham & Neu, 2004). This may influence curriculum interpretation and/or delivery.
For example, if the standardized test uses STS[E] as primarily an aid for providing a
contextualization for other science content, the educator may have little incentive to focus
on these parts of the curriculum if it means that they may be portrayed negatively in
terms of the testing results. Graham and Neu (2004) speak to this point here where they
state,

Between these two camps, various opinions are espoused on the value of the
class-time spent on the tests—a sort of transaction cost approach to the debate—
and on the possibility that some teachers ‘teach to the test’, as the popular phrase
goes, thereby skewing the results. (p. 297)
Kempf (2015) provides perspectives that corroborate the above claims from various educators here regarding the impact of standardized testing on classroom practice:

Another Chicago teacher explains: “it’s hard to differentiate test prep,” while an Ontario grade three teacher puts it plainly: “inquiry based learning and time dedicated to project-based learning are abandoned because of testing.” Although differentiation may be possible to limited and differing degrees in standardized classrooms, it is clear that its absence is widespread, and increasingly so. (p. 86)

The action of test taking on students can also have far-reaching impacts. Graham and Neu (2004) state that,

Learning to submit to instruction and testing, to sit still at a desk for hours each day, to depend upon an institution (Illich, 1971), and to adjust one’s behaviour to produce socially acceptable results are all by-products of the modern education system that produces not just educated graduates, but docile citizens. (Foucault 1984a: 197). (p. 311)

It is important to note that students in Alberta do not participate in a standardized tenth-grade science test, so it is challenging to say if the standardized testing protocols present in Grade 9 would impact curriculum delivery at the Grade 10 level, however, they will take Diploma Examinations in their Grade 12 year if they continue to pursue an education in science. Standardized testing protocols where an emphasis is placed on individual accountability and efficiency may be a manifestation of some facets of neoliberalism in education that also link in with measurements of ‘excellence’ or what governments or the public construct as measures of ‘excellence’. Kempf (2015) comments here about this discourse:

The driving rhetorical force in the push for standardized testing is the idea of accountability. It is a seductive discourse. Who would dare disagree that teachers should be held to high standards, that students should be well educated and cared for, that money from taxpayers (otherwise known as citizens, or even sometimes as people) should be carefully spent, that public servants who do their job poorly should be forced to improve or lose their job, or that we should have clear tools for understanding how well our education systems are working? (p. 25)

He also states that while these are important goals in our educational systems that there is no proof that standardized testing actually can accomplish these objectives.

This phenomenon seems to resemble a bit of an alliance to Foucault’s (1977) discussion of Bentham’s Panopticon in *Discipline and Punish*. The Panopticon was a prison design, in which prisoners were potentially on display to their guards without
knowing if they were or were not being observed. Foucault (1977) discusses here regarding the function of this system:

Hence the major effect of the Panopticon: to induce in the inmate a state of conscious and permanent visibility that assures the automatic functioning of power. (p. 201)

In the case of standardized testing, the tests themselves may be thought of as a kind of Panopticon where the test-takers and their teachers may feel as though they are being monitored with or without being directly observed. Bencze et al. (2009) state that,

Under the influence of neoconservative capitalism, school science often is more like a protracted test, rather than an opportunity to be educated in ways that would be best for individual students, societies and environments. (p. 85)

Carter (2010) also frames testing protocols such as the PISA test in the context of neoliberalism and comments here about these practices:

Meadmore’s (2001) analysis of standardized student testing regimes like PISA explains this point further. Meadmore argued that the neoliberal desire for increased surveillance, regulation, and accountability is intrinsic to such assessments. Productive of both power and performativity such that students, classes, schools, or systems must show quantifiable results, Meadmore believed testing regimes like PISA monitor outcomes and position everyone on scales so improvements can be claimed and deficiencies blamed. (p. 226)

8.5.2 Sustainable Development Political Discourses & STS[E] Curricula

All provinces explored seemed to share similarities on linkages between the environment, sustainable practices and job or economic considerations (i.e., see the individual cases for more detail associated with these considerations) which seems to align generally with a sustainable development context.

In terms of a sustainable development (i.e., note that in the individual cases presented earlier that other provincial foci were explored regarding the environment such as a conservation theme) focus across the provinces presented here, I found Sauvé’s (1996) use of the depictions from the Calgary Latin American Group (1994) to be an interesting way to explore some of the provincial nuances regarding these depictions. Alberta seems to focus more so on resource management and stewardship and also references technological innovation associated with carbon sequestration that may align with a ‘continuous development’ association as depicted by the Calgary Latin American
Group (1994) (see Table 8.6). Ontario describes approaches to sustainable development with an emphasis on green job creation, reduction in emissions and a focus on renewable sources of energy. These approaches might align with a blend of “Development as dependent on a world order” and an “Alternative Development” stance as described by the Calgary Latin American Group (1994) (see Table 8.6). Manitoba also has discourses that might be aligned with the “Alternative Development” approach (see Table 8.6), but it is unclear how and when these approaches might be implemented and given the prioritization of economic discourses, it may be that Manitoba’s approach also overlaps with framework category, “Development as dependent on a world order” (Calgary Latin American Group, 1994).

Based on these discussions, we may see certain translations of these discourses about sustainable development into the STS[E] curriculum to varying degrees (see Table 8.6). For example, in Alberta the political discourse seems to emphasize in part the conservation and efficient use of energy and we see this mirrored in the STS curriculum where we see the word, ‘efficient’ emphasized and also the phrase, “…to make judicious use of natural resources.” The political discourse states that, “…we are as serious about the environment business as we are about the energy business…” and we may arguably see business and environmental languages used together in the STS outcomes in the form of cost/benefit analysis (see Table 8.3 above).

Ontario’s political discourse seems to suggest that we can have both a strong economy and a green focus. Their discourse seems to focus on the reduction of emissions. We see this possibly mirrored in the STS[E] expectations through the emphasis placed on climate change initiatives such as retro-fittings, tree planting and carbon offset plans. These initiatives seem to be somewhat consistent with a focus overall of the reduction of emissions.

Manitoba includes discussions of hydroelectric energy or ‘Manitoba’s oil’ and also wind energy generation that may suggest a focus on alternate forms of energy creation, not necessarily a reduction in the use of energy. We may see a mirroring of a sustainable development focus based on the schematic from the curriculum front matter where their curricular interpretation of sustainable development focuses on the interplay among the economy, health and well-being and the environment. The selected STS[E]
outcome may mirror some of these focal points where there is emphasis on some technologies that may reduce air pollutants (see Table 8.6).

TABLE 8.6: Some possible provincial perspectives about sustainable development linked to selected data from some documents explored.

<table>
<thead>
<tr>
<th>Province</th>
<th>Selected Statements from Political Documents</th>
<th>Examples of Discourse Perhaps Aligned with Sustainable Development Approaches from the STS[E] Curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>“…Conserving and using energy efficiently. Goal: to reduce greenhouse gas emissions by transforming how we use energy, applying energy efficient solutions, and conserving energy. -Implementing Carbon Capture and storage. Goal: to store quantities of CO₂ in Alberta’s geological formations rather than releasing it into the atmosphere. -Greening energy production. Goal: to transform the way we produce energy and to introduce cleaner, more sustainable approaches to energy production…” (p. 7, Alberta’s Climate Change Strategy: Responsibility/Leadership/Action, 2008). “…If we talk about being a leader in the energy, agriculture or forestry business, then we are in the environment business. Our customers expect this, and Albertans themselves demand it. Clean air, fresh water and thriving biodiversity are part of our identity as Albertans and Canadians — something that Alberta shares with visitors from around the world through our exceptional tourism industry. But we cannot just spread the word on the steps we have already taken. Alberta must take meaningful, effective action to show we are as serious about the environment business as we are about the energy business. This includes ongoing work with stakeholders and industry on the development of a new tailings management framework and taking action to protect the Athabasca River and its neighbouring ecosystems. Alberta must build on the leadership that made us the first jurisdiction in North America to regulate greenhouse gas emissions, and among the first to put a price on carbon…” (Alberta Speech from the Throne, November 17, 2014) “…Advance World-leading Resource Stewardship: we will develop our natural resources responsibly to protect our environment and grow our markets…” (Alberta by Design: Reaching our full potential: Building on a legacy of real-life leadership &amp; securing the promise of Alberta’s future, 2012).</td>
<td>Are there relationships between solar energy, global energy transfer processes, climate and biomes? What evidence suggests our climate may be changing more rapidly than living species can adapt? Is human activity causing climate change? How can we reduce our impact on the biosphere and on global climate, while still meeting human needs? (p. 29)</td>
</tr>
<tr>
<td>Ontario</td>
<td>“…We don’t have to choose between a strong economy and a healthy environment. Faced with the challenge of climate change, the only way to have a strong economy is to go green. And the only way to go green is to have a strong economy…” (Go Green: Ontario’s Action Plan on Climate Change, 2007, p. 3).</td>
<td>assess, on the basis of research, the effectiveness of some current individual, regional, national, or international initiatives that address the issue of climate change (e.g., Drive Clean, ENERGY STAR, federal and provincial government rebates for...</td>
</tr>
</tbody>
</table>
“…Your government will move forward with Ontario’s plan to combat climate change by working towards meeting Ontario’s goal of reducing the emissions that contribute to climate change by six per cent below 1990 levels by 2014, 15 per cent below by 2020, and 80 per cent below by 2050. It will achieve this, in part, by making our energy cleaner and greener, moving forward with the province’s first long-term electricity plan in a generation.

