USING ONLINE PEDAGOGY TO EXPLORE STUDENT EXPERIENCES OF
SCIENCE-TECHNOLOGY-SOCIETY-ENVIRONMENT (STSE) ISSUES IN A
SECONDARY SCIENCE CLASSROOM

by

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A thesis submitted in conformity with the requirements for the degree of
Doctor of Philosophy,
Graduate Department
of
Curriculum, Teaching and Learning,
Ontario Institute for the Studies in Education
University of Toronto

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Using Online Pedagogy to Explore Student Experiences of (SCIENCE-TECHNOLOGY-SOCIETY-ENVIRONMENT) STSE-Based Issues in a Secondary Science Classroom

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Abstract

With the proliferation of 21st century educational technologies, science teaching and learning with digitally acclimatized learners in secondary science education can be realized through an online Science-Technology-Society-Environment (STSE)-based issues approach. STSE-based programs can be interpreted as the exploration of socially-embedded initiatives in science (e.g., use of genetically modified foods) to promote the development of critical cognitive processes and to empower learners with responsible decision-making skills.

This dissertation presents a case study examining the online environment of a grade 11 physics class in an all-girls’ school, and the outcomes from those online discursive opportunities with STSE materials. The limited in-class discussion opportunities are often perceived as low-quality discussions in traditional classrooms because they originate from an inadequate introduction and facilitation of socially relevant issues in science programs. Hence, this research suggests that the science curriculum should be inclusive of STSE-based issue discussions. This study also examines the nature of students’ online discourse and, their perceived benefits and challenges of learning about STSE-based issues through an online environment. Analysis of interviews, offline classroom events and online threaded discussion transcripts draws from the theoretical foundations of critical reflective thinking delineated in the Practical Inquiry (P.I.) Model. The PI
model of *Cognitive Presence* is situated within the *Community of Inquiry* framework, encompassing two other core elements, *Teacher Presence and Social Presence*. In studying *Cognitive Presence*, the online STSE-based discourses were examined according to the four phases of the P.I. Model. The online discussions were measured at macro-levels to reveal patterns in student STSE-based discussions and content analysis of threaded discussions. These analyses indicated that 87% of the students participated in higher quality STSE-based discussions via an online forum as compared to in-class. The micro-level analysis revealed students to attain higher cognitive interactions with STSE issues. Sixteen percent of the students’ threaded postings were identified in the Resolution Phase 4 when the teacher intervened with a focused teaching strategy. This research provides a significant theoretical and pedagogical contribution to blended approach to STSE-based secondary science education. It presents a framework for teachers to facilitate students’ online discussions and to support learners in exploring STSE-based topics.
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I like to express my deep appreciation to Dr. Erminia Pedretti for the supportive and collegial learning environment she provided throughout my doctoral work. As my faculty advisor and thesis supervisor, I am extremely grateful for her flexibility in meeting with me on numerous occasions to discuss my thesis. For the guidance and support throughout the dissertation development and completion, I wish to thank Drs. Clare Brett, Jim Hewett and Douglas McDougall. In addition, I thank Dr. Clare Bret for kindly pursuing as my thesis supervisor and generously giving her valuable time, expertise and thoughtful suggestions in my doctoral research work after Dr. Pedretti’s departure for maternity leave.

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Finally, I wish to thank my wife, Lynn for the innumerable sacrifices and who has always been by my side during my doctoral program listening to all my joys and woes. Especially, during my pancreatic surgery and recuperation months during my PhD program, Lynn provided me with unlimited love and kindness to enable me to pursue and complete my thesis. Indeed, our daughter, Julianna happily shared her knowledge and experience, while preserving Lynn’s sanity during my PhD program, thus creating a smooth path for me to complete my thesis.
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Dedication

This thesis is dedicated to my family members especially to my parents in Singapore. My parents, Roman Ayyavoo-Avani and Lourdumary Ayyavoo, who continue to inspire, support, transform and instill the love of adventure for lifelong learning about the natural world in both myself and three sisters, Jacintha, Helen and Annetha.

My Dad is Indian born and as an audacious teen travelled to the British settlement in Singapore in the early 1950s. His adventurous nature enticed him to learn new trades and skills leading him to join the Volunteer Settlement Police force for the colony of Singapore. Refocusing his energies into a novel business venture, he created opportunities to travel and explore South East Asia. His desire to learn through various situations inspired me to expand my curiosity to acquire new experiences in science and education which brought me to Canada.

My Mom, also a British-subject, was born in the colony of Singapore and was educated in an all-girls catholic school. Her father’s love for cultivation of garden vegetables and breeding pigeons translated into an enthusiasm for the wonders of the natural world of flowers, plants and animals. She taught me the ways of nurturing plants and the love for observing animals and human behaviour, and the love of science while growing in the catholic faith.

Such is the nourishing environment that my parents, Mary and Roman Ayyavoo cultivated for my own desires for education. I continue to define my place in science education by understanding natural phenomena and the social-psychological-scientific-technological influences that underpins my 21st century education. My continued educational growth is sustained now by my wife, Lynn (a political science/business major) and my daughter, Julianna (a mental health psychology major). My relationships with my family continue to lay the foundation for my educational transformation for which I am eternally and deeply grateful.
CHAPTER I
INTRODUCTION

1.1 Online STSE-Based Discursive Science

The current educational practice of Science-Technology-Society-Environment (STSE) – based education reflects the growing adoption of issues-based discursive science pedagogy which has developed over the last 40 years. Throughout this time, the power of discursive science pedagogy has produced opportunities for student interaction and a wide variety of ways of teaching STSE-based issues leading to many distinct pedagogical approaches (Pedretti & Nazir, 2011). While 40 years ago teachers may have relied on articles in newspapers and magazines as a source of social issues in science for students’ discussion, today’s teachers are not limited by such constraints. In today’s classroom, the availability and use of the Internet means that learning around STSE-based issues can continue to happen outside of the classroom timeframe, and indeed outside of any national time zone. The purpose of this chapter is to introduce STSE-based education, digital learning in science, story of my transformation as a digital immigrant, marginalized STSE-based issues in the physical sciences, my research questions and an overview of the chapters of my dissertation.