Your government will replace coal, double renewables, double conservation and modernize our nuclear capacity. Ontarians understand that we don’t have to choose between the environment and the economy — that in fact, we can grow our economy by making it greener…” (Ontario Speech from the Throne, November 29, 2007).

“…Highlights of a Greener Ontario We will:
- Make our energy greener and cleaner, with the province’s first long-term energy plan in a generation. Our plan will replace coal by doubling renewables and doubling conservation.
- Build more rapid transit, with Move Ontario 2020, the largest transit expansion in Canadian history.
- Reduce emissions that cause climate change by 6% below 1990 levels by 2014, 15% below by 2020 and 80% by 2050.
- Provide rebates and tax incentives for Ontarians to buy energy efficient appliances and make energy saving investments in their home…” (Moving Forward Together, 2007).

Manitoba

- “Manitoba’s oil” which refers to hydroelectric energy creation. Hydroelectric energy creation is arguably a ‘greener’ form of energy than coal-fired electrical generation, and has environmental and social considerations such as the impact of damming various bodies of water. Wind energy is explicitly mentioned here, “Develop alternative energy such as wind power to create jobs in rural communities” (Manitoba NDP Election Platform, 2011, p. 10).

“Manitoba has an abundance of both wind and water. In fact, hydro provides a perfect backup system for wind power. We can store water when the wind is blowing and release water to generate electricity when the wind is calm. Wind power investments continue to grow and new, low-impact, hydro generation is under construction” (Next Steps: 2008 Actions on Climate Change, p. 17).

Manitoba

Investigate the social, economic, and environmental impacts of a recent severe weather event.
Include: related consequences of personal and societal decision-making. (p. 3.22)

Investigate technologies that are used to reduce emissions of potential air pollutants.
Examples: catalytic converters in automobiles, smokestack scrubbers, regulation of vehicle emissions, disposal of PCBs from electrical transformers, elimination of CFCs from
“Manitoba received an “A” rating from the Canadian Energy Efficiency Alliance (CEEA) widely used in Manitoba, thanks to low-interest loans and other support. All these strengths will help Manitoba improve our standing as a clean energy provider and meet our future goal: to be coal-free and have one of the lowest carbon-energy systems on the continent” (“Energy: Expanding Clean Energy and Energy Efficiency-Manitoba Helping the World, (Next Steps: 2008 Actions on Climate Change, p. 17).

“Our first duty, however, is to ensure that the quality of Manitoba's environment remains secure. Your government will take immediate steps to protect our water resources and preserve our lakes, rivers and streams” (Manitoba Speech from the Throne, November 25, 1999).

“refrigerants and aerosol propellants...” (p. 3.19)

An Inconsistent Discourse?

As described above, I may be able to make the claim that some facets of the selected political discourses may make their way into aspects of the STS[E] discourse present in the science curricula. A nod to the complexity of this research may be the next example that I present. One area that I did not feel was consistent from the political discourse to the STS[E] curriculum discourse was found in the various climate change action plans from the provinces (i.e., from about the time of curriculum release or formulation, not the most recent versions of these documents) and the STS[E] curriculum outcomes or expectations regarding climate change.

After exploring the STS[E] curricula present in the selected three provincial representatives, I found certain elements present in the units focusing on or related to climate change to be interesting as discussed throughout the case studies. I find it very positive that each province included a unit devoted to addressing issues pertaining to this field at the tenth-grade level (see Table 8.7 for Wordles™ depicting these units).
TABLE 8.7: Wordles™ of climate change related units across the provinces at the tenth-grade level.

<table>
<thead>
<tr>
<th>Province</th>
<th>Wordle™ depicting the curriculum outcomes/expectations in the climate change related unit</th>
<th>Some emphasized words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td><img src="image1" alt="Wordle" /></td>
<td>Climate, energy, change, explain, global, biomes, describe, investigate</td>
</tr>
<tr>
<td>Ontario: Academic</td>
<td><img src="image2" alt="Wordle" /></td>
<td>Climate, change, describe, global, Canada, carbon, heat, water, course, effect, greenhouse, anthropogenic</td>
</tr>
<tr>
<td>Ontario: Applied</td>
<td><img src="image3" alt="Wordle" /></td>
<td>Greenhouse, climate, change, effect, gases, carbon, increase, emissions, global, describe, course</td>
</tr>
<tr>
<td>Manitoba</td>
<td><img src="image4" alt="Wordle" /></td>
<td>Weather, include, climate, change, severe, event, consequences</td>
</tr>
</tbody>
</table>
All provinces explored in this study appeared to have a theme of ‘uncertainty’ when the units associated with climate change were analyzed such as illustrated here through the following curriculum outcomes and expectations:

investigate and identify human actions affecting biomes that have a potential to change climate (e.g., emission of greenhouse gases, draining of wetlands, forest fires, deforestation) and critically examine the evidence that these factors play a role in climate change (e.g., global warming, rising sea level(s)). (Alberta Science 10, p. 31)

describe the limitations of scientific knowledge and technology in making predictions related to climate and weather (e.g., predicting the direct and indirect impacts on Canada’s agriculture, forestry and oceans of climate change, or from changes in energy transfer systems, such as ocean currents and global wind patterns). (Alberta Science 10, 2005 minor revisions 2014, p. 31)

demonstrate an understanding of natural and human factors, including the greenhouse effect, that influence Earth’s climate and contribute to climate change. (The Ontario Curriculum Grades 9 & 10, 2008, p. 78)

analyse current and/or potential effects, both positive and negative, of climate change on human activity and natural systems (e.g., loss of habitat for Arctic mammals such as polar bears and loss of traditional lifestyles for Inuit as Arctic ice shrinks; famine as arable land is lost to desertification; an increase in water-borne disease and human resettlement as coastal lands are flooded; expansion of the growing season in some regions). (The Ontario Curriculum Grades 9 & 10, 2008, p. 78)

Investigate and evaluate evidence that climate change occurs naturally and can be influenced by human activities. (Senior 2 Science: Manitoba Curriculum Framework of Outcomes, 2001, p. 3.22)

Generate interest in the learning outcome by having students predict the potential consequences of climate change (especially due to global warming perceptions). Since the science of climate change is in a state of flux, be cautious about the extremism on both sides of the debate (e.g., both global warming and cooling should be discussed in relation to a higher CO2 future for the atmosphere). (Senior 2 Science: A Foundation for Implementation, 2003, p. 210)

I found this interesting because while we should aspire to have citizens examine science and other subjects critically (i.e., also inclusive of climate change); however, it did not appear to be consistent with some of the more general political culture embedded in the
Climate scientists agree: climate change is happening here and now. Based on well-established evidence, about 97 percent of climate scientists have concluded that human-caused climate change is happening. This agreement is documented not just by a single study, but also by a converging stream of evidence over the past two decades from surveys of scientists, content analyses of peer-reviewed studies, and public statements issued by virtually every membership organization of experts in this field. (American Association for the Advancement of Science, 2014 in Klein, 2014, p. 31)

This could be a manifestation of some of the power struggles during the curriculum construction process that resulted in a compromise regarding the wording of certain climate change-related outcomes/expectations or perhaps a reflection of the state of climate change science at the time of curriculum construction when it was more insecure or simply a misalignment of timing (i.e., as in a few cases the curriculum was written prior to the release of the climate change action plans explored in this study). The ‘confusion’ regarding some of the wordings used for outcomes/expectations that may frame climate change in a more positive context is problematic and may speak to some of the findings from a recent study by Plutzer et al. (2016) about climate change education in the United States where they found that,

...Mirroring some actors in the societal debate over climate change, many teachers repeat scientifically unsupported claims in class. Greater attention to teachers’ knowledge, but also values, is critical. (p. 1)

They also found that,

Notably, 30% of teachers emphasize that recent global warming “is likely due to natural causes,” and 12% do not emphasize human causes (half of whom do not emphasize any explanation and thereby avoid the topic altogether). (p. 1)

It is not clear if this pattern would be present in Canada; however, through the use of discourse analysis, I previously explored the problematic aspect of placing climate change units in a non-prioritized curricular position as well as the uncertain framing of some aspects of climate change. I have many remaining questions about implementation of the various climate change units (i.e., or units affiliated with climate change). Plutzer
et al. (2016) speculate as to why teachers might consider teaching climate change in this manner and comment how teachers may want to present a ‘balanced’ perspective on these issues: they may experience some pressures not to teach climate change (i.e., from parents, community representatives or others; although they report only 4.4% of the teachers they surveyed expressed this viewpoint), lack of teacher expertise on this topic and teacher misinformation about the consensus on climate change as demonstrated here:

...Yet, when asked “what proportion of climate scientists think that global warming is caused mostly by human activities?”—only 30% of middle-school and 45% of high-school science teachers selected the correct option of “81 to 100%.” (p. 2)

These findings seem to intersect with some of the previous discussions using the work of Oreskes and Conway (2010) regarding the dissemination of science information to the public and how in particular, the media may present a more ‘balanced’ coverage of a topic such as climate change despite a very high degree of consensus in the science community regarding the anthropogenic nature of climate change.

Another possible lens for viewing some of these complex curriculum choices may be application of some aspects of ‘Game Theory’ with the qualification that many of the economic ‘games’ analyzed assume that actors are completely rational entities, which of course may or may not be the case (i.e., there are sometimes irrational aspects of decision-making). The ‘prisoner’s dilemma’ is one example of a game where the ‘players’ can either decide to cooperate for the best outcome for both parties or decide to not-cooperate for a potentially better outcome for the individual (and a much worse potential outcome for the other individual) such as described here:

Game theorists call a simplified version of this scenario the “prisoner's dilemma”. In it, two prisoners accused of the same crime find themselves in separate cells, unable to communicate. Their jailers try to persuade them to implicate one another. If neither goes along with the guards, they will both receive a sentence of just one year. If one accepts the deal and the other keeps quiet, then the turncoat goes free while the patsy gets ten years. And if they both denounce one another, they both get five years. (The Economist, no author, 2007, http://www.economist.com/node/9867020) paragraph #4

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43 Game theory explores "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers" (Myerson, 1991) (see Wikipedia: https://en.wikipedia.org/wiki/Game_theory for more introductory information).
In the same article, the author further explores potential applications of some aspects of the prisoner’s dilemma to climate change policy here,

Pessimistic souls assume that the international response to climate change will go the way of the prisoner's dilemma. Rational leaders will always neglect the problem, on the grounds that others will either solve it, allowing their country to become a free-rider, or let it fester, making it a doomed cause anyway. So the world is condemned to a slow roasting, even though global warming could be averted if everyone co-operated. (The Economist, 2007, paragraph #5)

Wood (2010) has also explored these constructs regarding climate change policy and applications of game theory and states,

A key reason why achieving international cooperation to address climate change is difficult is that there are strong free-rider incentives. These incentives arise because climate change mitigation is a global public good - everyone benefits from there being less global warming, and everyone has an incentive for someone else to take on the burden of emission reductions. (p. 3)

If further explore the prisoner’s dilemma game, such as illustrated by Wood (2010) and his applications to climate change policy (e.g., his prisoner’s dilemma matrix depicting the choices for countries to either pollute or abate), and consider some possible outcomes associated with STS[E] and the climate change-related curriculum we might consider an association possibly such as this that may summarize some of the actors and possible actions involved in these deliberations (see Table 8.8).

**TABLE 8.8: Some possible applications and outcomes of the ‘Prisoner’s Dilemma’ game to the climate change curriculum modeled after Wood’s (2010) explorations and analysis of climate change policy.**

<table>
<thead>
<tr>
<th>Possible Stakeholder Choices About Climate Change Education</th>
<th>Climate Change is largely Anthropogenic</th>
<th>Climate Change is due to natural factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible Stakeholder Choices about Climate Change</td>
<td>-Compromise</td>
<td>-Impasse</td>
</tr>
<tr>
<td>Climate Change is largely Anthropogenic</td>
<td>-‘Balanced’ Curriculum</td>
<td>-Curriculum favours influence from stakeholders that want to protect the environment</td>
</tr>
<tr>
<td></td>
<td>-Positive and Negatives are described</td>
<td></td>
</tr>
<tr>
<td>Climate Change is due to natural factors</td>
<td>-Impasse</td>
<td>-No inclusion of climate change content in curriculum</td>
</tr>
<tr>
<td></td>
<td>-Curriculum favours influence from stakeholders that favour business/development</td>
<td></td>
</tr>
</tbody>
</table>

Based on the work of Wood (2010), we might see the following possible outcomes emerge: compromise, imbalance or impasse (see Table 8.8 above). A ‘compromise’ in
this context might be represented by outcomes that represent both sides of the climate change debate, whereas an ‘imbalance’ might be presented as a leaning toward either side and an ‘impasse’ could be represented by an omission of climate change-related curricula.

It might appear from some of the explorations presented in this thesis that the provincial stakeholders have opted to perhaps take the cooperation or win-win outcome of the prisoner’s dilemma (see Table 8.8 above). This style of ‘compromise’ may have been based upon some of the insecurity related to the science of climate change at the time of the tenth-grade curriculum constructions. This may also speak to the earlier discussions about aspects of the Canadian culture that focus on compromise and collaborations.

**8.6 Some Concluding Thoughts**

As I had described in my introductory segment of this chapter, originally I thought that there could be perhaps some associations among the political climates present in each province that may in some way influence the STS[E] curriculum sections. After exploring a few selected political documents as presented in the individual case studies and in this cross-case chapter, it seems that the general political sphere may have some limited influence on the outcomes/expectations present in the STS[E] curriculum at the tenth-grade level as it might be argued that we can see some translations of socio-economic aspects of political discussions into the curriculum. It seems that general political culture may influence the tenth-grade level STS[E] science curriculum in these select provinces in portions of the curriculum that are not technically considered ‘curriculum’ such as the document front matter or perhaps the number of outcomes or expectations present. We see provincial commonalities among the STS[E] curriculum that seem to be present regardless of political climate such as the emphasis placed on Levinson’s (2010) deliberative category or associations with Pedretti and Nazir’s (2011) logical reasoning current suggesting that again, there may be some influence, but political climate is not the only influence—it is complex and messy!
The final chapter of my thesis that follows will briefly explore some additional theoretical perspectives perhaps associated with STS[E] curriculum construction and will end with some possibilities for future research directions associated with this study.
Chapter Nine: Some Final Thoughts, Considerations and Theoretical Perspectives


9.1 Introduction

Exploring possible political influences on selected aspects of the science curriculum is far from straightforward. My research questions focused on finding some possible answers to the following questions:

1. What are some of the STS[E] discourses present in the tenth-grade in the provincial science curriculum documents (i.e., of Alberta, Manitoba and Ontario)?
2. What are some possible factors (e.g., provincial political representations) that may influence curricular discourses present in tenth-grade STS[E] outcomes/expectations?

My central finding was that provincial representations of STS[E] discourses tended to focus on Levinson’s (2010) deliberative model of democratic participation in science education (i.e., with some caveats as explored in detail throughout each case study and in subsequent cross-case analysis presentations). This STS[E] curricular emphasis seemed to be present regardless of provincial political representations.

This chapter focuses on some additional theoretical considerations and factors perhaps associated with the STS[E] curriculum. However, as these considerations emerged as I explored the curriculum documents, I am relying more so on theoretical perspectives as it was not my original intent to explore these emergent themes. After I explore a few additional theoretical considerations that may be linked to the STS[E] curricula in each province, I present some concluding thoughts, recommendations (i.e., as in alignment with a case study approach) and some possible future research directions.

I have classified my thoughts about some additional factors that may influence curriculum and STS[E] curriculum development into the following three thematic areas: cultural-geographic considerations; educational-political intersections and the role of scientists on curriculum development. The following chapter briefly explores these three broad categories primarily drawing from theory in these areas.
9.2 Some Cultural-Geographic Considerations

This is a broad thematic category that provides some commentary and perspectives as to whether facets of a more generalized ‘Canadian’ culture may exist. My thought process on working through this exploration was associated with one of my findings that Levinson’s (2010) deliberative framework category appeared to be emphasized across the three provincial studies (see Tables 5.2, 5.4, 6.4, 6.5 & 7.3 presented in the previous case study chapters), with of course, some caveats and variations across the provinces. I found this common emphasis to be interesting and decided to explore some perspectives about Canadian culture in general to see if there might be some intersections.