Many science education researchers argue that a Science-Technology-Society-Environment (STSE) emphasis in science education encourages reflection and collaboration among students as they discuss socially relevant STSE issues, such as the production of genetically modified foods, the legalized use of marijuana and the fluoridation of drinking water (Furberg & Ludvigsen, 2008; Sadler, 2009; Zeidler & Nichols, 2009; Zeidler, Sadler,
Applebaum & Callahan, 2009). Accordingly, reflection and active examination of relevant STSE issues may allow students to participate in responsible decision-making, and action and citizenship to develop civic perspectives to make concrete contributions towards a global future.

By working with STSE issues, the connection with science in students’ lives and the community tends to emphasize character development and an increased sense of social interaction and democratic participation (Driver, Newton, & Osborne, 2000; Kolsto, 2001; Sadler, 2004). According to McInerney and Roberts (2004), social interactions are beneficial in that they foster a sense of community in science classrooms which helps students discuss STSE issues in face-to-face class settings and online computer-mediated forums.

The online text-based interactions or blogging (posting content on a Web log or online journal) of 21st century learners allows current students to seek alternative stimulation in a techno-savvy world. Today’s digital learners are frequently surreptitiously texting and discussing issues and thereby participating in fora to voice their opinions. Cyberspace can be an avenue for discussion that may allow for the continued development of scientific knowledge and the critical thinking skills needed to negotiate socially-laden issues in science.

STSE-issue based topics in science require students to engage in a certain kind of thinking through dialogue, discussion, debates, and argumentation (Sadler, 2009; Zeidler & Nichols, 2009, Zeidler & Keefer, 2003). Researchers in this field of study, especially Sadler, Zeidler and colleagues, support the idea that the intent of student verbal engagement is to create personal meaning by using evidence-based reasoning and provide students a context for understanding scientific information. Some examples of STSE-issues include: the proliferation
of endemic diseases such as Swine flu (H1N1), genetically engineered crops using genetically modified organisms, global economic distress, and environmental crisis. These social issues in science can be potentially critiqued and discussed in science classrooms more than is currently the case (Bencze & Sperling, 2012). Social issues are embedded in the STSE movement (Hodson, 1992, 2003; Hughes, 2000; Pedretti, 1997, 2005; Pedretti & Little, 2008) which includes instructional practices that develop students’ critical decision-making skills through, for example, debates, town-hall meetings, opinion pieces and, as focused upon in this thesis, online text-based interactions.

Digital learning advocates (see, Furberg et al., 2008; Teed, Zandvliet & Ormond, 2011) who promote discussion of social issues (e.g., STSE-based issues) have added technological literacy to the list of positive learning outcomes for their students. With growth in digital learning especially with text-based discussion opportunities, there is interest in finding ways to use this medium of learning to encourage critical and reflective thinking skills as a positive outcome in education (see Arend, 2009; Lossman & So, 2010; Yager, 2007). Online educators (for example, De Leng, Dolmans, Jöbsis, Muijtjens, & van der Vleuten, 2009) advocate e-learning strategies as a viable instrument to facilitate discussion around science concepts. Indeed, educators continue to emphasize the importance of discussion in learning new science concepts, underlining the fact that the opportunity to discuss allows for students to choose a position on an issue, as well as, argue and defend their deep understanding of scientific issues in society (Hughes, 2000; Kolsto, 2001; Lossman & So, 2010; Osborne, Erduran & Simon, 2004; Zeidler & Sadler, 2008).
To obtain deep understanding of students’ meaning construction, it is important for learners to be familiar with ‘doing science’ with modern digital devices in their class as well as being sensitive to societal values, demands and expectations (Furberg et al., 2008). The aim is to challenge students to articulate their arguments with their peers by using their technological devices in the 21st century classroom. For example, in the chemistry classroom, chemical probes can be used to measure the pH or temperature of polluted stream systems, thus allowing students to understand the extent of water contamination due to environmental toxins. The 21st century science classroom that also chooses to include iPhones and iPads in its instruction and practice has the potential to connect globally in order to share data and ideas, thus allowing for students to discuss STSE-based issues with their peers around the world. For example, students can measure water contamination with a chemical probe in Toronto and compare their results with students doing the same experiment in Malaysia, and then engage in an online critical discussion through their iPhones, iPads, and notebooks about differences in results and possible interpretations of the environmental degradation.

In order to investigate the value of online learning within the context of STSE-based issues, I engaged in a case study where I observed a physics teacher using both online and offline discursive science pedagogy. In this case study, I noted how the online forum engaged high school students in critical, reflective thinking about STSE-based issues embedded in the senior physics course. My primary research interest was to document senior physics students’ engagement in Science-Technology-Society-Environment (STSE) issues using the school board’s online environment in a high school located in a large urban Ontario city. During my
observation, I paid attention to the rich classroom interactions (between teacher-student, student-student) in which the online discussion and learning around both physics knowledge and its application to STSE-based issues occurred. With the proliferation of 21st century educational technologies, critical and reflective thinking opportunities can be further developed through online discussions that engage students to have voice and to participate in dialogue.