Canada is a large country with regional differences in culture, language, socio-economics, geography among others. Despite these differences and regional ‘flares,’ some scholars have explored whether there may be some commonalities that could link Canadians across these areas and have questioned whether there might be some common Canadian cultural characteristics. For example, Guiniven (2002) explores this idea here regarding a generalized sort of Canadian spirit in stating,

Canada’s unique culture emphasizes compromise over confrontation, which enables it to deal with public issues in a manner that generally keeps them from reaching flash points or garnering significant media attention beyond its borders. (p. 393)

Guiniven (2002) also draws from the experiences of a public relations professor and further comments that,

…Walmsley, a former PR practitioner in western Canada who now is a public relations professor, talked about Canada’s “culture of consultation. We’re a nation that was formed by committees, in a way.” She said practitioners in Canada are “more apt to take them (activists) seriously at a formative stage, and we’re less likely than the US to start out with a policy of confrontation” [B. Wamsley, personal communication, November 10, 1998]. Canada, Deutsch said, “is a community of complementary habits and facilities of communication,” [Quoted in, I. Angus, A Border Within: National Identity, Cultural Plurality, and Wilderness, McGill-Queen’s University Press, Montreal, 1997. p. 14] and Grant noted the essential role played by communication because Canada as a nation “is based on effecting a compromise between extremes.” (p. 395)
And also claims that,

…there appears to be more willingness in Canada to employ two-way symmetrical public relations at the outset of a public issue dispute, to search for a compromise initially rather than to gear up for confrontation. (p. 396)

These perspectives on some more general aspects of Canadiana need to be of course interpreted with caution as they are generalizations, but could in part help to explain why we perhaps see an emphasis on more discussion-based or deliberative-associated learning outcomes (Levinson, 2010) as opposed to more action-oriented styles of STS[E] presentations such as praxis, dissent and conflict, or the socio-ecojustice current (Pedretti & Nazir, 2011) in the science curriculum at the tenth-grade level across different regions of Canada (i.e., and noting that this exploration does not incorporate all provinces and territories in Canada). If collaboration and consensus are considered cultural-norms and generally with what Canadians may be more comfortable, it may be one facet worth considering regarding the discourses present in STS[E] curricula.

Aikenhead’s (2001) discussion of the “deliberation model” of curriculum development (Orpwood, 1985) might be an interesting extension of this Canadian cultural context where some scholars assert that there may be a cultural emphasis on consensus-building. Aikenhead describes this curriculum model here in stating,

Deliberation is a structured and informed dialogue among various stakeholders, guided by a balanced combination of top-down and grass roots methods.\(^{44}\)

Ultimately, it should be noted that power would still tend to reside with the experts in given fields despite these conversations, debates and discussions (Levinson, 2010).

It is interesting that perhaps some of the political dialogue, debate and exchange occurring among stakeholders to produce the science curriculum is potentially being mirrored via the emphasis that seems to be placed on Levinson’s (2010) deliberative framework in the STS[E] curriculum (see Tables 5.2, 5.4, 6.4, 6.5 & 7.3 presented previously).

\(^{44}\) Article accessed from: https://www.usask.ca/education/profiles/aikenhead/webpage/CJSMTEedpol.htm
If You Liked It, Then You Should have put a Standardized test on it...?

A common sort of tool used in various regions as a type of educational-political instrument is the standardized test. If we look at different jurisdictions both within and outside of Canada, the standardized test tends to be the political tool of choice to present accountability to the public and a seemingly transparent measure to assess and safe-guard the educational system. Kempf (2015) comments here about this linkage in stating that,

Test scores, widespread and comparative, have been important tools for politics and politicians. Scores can powerfully support the rhetoric of accountability and they can appear to both illustrate and solve problems. The incumbent politician proudly declares that literacy rates have improved ten percent under her stewardship, while the outraged challenger points out that 30 percent of children still cannot pass a basic proficiency test. Parties promising change rely on education reform to articulate and define policy, and ST results are among the most convenient and communicable metric. (p. 66)

The extent to which these tests are used seems to be associated with regional and also international considerations and as such I have decided to include this discussion under the broader theme of cultural-geographic explorations.

It is interesting that the more politically right-aligned province at the time of curriculum construction and implementation (e.g., Alberta) used a higher degree of standardized testing in science (i.e., inclusive of science at the Grade 9 level and Grade 12 level); the more middle-ground Ontario used slightly less (i.e., focusing on the EQAO at various grade levels and at the high school level the Grade 9 mathematics EQAO and the Grade 10 Literacy Test); and the more left-aligned Manitoba at the time focusing on the PISA in science and standardized testing at the Grade 12 level in language arts, applied and pre-calculus mathematics (i.e., 30% of final grade) and essential mathematics (i.e., 20% of final grade). It would seem that government educational priority seems to focus on mathematics and literacy in the cases of Ontario and Manitoba given that these areas are publically tested whereas Alberta tends to focus on a greater range of subject areas if we consider the Diploma examinations at the Grade 12 level that include science (i.e., and comprise 30% of the student’s final grade). Testing results and protocols are powerful; they are a way to exert power by perhaps making “governable subjects” as

previously discussed in the Alberta case chapter (Graham & Neu, 2004); so if we consider for a moment what is present versus what is absent; there is no provincial science standardized test in place in Ontario or Manitoba, but there is in Alberta (i.e., at the Grade 9 and 12 level and excluding ‘voluntary’ types of standardized tests such as those associated with Advanced Placement or International Baccalaureate programs).

The common standardized testing protocol to all three provinces is the Programme for International Student Assessment (PISA) that includes a science-based test. What might this mean for STS[E] curriculum development and education? Sadler and Zeidler (2009) explored the PISA science examination administered to 15-year old students and the possible connections and associations with socio-scientific issues (SSIs). They stated that the PISA approach to assessment in science was perhaps broadly aligned with a socio-scientific issues approach (i.e., where they explored various assessment questions that had been released) where, “…Both approaches emphasize preparing students for life and citizenship, complex reasoning and reflective practices, and robust understandings of the nature of science particularly as it is practiced in society” (p. 909) as demonstrated through the following areas of PISA competencies,

1. identifying scientific issues,
2. explaining phenomena scientifically, and
3. using scientific evidence. (p. 914)

Sadler and Zeidler (2009) found that upon more in-depth explorations that,

…and we contend that the more specific aspects of the PISA assessment are not well aligned with the SSI movement but recognize that there are substantive differences in the scope and purpose of these two initiatives and that these differences mitigate against full alignment. (p. 917)

According to the 2012 released testing data from OECD regarding PISA, Alberta has the highest relative average score (539) of the three provinces explored here, followed by Ontario (527) and then Manitoba (503). Without an in-depth analysis of what these numbers constitute and whether the numerical spreading is significant, who might be excluded from testing and depictions and further exploration of what questions are asked of students on this test it is challenging to say what is actually being measured and the possible associated meanings, however, if we consider Bloche’s (2014) claim regarding PISA and a possible Vision II alliance the results are interesting and may
warrant further study regarding the connections with STS[E] and the ways that this test might shape aspects of curriculum development and implementation (i.e., with the acknowledgement that Sadler & Zeilder (2009) cite issues regarding connections to SSIs).

### 9.3 Educational-Political Intersections

This thematic exploration focuses on some of the intersections between education and politics (i.e., small ‘p’ politics) and examines some facets of stakeholder interaction that might influence the curriculum development process inclusive of the STS[E] curriculum. A useful way to consider some of these complex interactions and associations may be found in the descriptions presented by Parsons and Beauchamp (2012) (i.e., where they have adapted this work from Thijs & van den Akker, 2009). They organize the various levels of curriculum and provide some descriptions and examples of these levels such as: supra (international level); macro (provincial, national, regional); meso (school jurisdiction, school); micro (classroom, teacher) and nano (student, individual). The focus of this thesis was primarily on what they have described as the ‘macro’ level as I have explored provincial curriculum documents. This part of my thesis will briefly revisit and explore some of those stakeholder interactions based on theory and some limited data that I will present.

In my introductory discussions about the provincial curriculum construction processes, I presented information from each government where they detail the provincial processes for curriculum development and revision as well as detailing these processes in each case study (i.e., to the extent that I could find information). Although the depictions differ from province to province, the processes for development are quite similar where drafts are developed and then vetted through various stakeholders.

There appear to be many reasons why a province or other jurisdiction might want to re-design or review a curriculum document. Beauchamp and Parsons (2012) present the following reasons as possible ‘sparks’ for igniting various curriculum discussions and revisions in Canada as potentially being linked to:
changes in government policies
-emerging socioeconomic issues (e.g., British Columbia’s low graduation rate of Aboriginal students)
-influence of research findings
-age of existing curriculum
-stakeholder and educator feedback
-significant changes in subject or discipline content (e.g., the fall of the Berlin Wall) and/or the age or availability of learning and teaching resources. (p. 42)

Within these curricular construction processes, Beauchamp and Parsons (2012) explore the role of government and other stakeholders in the processes and state that,

…These roles can include leading, developing and distributing curriculum, developing assessment standards and providing lists of either prescribed or recommended resources. (p. 46)

They also confirm that,

…All Canadian provincial and territorial ministries write at least a portion of their own programs of study. However, provinces and territories may be part of partnerships, such as the Western and Northern Canadian protocol or the Council of Atlantic Ministers of Education and Training. Within these partnerships, ministries may adopt curriculum without changing it, adopt it with modifications (e.g., Newfoundland and Labrador adapted the Western and Northern Canadian Protocol mathematics) or choose not to use it. (p. 46)

Curriculum Authorship Transparency

Manitoba is the only province represented here that includes the authorship of its curriculum documents as previously explored. This of course, does not represent all of the stakeholders and consultations that may have occurred to develop this curriculum. While superficially this could appear to be a relatively insignificant point, it may have some deeper implications. According to Posner (2004):

A logical place to start uncovering the story behind a curriculum is with the people who were involved in developing it. However, identifying the people behind the typical curriculum and their respective roles in its development can be challenging. Most textbook series list the authors and their institutional affiliations but provide little additional information about their respective roles or about other people involved in the development process. (p. 34)

This might suggest a relative transparency regarding some of the participants and consultations represented in the Manitoba science curriculum document; although as
commented on previously, much of the actual dynamics and power relationships that are present in the formulation of curriculum remains largely hidden. Aikenhead (2001) also speaks to this point where he stated that, “There are many stories to be told about “educo-politics”, but in our science education community we tend to avoid telling them publically”46.

The concept of the ‘black-box’ discussed by Latour (1987) may be a helpful concept to aid our understanding of some of the seemingly complex dynamics at play during provincial curriculum construction processes. For example, if we think of an ‘actor’ (i.e., an agent that can ‘act’ on someone or something) such as a curriculum expectation or outcome as a ‘black-box’, that is, a mixture of various influences, we may be able to explore the various actors involved in the construction process. Their pedagogical decisions, and the decisions of the other individuals in the curriculum construction process would be a complex network of all other actants acting upon them and vice versa. Posner (2004) reflects on Schwab’s (1971) assertion that curriculum development ideally would have contributions from people representing, “…the learners, the teachers, the subject matter, and the milieu” (p. 34). Without explicit knowledge of who is contributing what to these processes, we cannot clearly gauge the level of representation in these areas or in the cases of provinces that do not delineate their curriculum authorship, it is challenging to gauge precisely who has contributed and their contributions largely remain the proverbial ‘black boxes.’

9.4 Possible Influences of Academic Scientists on Curriculum Development

There are many possible sources of influence on aspects of the science curriculum. Some scholars have written specifically about the role of professional scientists and engineers on the construction of curricular documents in science and how they are influential actors regarding these processes.

Aikenhead (2001) discusses some of these power dynamics and struggles when discussing the political wheelings and dealings involved in curriculum constructions which, from his perspective (i.e., in Saskatchewan), have included such tactics as “…blackmail, committee tampering, strategic timing, and wielding brute social power.

46 Article accessed from: https://www.usask.ca/education/profiles/aikenhead/webpage/CJSMTEedpol.htm
through elitism” (p. website). Aikenhead (2001) discusses Fensham’s (2002) perspective on moving science education forward to encompass perhaps more of an alignment with Roberts’ (2007) Vision II science literacy and a shifting toward a more science-literate citizenship versus a Vision I science literacy (Roberts, 2007) which is associated with a more technical knowledge of science perhaps aligned with professional science and engineering. We might also consider alignments with Mode 1 and 2 knowledge production where Mode 1 focuses on knowledge of disciplines and Mode 2 focuses on, “…the context of discovery, the role of the disciplines, the skill mix of researchers and forms of organization they adopt, social accountability and reflexivity of the researchers and quality control” (Gibbons, 2000, p. 159).

Fensham (2002) envisions three steps or phases of curriculum development to accomplish this more progressive Mode 2 knowledge-production or Vision II (Roberts, 2007) curriculum as described by Aikenhead (2001) here:

- **Phase 1**: Societal experts systematically determine features of society endemic to an informed citizenry. Fensham's description of the Hong Kong project illustrates this phase.
- **Phase 2**: Academic scientists specify science content associated with the features of society identified in phase 1.
- **Phase 3**: Based on the phases 1 and 2, science educators develop a school science curriculum. (p. on website)

Aikenhead (2001) comments that shifting away from academic scientists setting the central agenda differs significantly from the status quo. This suggested initial consultation with societal experts might also help to mitigate or balance science-corporate relationships described by Bencze (2010) or Gough (2015) where she states that,

The vision for science education, and its emphasis on content, that is embodied in the STEM policy documents is very much an instrumentalist (Carr and Kemmis 1986) or a universal scientistic postured (Simonneaux and Simonneaux 2012) curriculum: education is seen as an instrument for achieving STEM and economic goals. (p. 450)

Aikenhead discusses Fensham’s (2002) characterization of academic scientists as participants in “educo-politics” that undermined various attempts to revise the science curriculum and how societal experts must embrace more of what Aikenhead (2001) described as a “Jablonskian type of approach” to out-smart the shenanigans of the
professional scientists regarding political decisions (i.e., influence various friends in high places). Aikenhead maintains that these forms of “devious educo-politics” operate covertly and that people are very reluctant to speak publically about tactics.

So does this actually happen where academic scientists thwart attempts by other educators and various Ministries to maintain the status quo regarding the focus on primarily a Vision I (Roberts, 2007) science perspective? Some scholars who have investigated this question in Canadian contexts would say yes. For example, Blades (1997) investigated the development of science curricula in Alberta during the 1990s through document analysis and interviews. He found that during the evolution of the new science curricula in Alberta that the first murmurs of discontent with the proposed changes which would focus on more STS content were from physics teachers who voiced their concerns with the reduction in the credit allocation for Physics 20 from a 5-credit course to a 3-credit course where they participated in letter writing campaigns (Blades, 1997). After various consultations and media reports circulated about the proposed changes, Blades (1997) writes about how administrators at the Faculty of Science, University of Alberta in Edmonton, “…felt concerns over the proposal to cut the credit value of Biology 20, Chemistry 20, and Physics 20” (p. 60). Blades (1997) conducted an interview about these concerns with the Associate Dean of the Faculty of Science where he reports that,

Well, it [proposed Science 10, 20, and 30 program] had very little science, it was a kind of pop science, program emphasis on technology-social science approach, but not much in the way of integrated science. Our understanding initially was Science 10, 20, 30 would be an integrated science of biology, chemistry and physics so students would get more of the physical sciences because of what was happening in the high school system; to meet the minimum 11 credits they were taking either Biology or Chemistry or likely just Biology to get the minimum credits [to graduate] and never physics. (quoted in Blades, 1994, p. 63 in Blades, 1997, p. 60).

Blades (1997) also comments that this discontent from the academic science community continued to grow when various drafts continued to circulate to the point where,

…In February, 1989, the Faculty of Science at the University of Alberta declared Science 30 unacceptable for admission to science courses in their faculty, destroying the academic acceptability of Science 30 at the University of Alberta. (p. 61)
The Alberta Ministry of Education and the Education Minister was feeling the political pressure and opted to delay the release of the documents (Blades, 1997). Blades (1997) writes about how the pressures and controversy became so intense that,

…Byfield [editor and publisher of the Alberta Report] calls for the Government of Alberta to fire the present Minister in favor of someone willing to “consult others outside the department, not in it, to find out what kind of schools will enable Alberta to meet the competitive challenges of the 21st century. (p 63)

Blades (1997) also reports that the Alberta Medical Association jumped on the critical bandwagon and declared that the proposed science curriculum would, “…threaten the long-term future of Medicare and the care that will be available to our patients” (Alberta Medical Association, 1989, in Blades, 1997, p. 65). As a result of these intense debates and critical media coverage, the Alberta Ministry of Education modified their drafts so that the ‘new’ curriculum included more traditionally covered topics (Blades, 1997). Despite all of this pressure from various scientific communities, Blades (1997) reports that,

…my colleagues at Alberta Education continued to defend the new program with enthusiasm arising from their conviction that renewal towards an STS emphasis and program structural changes were crucial to developing the scientific literacy and citizenship of students. (p. 67)

If we review some of what I have previously presented in the Alberta case study about the current Science 10 curriculum document, we might consider Alberta’s combination of ‘STS and Knowledge’ outcomes as perhaps a fusion of Fensham’s (2002) phase 1 and 2 where both societal experts and professional scientists are represented. However, the knowledge-based outcomes appear first in the Science 10 document; this discourse suggesting that the scientist- participants are the winners as the STS content appears to either be at the end of each segment or appearing much less frequently than the more content-driven knowledge-based outcomes which appears to be in alignment with the detailed accounts provided by Blades (1997). Manitoba has many outcomes devoted to various styles and approaches to STS[E]-related practices and interweaves some of them into the contextualized science curriculum as well as their General Learning Outcomes; however, again, some of those outcomes appear to be siloed in a separate Strand 0. Could this be another example of educo-politics at work and perhaps the power
of various science communities on curriculum construction processes or simply an organizational feature based on where development teams thought this content was best presented for teachers?