1.2 Computer-Mediated STSE-based Discussions in High School

Essentially, an STSE education seeks to place science in its social, cultural and political context, thereby bringing socially relevant issues into classroom discussions. Educational research has identified a number of difficulties (such as resources, time, teacher and student resistance) in the implementation of STSE-issues based discourse approaches in science pedagogy (Kolsto; 2001; Mansour; 2007; Pedretti & Little, 2008; Yager, 2007; Zeidler & Sadler; 2008). However, technology-mediated learning contexts have the potential to minimize implementation challenges and therefore engage, challenge and provide opportunities for students to articulate their views and attend to STSE-based issues in science. This case study was designed to observe and understand the experiences of students as they engage in online discussion on STSE-based issues in a high school physics course. Evidence reported by Furberg and Ludvigsen (2008) demonstrate the value of technology-mediated activities in deepening students’ understanding of STSE issues which, according to Levinson (2006), inspires learners to link controversial issues (for example, embryo selection and waste disposal) to science content.
In today’s classrooms, technology-mediated learning has presented itself in different forms, such as blended learning environments, videoconferencing, podcasts and many other multimedia learning resources including, video clips, graphics, animations and graphic images (Technology’s Influence on High School Completion, 2007). These technology-supported learning tools demonstrate the potential to support learning and this has fuelled the increasing amount of online education that is being integrated in a hybrid way within face-to-face interactions in high schools. Specifically, Gambrell (2004) and Larson and Murray (2008) indicate that the use of computer-mediated discussions is facilitating the development of thinking and skill acquisition into high school classroom implementation.

Furthermore, Larson and Murray (2008) suggest that computer-aided discursive processes leverage high school students’ engagement in discussions and thereby facilitate higher-order thinking skills. Newmann (1990) defines higher order thinking skills as those that “challenge the student to interpret, analyze, or manipulate information, because a question to be answered or a problem to be solved cannot be resolved through the routine application of previously learned knowledge” (p. 44). Students may often value challenge and active discussion of ideas that promote thinking and reflection (Roehling, Kooi, Dykema, Quisenberry & Vandlen, 2010). With an increase in the number of high schools using an online-mediated forum in high school courses (Larson & Murray, 2008), the online communication venue has shown promise in providing opportunities to voice opinions and actively discuss STSE-based issues in science which is discussed next.
1.3 **Rationale for Online STSE-Based Discursive Science**

Researchers suggest that science courses encompassing socioscientific issues carry the potential to bring challenging arguments into classrooms (see for example, Furberg & Ludvigsen, 2008; Pedretti et al., 2008; Zeidler et al., 2009). Lively discussions in science classrooms tend to foster critical and reflective thinking, which, in the online world has been termed *Cognitive Presence*. *Cognitive Presence* is a term used by Garrison, Anderson and Archer (2001) to characterize one element of effect from the online learning contexts derived from the Community of Inquiry (CoI) Model (Garrison et al., 2001). In Garrison and his colleagues’ (2000) Practical Inquiry framework within the CoI Model, the phrase cognitive presence is defined as learners’ ability to encompass critical analysis, reflection and discourse in order to construct personal meaning through sustained communication and collaboration (Ennis, 2008, 1991; Garrison et al., 2000; Garrison, Anderson & Archer, 2001; Schrire, 2006).

Communication and class collaborations have also been explored through other applications of this framework by other educational researchers (for example, De Leng, Dolmans, Jöbssis, Muijtjens, & van der Vleuten, 2009). Unfortunately, an overcrowded secondary science curriculum often leaves little opportunity to debate, argue or collaborate about specific science knowledge related to social issues in face to face classrooms. It is here, potentially, that the online forum could be a practical method for including STSE-based discussion in science.

This dissertation outlines an investigation of computer-mediated technology as a pedagogical method to elicit critical discussions in secondary science classrooms. Since
controversial STSE-based issues are included as an overall expectation in all of the Ontario’s Ministry of Education’s (2008) high school science courses, this case study was designed to observe the critical analytical skills resulting from the application of STSE-based issues in science courses through an interactive online approach. In the following section, I introduce my experiences with STSE-based application in my science classrooms, and describe how these experiences have shaped and contributed to my professional development and ignited my continuing interest in the field of science teaching.

1.4 **Background: Transformation into Digital Immigrant with STSE Education**

Having taught in Singapore and Canada for more than two decades, I have developed deep educational interests in the advancement of scientific literacy for my students which encompasses three learning outcomes:

- Learning that embraces different intelligence modalities including technology-mediated communications;
- Development of Scientific, Technological, Societal, Ethical and Environmental attitudes;
- Training critical thinking and communication skills through student research (that is, Scientific Investigative Projects, or SIP) in the technology motivated 21st century science education.

Social networking is part and parcel of the 21st century education which welcomes my students as digital natives and, as a teacher, I have transformed into a digital immigrant. My science students, as digital natives, have grown up speaking and using digital language in their everyday life experiences. My journey as a digital immigrant started from my desire to combine my love of learning new technologies with my professional drive to engage with new pedagogical applications in order to enhance and advance the learning of the 21st century learners in my chemistry and biology classrooms.
With these millennium learners’, my practices in the classroom reflected my personal motivations in experimenting with new technologies such as Smart Phone features using digital text messaging for science classroom. Frequently, however, the only place where my students, who are swift digital learners, face opposition to handheld technology use, occurs in their classrooms. Classroom rules, school regulations including teachers’ apprehensions towards the new techno-teaching strategies and using e-learning prematurely for children seem to prevent our digital natives from interacting in their technological student-centered environment (Abrami, Bernard, Wade, Schmid, Borokhovski, Tamim, et. al., 2006). According to Abrami and colleagues (2006), the benefits of e-learning are enhanced when technology is understood to be important condition for learning and in making general opinion statements and meeting social demands with technology use. These researchers declare worth to student e-learning by stating: “[That] properly implemented computer mediated communication can enrich the learning environment [and] help reduce low motivation and feelings of isolation in distance learners” (Abrami et al., 2006, p. 5).