As noted in my previous chapter, there are issues with making generalizations about the power of academic scientists in the curriculum construction process. Blades (1997) provides some concrete examples of the role of the scientific communities in shaping curriculum outcomes, but this may or may not be the case in other jurisdictions. The work of Bloche (2014) sheds insights regarding the role of various stakeholders, including scientists, on curriculum proceedings in Ontario and her work indicates that the construction of the science curriculum prior to the release in 2008 involved many stakeholders inclusive of experienced science educators, universities and colleges, parent organizations and non-governmental organizations. She also claims that final control over the document was in the hands of the Ministry. Fensham (1993) would probably argue that scientific or academic influence was still being exerted via the experienced science educator stakeholders because,

…science teachers who have been so socialized by their own scientific studies in higher education that their conceptions of their subject for schooling conform to the knowledge content they were taught and learned in university or college. (p. 54)

It might appear that Ontario focused upon the ordering of Fensham’s (2002) phases since STS[E] is at the forefront of the curriculum, yet perhaps an academic science influence may have come into play regarding assessment and evaluation practices as STS[E] seems to take a backseat regarding its placement in the Application category at the bottom of the Achievement Chart thus undermining this curricular swap (Bloche, 2014).

After some reflection on this topic, I went through my own science evaluations and focused on the tests that I had previously used. In my pedagogical practices, I had always started my units with an emphasis on STS[E] topics and socio-scientific issues (i.e., in alignment with the curriculum), continued the discussions throughout my units and used the STEPWISE approach (i.e., in some courses). On almost every test-based evaluation, I listed the Achievement Chart category breakdown in the same way: Knowledge & Understanding; Thinking; Communication and then Application (i.e., although sometimes I embedded Communication in other questions or graded certain
questions twice). I had been emphasizing STS[E] via my classroom discourse and activities; however, on most test-based evaluations, I was perhaps sending the semiotic message to my students that STS[E] was basically an after-thought (i.e., although, it is challenging to say for sure how students would perceive this, also in most cases the categories were weighted equally). If we were to symbolize what matters to many kids, parents and schools, often it would be a grade or percentage (%). We may be living in the age of the Anthropocene, however a sub-variant of this classification seems to exist at every school: the ‘Markopocene’! Jokes aside, if I draw for a moment from my personal practitioner knowledge, an experienced and valued colleague once remarked to me, “What is assessed is remembered.” So what will kids remember about their science experiences based on assessment practices seem to place STS[E] education at the end?

Foucault’s (2008) conception of the ‘dispositif’ (i.e., apparatus/device) may be a useful construct to extend our understandings and offer some ‘theoretical dissections’ of aspects of these aforementioned curricular power dynamics and the apparent power of the science community on a more philosophical level. Foucault (1980) offers the following definition of this concept here as presented by Chaput and Hannan (2014):

…The apparatus itself is the system of relations that can be established between these elements. Secondly, what I am trying to identify in this apparatus is precisely the nature of the connection that can exist between these heterogeneous elements. [...] whether discursive or non-discursive, there is a sort of interplay of shifts of position and modifications of function which can also vary very widely. Thirdly, I understand by the term ‘apparatus’ a sort of – shall we say – formation which has as its major function at a given historical moment that of responding to an urgent need. (pp. 194–195)

Agamben (2009) offers the following take on Foucault’s notion of dispositif here as,

…anything that has in some way the capacity to capture, orient, determine, intercept, model, control, or secure the gestures, behaviours, opinions, or discourse of living beings. Not only, therefore, prisons, madhouses, the panopticon, schools, confession, factories, disciplines, juridical measures, and so forth (whose connection with power is in a certain sense evident), but also the pen, writing, literature, philosophy, agriculture, cigarettes, navigation, computers, cellular telephones, and –why not-language itself...(p. 14)
If we consider or frame dispositif as collections of actants who act together, we might also tie these ideas to some aspects of actor network theory. Bencze and Pouliot (2015) describe this as “…an aggregate of actants serving certain purposes” (p. 1).

If we consider Fensham’s (2002) phases that are made up of various communities of practice such as societal experts and community stakeholders; professional scientists and engineers at various levels and affiliated with different institutions; and then the assemblage of various science educators who construct the science curriculum and of course, an infinite number of other potential influencers (i.e., both human and non-human) we may link all of these entities as actors which could comprise a dispositif. In this case, various science communities and all of the living and non-living aspects of it might be collectively considered a dispositif.

An interesting consideration regarding how a dispositif may function at the curricular construction level could be the unscripted manner in which these grouping of stakeholders such as scientists may function at a given time and in a given location such as in the case of academic scientists, the Alberta Medical Association and the media (Blades, 1997). Bencze and Pouliot (2015) liken these uncertainties to how a “heavy metal band” might play music versus an orchestra with sheet music and a conductor. They describe these aspects of uncertainty here regarding the concept of dispositif:

A metaphoric way to think about it is in terms of a band playing music. A band may consist, for example, of different musicians, various instruments, sheet music (tailored to each instrument), perhaps certain chairs, perhaps a room with certain acoustics, a particular audience, certain financial arrangements (including contracts) among players, band managers and owners, etc. Unlike an orchestra, however, which typically has a conductor leading the players, the dispositif formed in connection to actions of L&D perhaps is more like a heavy metal band (pun intended), which tends to play a tune in a much more eclectic way than would an orchestra with a conductor.

They also liken these somewhat unpredictable associations and connections that comprise a dispositif to the ‘rhizome’ analogy of interaction as described here by Deleuze and Guatari (1987):

Let us summarize the principal characteristics of a rhizome: unlike trees or their roots, the rhizome connects any point to any other point, and its traits are not necessarily linked to traits of the same nature; it brings into play very different regimes of signs, and even nonsign states. (p. 21)
Dispositif may have some components thus that exist on the surface and are highly visible and then, like the rhizome, have other perhaps unseen channels of communication and influence which again, add to the complexity of interaction that may speak to the science curriculum development processes or what we see as the end result. Given the prevalence of Levinson’s (2010) deliberative framework across the provinces (i.e., with some noted and explored caveats), it may be reasonable to think of the science ‘rhizome’ as a part of this construction. Why would a deliberative framework (Levinson, 2010) perhaps be beneficial to this dispositif? Levinson (2010) reminds us that, “Government and corporate innovations depend on public acceptance” (p. 80).

In light of these additional considerations, we might speculate and perhaps re/imagine the earlier models of curriculum construction in science as described by Fensham (2002), Orpwood (1985) and others so that the stakeholders involved in these processes that may look something perhaps more aligned with Pierce’s (2013) actor-network depiction of genetically modified salmon and might take on a somewhat ‘messier’ and post-structuralist lens that becomes less linear and more uncertain.

A final thought about these political-educational intersections that may shape the science curriculum could be the relative stability of the public service. The civil servants who work for the various Ministries of Education across the country generally remain stable with changing governments and are reflective of diverse perspectives and viewpoints (i.e., although in most cases remain publically non-partisan) regardless of changing provincial governmental representation. This may also factor into the commonalities shared across the country regarding the STS[E] curriculum.

9.5 Some Suggestions

In alignment with a case study approach, I have proposed some suggestions based on my curriculum analysis work in each province. I begin with some suggestions specific to the province and then present more general curricular suggestions that may be applicable to differing contexts and perhaps for policy-makers involved in curriculum decision-making to consider in light of this work. These suggestions are drawn from my curriculum analyses, various theoretical lenses and in some cases my personal practitioner experiences and viewpoints.
9.5.1 Specific Provincial Curricular Suggestions

Alberta

As I have conducted my analysis work to construct this case study, I have made note of a few suggestions regarding the Alberta Science 10 curriculum document as in alignment with a case study approach. I suggest the following:

- Consider moving Unit D to Unit A’s position in the order of units in the curriculum document to highlight to the reader of this document the importance of curricular outcomes that address the environment and climate change. This would also align more so with the messages present in the Alberta Climate Change Action Plan (2008).

- Consider changing ‘STS’ to ‘STSE’ to reinforce the importance of the environment by adding the ‘E’ to the curricular headings and titles.

- Additional cultural references and examples may be beneficial to incorporate such as scientists from a variety of cultures and multi-gendered representations.

- Consider introducing various verbs to connote science as an ‘action’ (i.e., where appropriate) as opposed to curriculum outcome verbs that suggest that science is more of a teacher-directed process to align with a more student-directed approach to learning.

- Inclusion of the individuals and stakeholders who contributed to the writing/authoring of the document; perhaps making the curriculum construction process more transparent to the reader.

- Consider changing the wording associated with student action plans to focus on the implementation of their actions regarding climate change.

Ontario

I suggest the following regarding the Ontario curriculum based on this study:

- Consider changing the order of the Achievement Chart categories to reflect the changes in the delivery of the curriculum expectations that prioritize STS[E]. Moving the Application category to the first position on the Achievement Chart rubric would align more so with the order of the curriculum expectations (i.e., in certain courses). I would also suggest making the Application category a new category devoted only to STS[E] to emphasize the importance and stand-alone nature of this set of curricular expectations.