Our young digital learners in schools are motivated and eager for the opportunity to communicate digitally or electronically through social media and this motivation may be an additional way of enhancing scientific discussion beyond the traditional face to face science learning in classroom. The role of student communication technologies in the learning process is both dynamic and complex and requires students to be trained in using e-learning features effectively. Yet little research has been done to date in Canada that can inform secondary science teaching and learning using online discussions which can be beneficial to our socially and technologically connected lives (Abrami et. al., 2006).
My pedagogical experiences in teaching science linked with technology incorporate not only the science deliberation through the face-to-face in class method, but also integrate visual, kinesthetic and technology-favoured student-centered learning styles. In this teaching repertoire, I recognize the importance of interaction and communication technologies while simultaneously being dedicated to improving student science learning. Throughout my years of teaching practice in Asia and North America, I have observed that learners are equipped with digital skills and literacies that are not necessarily taken advantage of learning in classrooms today. Students talk about communication technologies, such as chat rooms, discussion boards and video conferencing as being interesting electronic venues in which to discuss matters relevant to them, but yet they cannot engage with them in most of their school classrooms. I embrace the opportunities technology-mediated communication offers as a means to teach STSE because it allows all learners to share personal perspectives that can inspire and empower others from different cultures and backgrounds.

Meanwhile, I continue to supplement my teaching repertoire with STSE-based investigations to motivate students to communicate about community matters and problems. Learner-designed investigations address and present students with issues-based topic through exploratory studies. For example, my biology and chemistry students used biological indicators (for example, Benthic Macro-Invertebrates) to test watershed, biochemical impacts on environment and ecological behavioral studies (see Ayyavoo, 2004; Ayyavoo & Ayyavoo, 2006). I continue to promote and implement student designed projects on responsible consumerism and environmental consciousness through cooperative-group dynamics. For
example, in my grade 12 Biology course, I began by taking students outside to the Don River (a
large river flanked by a highway) to investigate on river pollutants, and then had students use
their results to facilitate a class debate on environmental calamities. This particular project led to
students collaborating and publishing an article with me on their findings and making
connections to environmental degradations (Ayyavoo, Duchen, Savage & Shrumm, 2004).
Renewed interests in the large river (for example, the Don River) investigations led my current
students to present their longitudinal studies at ENO (Environment Online) International
Environment conference (Kuala Lumpur, 2011) with STSE-based discussions using biological
agents.

The implementation of STSE-based issues is valued in my science courses and has
resulted in my students receiving awards and accolades for their student-designed Scientific
Investigative Projects (SIP), which in turn has led to recognition by various educational institutes
of my contribution to science education. Empowering students with a variety of learning
strategies in my science pedagogy has lauded me with the 2002 Sigma Xi University of Toronto
Science Teacher Award, 2005 NABT North American Environmental Teaching Award, 2005
Central Canada’s Outstanding Biology Teaching Award and the 2006 BioTeCanada’s National
Biotechnology Teaching Excellence Award.

As a result of my experiences in science education and the numerous award recognitions
I received over the years, the Ministry of Education seconded me in 2008 to take the current
Ontario Science Curriculum, and create e-learning science courses (Ontario’s E-Learning
Strategy, 2006). These courses were developed following the curriculum expectations in science,
but were to be delivered in a virtual environment. As the leader of a team of science teachers from across Ontario, I collaborated in the development of virtual labs, animations, storyboards and science concepts that would support computer-mediated communication between students and teachers online.

In 2009, I was invited to be a part-time Information Technology teacher for the board in which I teach. In this position, I continued to develop science curriculum materials and teaching strategies to implement my board’s online science courses to satisfy the Ministry’s science curriculum expectations.

Furthermore, my instructorship position at a local university where I taught biology education incorporating digital learning to teacher candidates, motivated the formation of my doctoral research question which is situated in the intersection of STSE-issues based science education blended with computer-mediated communication in science courses. As part of teacher candidate education, I taught teacher candidates how to use STSE-based issues in their biology classrooms, and discovered that they too experienced challenges in implementing STSE-based education in their placements (due to an overcrowded curriculum, associate teacher hesitancies, and curriculum delivery time restrictions). In my courses, teacher candidates recognized the importance of STSE-based education and wanted to implement this in their practicums. I therefore, supported students in investigating ways to incorporate STSE-based issues in their biology classroom. Indeed, the parallels in experience of teacher candidates sparked my own interest in developing alternative strategies for including STSE-based issues in science courses.
Over the years, I have paid attention to persistent science educators’ (classroom teachers, online teachers, student teachers) complaints of an overcrowded Ontario science curriculum and lack of time to devote to STSE-based discussions. To address the limited student-to-student and student-to-teacher discussions of STSE-based issues in science courses, I was prompted to search for alternative venues and opportunities for science teachers and students to implement STSE-based discussions in their courses, and it is here that I was led to consider the role of the use of computer-mediated discussion of STSE-based issues online.