- Consider making expectations and the verb usage of the academic curriculum to be more ‘hands-on’ as with the applied curriculum to enhance student connection with the
material or consider removing the applied and academic distinctions and offer one curriculum level for all students as the ‘classes’ of science education appear to be problematic. I would also suggest moving the more citizenship-oriented curriculum expectations in the applied Grade 10-level science curriculum to the STS[E] segment where they would take on a prioritized curricular positioning. However, another consideration regarding this change may be that the assessment practices found in the skills and attitudes section may highlight this outcome more so than in the STS[E] segment, so perhaps it makes sense to consider moving the ‘designing an action plan’ related expectation to the ‘Developing Skills of Investigation and Communication’ section.

-Consider adding the word, *implementation*, to the expectations associated with climate change action plans. Consider editing the curriculum expectations associated with climate change to remove the word, ‘positive’ and consider revising the example associated with extended agricultural growing season in the applied level curriculum to reflect the most current climate science information consensus.

-Consider adding the names of contributors to the writing and construction of the curriculum document to make the authorship and stakeholders involved more transparent to the reader.

*Manitoba*

I have made note of some suggestions regarding the Manitoba tenth-grade curriculum:

-Consider more integration of STS[E] outcomes from Cluster 0 into the clusters involving science content with of course the acknowledgment that this is done via the General Learning Outcomes and also some of the specific outcomes associated with STS[E]. It is challenging to envision how to integrate these STS[E] perspectives and actions when presented in a decontextualized fashion.

-Consider the updates to the Weather Dynamics unit more in alignment with current science thought regarding climate change and perhaps prioritizing the ordering of this unit. A more descriptive title acknowledging the importance of climate change may also be useful, e.g., Weather Dynamics and Climate Change or Climate Change and Weather Dynamics.

-Consider consultations with educators regarding the usefulness and length of the Framework for Implementation (2003). There are many excellent suggestions and pedagogical strategies presented, however, the length of the document is daunting (i.e., it is over 600 pages in length).
9.5.2 General Cross-Provincial Curricular Suggestions

Here are some suggestions for consideration regarding curricular revision that may be applicable across the provinces studied here (i.e., and may also be applicable to additional jurisdictions both within Canadian contexts and internationally):

- Consider moving the units associated with climate change to a prioritized curricular position. Consider changing the focus of weather-based/related units to a climate change focus. Consider removing examples or wording that suggests that the science of climate change is uncertain to be more aligned with current science perspectives.

- Consider an STS[E] curriculum that is contextualized within the units of study, has a prioritized position within each unit of study and has assessment and evaluation practices and guidelines that clearly link to and reflect a prioritized positioning of these outcomes/expectations. Consider an assessment schema (i.e., if used) that uses the title, STS[E] or as aligned with this curricular segment.

- Consider streamlining and keeping the total number of outcomes or expectations to a minimal number.

- Consider using language to make informed consent explicit via the discourses and languages used; especially regarding the presentation of medical procedures and choices.

- Consider introducing additional verbs to connote science as an ‘action’ (i.e., where appropriate) as opposed to curriculum outcome verbs that suggest that science is more of a teacher-directed process to align with a more student-directed approach to learning.

- Inclusion of the individuals and stakeholders who contributed to the writing/authoring of the document; perhaps making the curriculum construction process more transparent to the reader and may help us to more easily deconstruct some of the curriculum story (Posner, 2004).

- Continue to include community-based stakeholders (i.e., inclusive of students & children) in the development of the science and STS[E] curriculum. For example, consider asking children what issues are important and relevant to them.

- Consider changing the wording associated with student action plans in the science curriculum to focus on the implementation of their actions.

- Provide professional development to educators regarding the importance of STS[E] education and opportunities and approaches to support their classroom choices and how to assess STS[E]-based outcomes or expectations.

- Consider having educators from a wider variety of subject backgrounds teach science and technology at the Grade 9 and 10 level; perhaps those who have some science expertise and interest (i.e., of course considering educator comfort level with this idea).
This may assist with cross-curricular implementation and enhance STS[E] education.

-Ensure that all stakeholders have an equal ‘voice’ during curriculum proceedings to provide representation from a variety of positions in society to inform our science and technology curriculum.

Regarding the climate change or associated units across the provinces, I want to begin by restating that I find it hopeful and positive that this most important topic is being addressed. I have made several recommendations for each individual case study regarding this unit but feel the need in light of a potentially common critical trend (i.e., possibly due to the timing of the curriculum and the instability of the science of climate change during this period) of climate change across the provinces studied such as described in the previous chapter (i.e., and as described by Oreskes & Conway, 2010) to suggest the following recommendations from Alsop et. al. (2015) that in some cases would apply to the climate change STS[E] curriculum content and perhaps to systemic adjustments in others:

1. Education Should Have a Greater Role in Reponses to Climate Change
2. Schools and School Boards Need Climate Change Leaders
3. Climate Change Education Requires Understanding Human Ecology as Constantly Being Shaped by and Embedded with Global Ecosystems
4. Climate Change Education Needs to be Interdisciplinary
5. Climate Change Education Needs to Embrace Climate Change as a Condition of Contemporary Environmental and Social Imbalances
6. Climate Change Education Should be Place and Community Inspired and Responsive
7. Climate Change Education Needs to Effectively Engage the Political
8. Climate Change Education Needs to Engage Indigenous and Local Cultural Knowledges and Practices
9. Climate Change Education Should be Imaginative, Exciting, Hopeful and Playful. (pp. 8-10)

Regarding day to day science teaching to respond to recommendations surrounding the interdisciplinary, responses to social justice concerns, place-based and community contextualized education, engaging the political and generally responding to a greater degree to issues related to climate change I also see Bencze’s STEPWISE pedagogical framework as one potential approach to guide both students and educators toward more engagement with the curricular expectations/outcomes in science (i.e., inclusive of STS[E] content) and as a way for students to become more empowered and
thoughtful citizens in the contexts of informed decision-making and actions about STS[E] issues that they view as important. His framework may allow intersections and connections in the science classroom to be made among both the deficit/deliberative and praxis/dissent and conflict approaches to citizenship.

9.6 My Research Contributions, Research Limitations and Possible Future Research Directions

This research represents a contribution to the large body of scholarly studies devoted to the area of STS[E] education. My explorations have centred on some of the discourses that may be present in STS[E] curricula across three different political landscapes using the tools of document analysis, discourse analysis and various theoretical framework applications. In addition to applying various frameworks to deconstruct the STS[E] curricula, I have been able to offer perspectives regarding how these tools may work in practice when exploring empirical data in these contexts. My contributions to STS[E] research that have resulted from this study include these unique perspectives and explorations of novel areas regarding STS[E] influences such as the general political context (i.e., which I have found has a limited influence on STS[E] curricula). This combination and the associated details that have been presented in my case studies represent an addition to this rich area of scholarly research.

Some Theoretical and Methodological Implications

The findings from my study may have implications for research, particularly for scholars who might consider working with frameworks or discourse analysis. As mentioned previously, it can be quite challenging to categorize data using frameworks. Scholars such as Pedretti and Nazir (2011) comment that they conceive their ‘currents’ to be flowing and overlapping which I agree with, especially after exploring these intersections using curricular data. I might suggest a more visual depiction of this conception so that it is very clear to the reader that this is the case. For example, perhaps instead of having solid lines in a table that demarcate categories, I suggest perhaps perforations or maybe the use of circular organizers to denote these overlaps. I might suggest to Levinson re/imagining his last two categorizations in his framework for
democratic involvement in science education as a merger of the praxis and dissent and conflict. It was challenging in some cases to clearly state that a particular outcome/expectation belonged to one or the other. There may also be some justification for a merging of the praxis and dissent and conflict if we consider Habermas’ cognitive interests (e.g., such as described by Lovat, 2013) such as technical knowledge; communicative knowledge and emancipatory knowledge (i.e., a blend of reflective and critical) which may reflect deficit, deliberative and a blended praxis/dissent and conflict framework depiction.

Document and discourse analysis were powerful tools to deconstruct and in some cases to re-imagine STS[E] curriculum. I see wider implications for the use of these tools in educational contexts and settings and I would urge academics and curriculum developers to consider the use of these methods to critically analyze various documents and texts.

Teacher Educators and Practitioners

The findings from my study may have implications for both teacher educators and practitioner in various educational fields. My findings suggest that STS[E] education may focus on a more deliberative style of democratic participation in science. We might consider reflecting on our practices and thinking about how we present STS[E] education to our pre-service teachers or perhaps how STS[E] is presented to in-service teachers via workshops or other opportunities. I might suggest the following reflective questions to aid in these explorations of teaching practice:

- What sorts of STSE examples do you provide to your students inclusive of how to assess STSE?
- What currents and democratic participation styles might you envision presenting to your students? Why?
- How might your students perceive STSE education via participation in STSE activities?
- Do you do a one-time lesson or do you tend to infuse STSE activities across your course offerings?