This interest informed my pilot study on the use of technology-mediated STSE-based discussions in an urban high school science course, which in turn directed and formulated my doctoral research questions. My doctoral research consequently, focuses on students’ online discourse in the context of STSE-based education.

1.5 STSE-based Issues Marginalized in Physical Sciences

STSE-based issues are often associated with biology courses but marginalized in physical science courses. STSE-based topics in biology are encompassed through course contents such as ecology with topics involving environmental issues, genetics with issues associated with genetically modified organisms, internal biological systems with treatment of diseases and xenotransplantation. But STSE issues-based science topics are rarely part of physics or chemistry classes for various pedagogical reasons. Hence, STSE-based discussions germane to physical science, namely chemistry and physics courses, do not seem to surface easily in science classrooms.

There are STSE-based topics associated with physics and chemistry courses as identified and suggested in science curriculum, (Ontario Science Curriculum, 2008; 2000) but issues-based
science topics are infrequently used in classrooms (Hughes, 2000; Pedretti, 2003). In the latest Ontario science curriculum (2008), STSE-based issues are manifested in all secondary sciences including the physical sciences. For example, socially-related science topics within the Ontario chemistry curriculum relate to artificial sweeteners such as aspartame in foods related to diabetics and weight gains, PABA in Sunscreens and pharmaceuticals in our drinking waters. Similarly, physics topics included in the Ontario science curriculum (2008) also reveal socially-related science issues. Such STSE-based topics include environmental costs of heating homes using conventional methods via coal, radiation issues in using nuclear technology in medicine, large amount of energy use for satellite launch and space junk creation with old satellites. It seems that some science teachers side-step from dealing with controversial socioscientific topics in science. If STSE-based issues are dodged, then controversy is avoided in science pedagogy (Hughes, 2000) especially in the physical sciences. Cross and Price (1996) further identify physical sciences are taught with theories and facts while controversial issues are circumvented. Despite the difficulty in identifying physical science teachers who implement STSE-based controversial issues in their classes, I was fortunate to locate a physics teacher who was addressing STSE-based physics issues in her senior science course.

In this doctoral thesis, I was able to identify and explore a singular bounded case study of an Ontario urban high school physics class in a blended (online and offline) teaching approach. All STSE-based physics discussions topics were identified in relation to the Ontario curriculum. The physics-based STSE discussions were managed by the teacher in their entirety. She corresponded with her physics students both in-class (offline) and through computer-mediated (online) discussions. This physics teacher developed two STSE-based online discussion conferences corresponding to the Forces strand and the Energy and Society strand of the Ontario
Physics Curriculum (2008). This bounded case study where STSE-based discussions were being implemented in the physics course became my research ground to explore students’ discursive experiences. The next section will introduce the research questions employed for this case study.

1.6 Research Questions

The purpose of my case study was to examine students’ experiences as they engage in Science-Technology-Society-Environment (STSE)-based issues in an online environment. In this exploratory case study, the relevant research questions of “what, how and why” attempt to capture the essence of holistic and meaningful characteristics of real-life events (Yin, 1998) of socioscientific discussions in science programs. My research was guided by the three research questions, as follows:

1. What are secondary science students’ experiences as they engage in STSE-based education?
2. What is the nature of science students’ online discourse in the context of STSE education?
3. What are the students’ perceived benefits and challenges of learning about STSE subject matter through an online environment?

These research questions were designed specifically to examine the online environment and the opportunities it provides students to engage in reflective thinking with socioscientific materials in high school science. In high school science education, some researchers perceive that one of the challenges is in the process of introducing socially relevant issues in science programs (Develaki, 2008; Gambrell, 2004; Hughes, 2000; Hodson & Bencze, 1998; Pedretti & Little, 2008; van Oostveen, Ayyavoo, Bencze & Corry, 2002). With this awareness, the overall
aim of this study was to observe extended discussion opportunities, both online and in class, which provided students with an opportunity to argue about socioscientific problems through a technology-enhanced medium.

1.7 Overview of the Thesis

This dissertation is divided into seven chapters: introduction, literature review, research methodology, three chapters of results with discussion, and an overall discussion and conclusion. In my introduction (Chapter 1), I introduce the current status of communication technology in education, provide a brief rationale for the need of online STSE-based discursive science, and discuss my background in teaching and my transformation into digital immigrant. Finally, I provide an overview of my doctoral research and present my research questions for this case study on the use of an online environment to deliver STSE education in a physics class.

In Chapter two, I provide a literature review on both STSE-issue based education and online learning. My literature review is divided into two parts. In the first half, I outline the six currents of STSE-issue based education that can inspire critical reflective thinking skills while presenting challenges that teachers encounter in connection to using issue-based education in the science classroom (both online and offline). In the latter part of this literature review, I discuss the benefits and challenges of online threaded discussions in asynchronous communication by citing proponents and opponents of online pedagogy. The STSE literature review serves to outline and substantiate the core ideas of my proposed thesis work, while situating these core ideas in the larger field of curriculum studies.
This chapter further focuses on the conceptual and practical values of an STSE-based education in science programs and the context through which critical analytical opportunities are provided. In particular, I examine science students’ critical thinking skills and their ability to understand socially-related science problems, and then identify implications related to teaching and learning through an STSE approach. I also examine the potentials and possibilities of using technology for online STSE issues-based discussions. I further describe the prospective online environment that could affect student participation through critical analysis of issues-based science topics.

This section highlights the benefits and limitations of computer–mediated discussions. These limitations suggest an effective pedagogy of facilitating issues-based science discussions may be a hybrid approach using both online and face-to-face interactions in schools. This chapter also discusses ‘The Conceptual Architecture’ of the computer-mediated pedagogical framework which illustrates how teachers and students interact with and through online issues-based science discussions. The next topic in this section describes the ’Practical Inquiry (P.I.) Model’ (Garrison, Anderson & Archer, 2001) with respect to the cognitive processes or presences. The cognitive interactions are examined in relation to the four phases of the P.I. Model through the electronic STSE discourses based on the Ontario context. This P.I. Model provides a method and tool to examine cognitive interactions described by Garrison et al. (2001) in the online environment described in the next section.

In the third chapter entitled “Research Methodology”, I explore the qualitative research methods utilized, in particular, the appropriateness of using the singular case study approach
where knowledge is collaboratively built through both offline (classroom) and online (e-learning) environments. The research methods focus on the recruitment of case study participants and the school board’s online environment. The other topics in this section encompass the researcher’s role, the teacher’s presence in-class and online, data collection and data analysis techniques. I also address both the methodological issues with respect to validity and reliability.

In the next three Chapters (4, 5 and 6), the findings are presented with respect to the three research objectives of the STSE-based case study. The three major artefacts for the research objectives are analyzed using the participants’ interview transcripts, online and offline discursive transcripts and my research observational notes. A detailed explanation of the data set with respect to the three thesis questions is also discussed.

In Chapter 7, I present an overall discussion and conclusion for the online pedagogy. I present a general discussion of my findings, discuss the limitations of the case study, and suggest the significance of the results and the blended online STSE Model for high school science. Before drawing conclusions to the case study of the selected secondary science (physics) course, this chapter presents the implications of online computer-mediated discussions with STSE-based issues in a senior science program.

In the next Chapter (2), I will present a review of the literature supporting STSE education, developing reflective thinking skills, STSE-based discourse through computer-mediated support and the conceptual architecture of the Practical Inquiry Model. This chapter
presents the theoretical underpinnings of my bounded case study of an Ontario urban high school Physics class.
CHAPTER II

LITERATURE REVIEW

Pedagogical Framework: The Importance of a STSE Issues-Based Education and Online Learning in Science Education

2.1 Introduction

In this chapter, I present a review of literature for both STSE-issue based education and online learning. This dissertation focuses on how the online environment can be used as a forum for discussing STSE-issue based education. The literature review is divided into two parts. In the first half, I outline the main tenets of STSE-issue based education aimed at encouraging critical reflective thinking skills. At the same time, I also present the challenges that teachers encounter using STSE-issue based education in the secondary science classroom. In the second part of this literature review, I discuss the benefits and challenges of online asynchronous threaded STSE-based discussions by an analysis of the research literature that highlights the benefits and challenges of online pedagogy. This analysis culminates in the description I provide for the Garrison’s et al. (2000) Community of Inquiry framework, which is composed of Teacher Presence, Social Presence, and Cognitive Presence. Using elements of this framework, I describe the Practical Inquiry (PI) Model of Cognitive Presence, part of the theoretic framework upon which this thesis is based and which I later apply in my results and discussion in Chapters 4, 5 and 6.

2.2 STSE Education

STSE education is a pedagogical practice that encompasses Science, Technology, Society and the Environment in secondary science curriculum. This definition of STSE includes an interdisciplinary focus in the sciences and society, but remains vague as a definition. Scholars continue to struggle with how to exactly define and distinguish STSE-issue based education from
other trends such as Social Scientific Issues (SSI) (Kolsto, Bungum, Arnesen, Isnes, Kristensen, Mathiassen, et al., 2006; Pedretti & Nazir, 2011; Teed, Zandvliet, & Ormond, 2011). Bencze and Sperling (2012) also underline the challenge in arriving at a widely accepted definition of SSIs and suggest that there are disputes with the relationship between STSE components, that is, amongst the different fields of Science and Technology and Society and Environment. These researchers found disagreements in their understanding of STSE-based issues in education, in that they found that STSE is not strictly contained within science concepts but involves other disciplines.

Applying STSE-issues in the classroom challenges the science teacher who needs to be competent in social issues and able to contend with a multitude of other perspectives from other disciplines. For example, the topic of fast foods and processed foods could explode into questions related to food chemistry, health issues, environmental issues, political and economic issues, social justice, etc. Pedretti and Nazir (2011) are two such scholars who have applied the metaphor of currents in an attempt to define and describe STSE:

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. 3)

In an earlier paper, Pedretti and Little (2008) discuss STSE education as multidisciplinary and encompassing stewardship, decision-making, ethics, action, critical social construction and the nature of science emphasis. In emphasizing these six cornerstones of STSE education, Pedretti and Little (2008) describe these STSE foundations:

1. *Stewardship* as the care and maintenance of the life-giving and life-sustaining environment;
2. **Decision-making** as how certain choices are made at the various levels of private, government and industrial sectors;

3. **Ethics** as the bonding of science and values in education;

4. **Action** as promoting responsible agents of change with deep understanding of issues and implications while developing a sense of ownership and empowerment;

5. **Critical Social Construction** as utilizing and determining through both intellectual and ethical skills to examine potential benefits and challenges of scientific developments and implications in society;

6. **Nature of Science Emphasis** as recognizing scientific knowledge which is subject to changes. Nature of Science (NOS) is theory laden and subjective because it is based on human imagination with socially, politically, economically and culturally driven forces.