Study Strengths and Limitations

As with any research endeavor, my thesis has both its strengths and limitations. The availability of documents supplied many perspectives and strengths regarding my
research questions, especially in the light of the application of various frameworks and explorations using some of the tools of document analysis and discourse analysis. Curriculum documents and the other more political documents explored represent the summation of various ‘battles’ (Inglis, 1985); they represent the winners. A limitation to this work is the absence of interview data to corroborate my findings. I am not entirely convinced that the collection of interviews would fully deconstruct these processes but they may provide additional insights. Interviews are a construction and what is said can be influenced by the interviewer’s presence in these proceedings (i.e., the Hawthorne effect). Another qualification of this research is that I have focused on three provinces and have not included any Canadian territories or Atlantic representation. The provinces were selected based upon distinctive political representation (i.e., the provinces differed from each other politically) to explore political landscape as one possible factor perhaps influencing STS[E] curricula in Alberta, Ontario and Manitoba.

As I moved through this process I made note of many areas that I would like to continue to explore. In conducting this research, I found that instead of answering all of my questions, it caused me to pose many questions that remain unanswered such as illustrated below in the various categories.

9.7 Some Remaining Questions

Curriculum Construction Process

The curriculum development process appears to be incredibly complex and I would like to gain additional perspectives about the selection of science and technology topics; and the STS[E] perspectives represented in the curriculum documents and also the extent or influence of political actors. I am also curious about additional cross-provincial and international analysis of science curriculum documents to see if any additional patterns emerge.

STS[E] Science Curriculum and Practitioner Relationships

I have many unanswered questions about the curriculum to practitioner relationship regarding STS[E] implementations. For example, to what extent might the placement of Application in the achievement chart for STS[E] impact practices or
perceptions about STSE in Ontario? How do practitioners assess STS[E]? To what extent does a blending of STS and knowledge impact the learner’s perceptions about STS education (e.g., in the case of Alberta)? In Manitoba, to what extent do teachers use the Foundation for Implementation (2003)? Do they use a textbook also or not? What sorts of actions (or perhaps not) do science students take on STS[E] topics (e.g., in Manitoba)? Does the ordering of the curricular units or strands actually make a difference in practice or are other factors potentially more influential? To what extent do teachers apply the Strand 0 STSE outcomes across the other science units of study at the tenth-grade in Manitoba? What professional development opportunities are presented to teachers regarding STS[E]? To what extent may participating in professional development related to STS[E] impact classroom practice?

Arguably, for individuals in our society to fully understand their democratic rights as citizens concerning various medical interventions, schooling concerns or the interpretation of statistics, a framework for science education which pushes the boundaries by incorporating STS[E] perspectives that also includes praxis, dissent and conflict and socio-ecojustice approaches could be beneficial to enhance democratic participation in both the science classroom and everyday life. These additional lenses that move beyond the deficit/deliberate approaches to STS[E] instruction may help to promote a more active citizenship potentially both in and outside of the classroom.

*The Role of Standardized Testing and Assessment Practices in Science Education*

Lastly, I have questions remaining about the role of standardized testing in science and assessment practices in science in general. I am curious about how teachers prepare students for the various standardized tests in science and to what extent do these testing protocols influence what is taught regarding STS[E]? What does the PISA test measure regard STS[E] relationships? Why are the scores between provinces different? To what extent is PISA potentially a tool of influence over the STS[E] curriculum development process?
9.8 Final Thoughts

To conclude, this study has taken me on many interesting paths and has led me to consider new perspectives and takes on documents and materials that I have used many times in my educational career and like many forays into research, has left me with many unanswered questions. Document and discourse analysis are powerful techniques to re-imagine how curriculum is constructed and how it might be deconstructed to glean novel meanings. This study has explored STS[E] discourses and has found that the provinces analyzed all tended to emphasize Levinson’s (2010) deliberative framework category of democratic participation in science education (i.e., to varying degrees). Perhaps a final thought may be a broader question, what does this mean for citizens taking these science courses? Does it perhaps mean that it is OK to question and ‘deliberate’ but perhaps not to actually engage in more citizen-directed inquiry and actions about the STS[E] issues explored? I am not sure what the answer is to this question and many others raised. From an educator and a researcher lens, I do know that STS[E] educational approaches are important, transformative and in the words of one of my former students, “Yes!! I love doing that STS[E] stuff!”
References


Explorations of the Alberta Science 10 (minor revisions 2014) STS and Knowledge curriculum using Bloom’s revised taxonomy (Krathwohl, 2002) to illustrate generally where STS and Knowledge outcomes may intersect with various framework categories and descriptions.

Cognitive Process Dimension

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<tr>
<th>Knowledge Dimension</th>
<th>Remember</th>
<th>Understand</th>
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<th>Analyze</th>
<th>Evaluate</th>
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<td>ENERGYFLOWGLOD2identify ENERGYFLOWGLOB3explain</td>
<td>ENERGYTECHB5describe ENERGYTECHB6define ENERGYTECHB9define</td>
<td>ENERGYFLOWGLOA2identify</td>
<td>ENERGYFLOWGLOD6assess, from a variety of perspectives, the risks and benefits of human activity</td>
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<td>ENERGYFLOWGLOB2investigate</td>
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<td>CHEMA3 identify</td>
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Explorations of the Ontario Grade 10 STSE academic level curriculum using Bloom’s revised taxonomy (Krathwohl, 2002) to illustrate generally where the expectations may be aligned with framework categories.

Cognitive Process

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Explorations of the Ontario Grade 10 STS[E] applied level curriculum using Bloom’s revised taxonomy (Krathwohl, 2002) to show generally where the expectations might align with framework categories.

### Cognitive Process

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<td>D. Metacognitive Knowledge (in general as well as one’s own) Strategic knowledge; cognitive tasks</td>
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APPENDIX C: EXPLORATIONS OF THE ONTARIO HANSARD (2006-2010) DEPICTING THE FREQUENCY OF VARIOUS EDUCATIONAL TOPICS DISCUSSED.

<table>
<thead>
<tr>
<th>Ontario Hansard Topic Related to Education</th>
<th>Frequency of Topic Appears in Hansard Search (i.e., from 2006 - 2010)</th>
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<tbody>
<tr>
<td>Transportation Infrastructures; School Transportation</td>
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<td>School Boards</td>
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<td>Financial Literacy</td>
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<td>Full-Day Kindergarten</td>
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<td>Black History Month</td>
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<tr>
<td>Teachers; Teachers’ Pensions; Elementary Teachers</td>
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<tr>
<td>Education Funding</td>
<td>15</td>
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<tr>
<td>Student Achievements</td>
<td>15</td>
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<td>Special Needs Students; ESL Funding</td>
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<tr>
<td>Education Amendment Act</td>
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<tr>
<td>Education [General]</td>
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<td>Private Members’: Caregiver and foreign worker recruitment and protections</td>
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<td>School Safety; Student Safety</td>
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<td>School Support Staff</td>
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<td>School Calendars</td>
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<td>Tourism</td>
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<tr>
<td>Teachers’ Collective Bargaining; Teachers’ Collective Agreements</td>
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<tr>
<td>Class Size</td>
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<tr>
<td>Autism Treatments; Autism Services</td>
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<tr>
<td>Ministry Spending</td>
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<tr>
<td>Aboriginal Education</td>
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<tr>
<td>Child Protection; Child and Family Services</td>
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<td>School Closures</td>
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<td>School Facilities; School Pools</td>
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<tr>
<td>World Teachers’ Day</td>
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<tr>
<td>Healthy Schools; Healthy Food for Healthy [Schools, Kids?]</td>
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<tr>
<td>Access to Education</td>
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<tr>
<td>Ontario French-Languages</td>
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<td>School Trustees</td>
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<td>Subventions Destinees</td>
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<td>Rural Schools</td>
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<td>Education Week</td>
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<td>Premier’s Awards</td>
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<td>Nowruz</td>
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<td>Investing in Ontario Act</td>
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<td>Parental Involvement</td>
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<td>Water Quality</td>
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APPENDIX D: EXPLORATIONS OF THE MANITOBA SENIOR 2 SCIENCE STS CURRICULUM FROM STRAND 0 USING BLOOM’S REVISED TAXONOMY (KRATHWOHL, 2002).

Explorations of the Manitoba Senior 2 Science STS[E] curriculum using Bloom’s revised taxonomy (Krathwohl, 2002) to depict where generally the outcomes may be aligned (outcomes associated with Scientific and Technological Attitudes in Strand 0 not classified).

**Cognitive Process**

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<tr>
<th></th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
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<tbody>
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<td>B. Conceptual Knowledge (theories)</td>
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<tr>
<td>S2-0-2c</td>
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<td>S2-0-2a</td>
<td>S2-0-2b</td>
<td>S2-0-4e</td>
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<td>S2-0-8d</td>
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<td>S2-0-2d</td>
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<td>S2-0-8g</td>
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<td>C. Procedural Knowledge (methods, techniques)</td>
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<td>S2-0-8f</td>
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