Science teachers who employ these six cornerstones of STSE-issue based education support students in understanding the multidisciplinary nature of science education, and help students make connections between science and history, culture, sociology, ethics, politics, economics and the environment (see for example Ayyavoo, 2004; Eick, Deutsch, Fuller, & Scott, 2008; Mets, 2005). Thus, STSE-issue based education has the potential to empower students to consider real world science-based reflections and make connections to the social and physical world around them (Duncan et al., 2011; Mrazek, 2004; Pedretti et al., 2011; Reis & Galvão, 2004; Zeidler et al., 2005). Although it is beyond the scope of this doctoral research to provide a detailed analysis of the STSE education of Pedretti and Little’s (2008) earlier work, my current
pedagogical approach and experience lies in the application of STSE issues in the Ontario science curriculum.

My conceptualization of STSE in this dissertation is to provide science learners with ‘research-informed actions’ as described by Bencze and Sperling (2012). Research-informed actions address STSE issues and use SSI guidelines to empower students (Bencze & Sperling, 2012). Research-informed action involves student-led research around a problem they have identified, finding a solution, and addressing it through suggesting specific action, thereby empowering students through engagement and contributing ideas to make positive change. In my study, I apply Bencze and Sperling’s (2012) approach to STSE issues. In this literature review, I examine Pedretti and Nazir’s (2011) framework of using ‘currents of STSE education.’

More recent studies on STSE-issue based education focus on the application of STSE in the secondary science curriculum in Ontario (Bencze & Sperling, 2012; Pedretti & Nazir, 2011). Bencze and Sperling (2012) discuss how STSE-based investigations allow for students to develop the expertise in an area, design a research project based on their area of expertise, and work towards finding a solution with respect to the STSE-based issue they set out explore. A recent study by Pedretti and Nazir (2011) outlines six key aspects (shown below), which they refer to as “currents”, of STSE-issue based education, and which expands upon Pedretti and Little’s (2008) previous discussion on the elements of STSE:

I. The application/design current;

II. The historical current;

III. The value-centred current;

IV. The socio-cultural current;

V. The socio-ecojustice current;
VI. The logical reasoning current.

The application /design current brings science and technology together to enable students to solve problems by designing new technologies especially within the STSE framework in school science. Researchers who analyse technological design projects (see, for example, Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005), suggest that school science is often presented as being composed of well-defined problems that have specific answers and that leave little room for creative exploration. Such examples include using an iodine dye test to identify the presence of starch in leaves in Biology, the standard flame test that produces the popping sound in the presence of hydrogen gas in Chemistry, or rubbing woolen fabric with an inflated balloon to visualize static attraction in Physics. The above examples, from secondary science courses, are traditionally well-defined problems in school science. These stand in contrast to so-called real world problems in which the focus is ill-defined and such problems, because of their complexity, tend to be avoided by teachers.

Pedretti and Nazir (2011) define the application/design current as “a definite emphasis on the transmission of disciplinary knowledge and development of technical and inquiry skills” (p.8) with intentions to address real world situations. One example cited from their paper, which makes a clear distinction between a real world problem and an ill-defined problem, is the design of an ergonomic pair of shears for an elderly person:

To make the exercise more authentic, details of a specific social context may be provided. A case study may be given of a person who once was an active gardener but is now prevented from pursuing their interest by a debilitating case of rheumatoid arthritis. Students are posed the challenge of developing a technological solution to ‘help’ this person. (p. 9)
This in-class exercise for secondary science students encourages them to verify their scientific understanding and use higher order thinking skills to apply their understanding of science concepts to solve an STSE-based problem.

The dominant feature of the application/design current is that it encourages students’ higher order thinking skills and creative effort in applying scientific knowledge. The three main types of application/design current used by classroom teachers emphasize student design. Firstly, students design an artifact (e.g., water wheel) to show their mastery in learning about a science concept. Secondly, students design a second artifact to perform a specific task given certain limitations (e.g., showing mechanical efficiency and durability of the water wheel). Finally students modify a technological devise or procedure to respond to an STSE based problem (e.g., easy grip long handle weed grabber for the elderly). The problem being solved here is the weeding of a garden for an elderly person who is arthritic and may not be able to bend down to pick weeds and/or may lack the manual dexterity to grab and pull out weeds. As is evident from these examples, the application/design current encourages students to continue to develop their critical thinking skills by enabling them to apply science concepts in the design of mechanical instruments that solve real world problems.

One of the main criticisms of the application/design current is that it reinforces the view of science as being process and product focused with little attention given to the social implications of the products being created (Hodson, 1998). Students tend to focus on the creation of artifacts and fail to take advantage of opportunities to consider the social, economic or environmental problems and/or implications of their products. In other words, the application/design current can encourage students to view science in a purely objective and decontextualized way and not see the subjective (contextualized view) of science; the
implications of science solutions in a real world context. Developing a social context about a certain design can lead students to reconsider impacts the product may have on the broader Science, Technology, Society and Environment (Pedretti and Nazir, 2011).

The historical current focuses on encouraging students to recognize the diverse contributions in science and consider gender differences, sexual orientations, Western or traditional practices of their cultures, religion, scientific and technological enterprises of these science contributors, and thus encourages students to bring a social context to their understanding of science. STSE-type historical activities target the affective domain, emotions and creativity (Pedretti et al., 2011) which is necessary to help students understand the progress of science in a social context. This current permits students to not only understand the conveniences in their lives due to science, but also forces them to consider the role democracy and social justice play in bringing this science to their lives. For example, in the application of this current, students may not only be interested in how oil is drilled, but may also consider a history of oil spills (such as the BP Oil Spill in the Gulf of Mexico in 2010) and the long-term environmental effects of oil spills on animal and plant wildlife. Other examples of the application of the historical current includes studying earthquakes in science class and then considering historical examples of earthquakes and the social-scientific issues created by these earthquakes, such as the after-effects of the Tsunami in Japan in 2011. Other scholars also suggest that a historical emphasis encourages revisiting of conceptual, procedural and contextual aspects of science:

Concerning science for democratic citizenship, I will argue that the inclusion of the history of science provides possibilities in relation to procedural and contextual aspects. Firstly, it makes it possible to teach aspects of NOS [Nature of Science] in contexts that might provide illustrations, depth and understanding. Secondly, it provides ‘full-scale’ illustrations of science–society interactions. (Kolsto, 2008, p. 978)
The main objective in science education is to prepare students to be scientifically literate by being critical and through engaging their sense of responsibility toward various STSE issues in science (Kolsto, 2001). Kolsto (2001) further highlights the need for students to be aware of a multitude of points of view concerning a scientific issue before developing their opinions, which are rooted in sociocultural influences. Thus, the application of the historical current becomes important in helping students acknowledge the social context within which science happens.

The third current emphasizes a value-centered system in science, which brings a human perspective to science by adding social values and feelings to STSE-based dynamics. Value-centered science education is valued by Zeidler and colleagues (e.g., Zeidler & Keefer, 2003; Zeidler, Sadler, Applebaum, & Callahan, 2009) who claim that STSE models carefully select moral issues in science in order to facilitate particular kinds of moral development in classroom. For example, the use of DDT as a pesticide, which later showed evidence as a human carcinogen, is an example of a discussion in a science classroom that could encourage not only the development of science knowledge, but also a moral understanding of the social issue that DDT has delayed effects on health (Zeidler & Keefer, 2003). Although values may be analyzed through different value systems and positions, students during in-class discussions receive opportunities to critically analyze various value positions about an issue with teacher and peers.

Sadler and Zeidler (2003) suggest that students be given the opportunity:

… to free themselves from blind reliance on science. To fully understand the power and potential benefit of science, students must be aware of its shortcomings and drawbacks. Most products of science do not have as devastating consequences as those reported. … but students should have the skills to judge the merit of scientific activity and discovery independent of the authority the name carries. (p. 281)

By providing opportunities to examine issues through debates and discussions, students are free to choose and defend their personal value for each issue presented in class. With the
value-centered current, students attempt to critique STS-based issues within a humanized view of
science by detailing the human dimension of values, emotions and thought process. According
to Bell and Lederman (2003), the human dimension of values is an intrinsic part of peoples’
considerations of socially-related issues. Scholars like Bell and Ledermann (2003) suggest
personal values and ethics hold more weight in decision-making than the understanding of the
nature of science. It reminds us that developing better decisions depends on moral, ethical and
value considerations (Sadler & Zeidler, 2003; Sadler, 2004) and that personal value development
may nourish a kind of intellectual growth which reduces reliance on authority figure (Sadler &
Zeidler, 2003). Such a value-added current is perhaps further developed when used in
conjunction with the sociocultural context, and it is this context which is presented next.

The fourth current is viewed in terms of sociocultural aspects of science and science
education. Hodson’s (1998) paper on ‘misinterpretation of science in the science curriculum’
examines the myth that “Science is exclusively Western and post-renaissance in its activity” (p. 205). Here Hodson describes an example with the studies in the following science and social
studies areas:

….in the history of medicine, astronomy and technology particularly rich in Islamic,
Indian and Chinese exemplars – help to promote awareness that current scientific ideas
are not derived solely from post-Renaissance Western societies. …. Islamic, Indian and
African scientific achievements have been similarly trivialized or falsely attributed to
Westerners. For example, when the Arab contribution to the growth of science is
mentioned at all, it is portrayed as no more than that of custodian of ancient Greek
knowledge. (p. 205)

Such biased Western-centered science portrays disturbing views observed in traditional science
education that serve to alienate students from non-western backgrounds and cultures, including
people in Aboriginal communities. Aikenhead (2002) describes the differences between the two
approaches in science, namely the Western and Aboriginal teaching styles:
The norms, values, beliefs, expectations, and conventional actions of First Nations peoples contrast dramatically with the subculture of science. … Western science was characterized as being essentially mechanistic, materialistic, etc. By comparison, Aboriginal knowledge of nature tends to be thematic, survival-oriented, holistic, empirical, rational, contextualized, specific, communal, ideological, spiritual, inclusive, cooperative, coexistent, personal, and peaceful. (p. 221)

This description illustrates the sociocultural current as he compares a western teaching style (specifically, materialistic, competitive, and masculine) to an aboriginal teaching style (by contrast, intimate, collaborative, and inclusive) (Aikenhead, 1997). These differences tend to make science an even more foreign subject and prevent students from gaining a personal worldview and appreciation of science in which they are culturally present. Aikenhead (2002) recommends that the teaching of science become cross-cultural and to do so he makes two significant recommendations:

[First], knowledge of nature learned in school science should combine both Aboriginal and Western knowledge systems.

[Second], a group of teachers who are already fulfilling some of the principal roles of a culture broker should be identified, and they should form a working network with other educators who could facilitate their collaborative efforts. Together, they should develop:
(a) an array of culturally responsive instruction and assessment practices;
(b) a culturally sensitive science curriculum; and
(c) specific lessons, units, or modules for other teachers to use. (p. 290)

These recommendations provide for a culturally responsive science education (Aikenhead, 2002). Cultural diversity and traditions support learning communities and teaching materials can be developed to fit the meaningful context of the cultures of these school communities.

Essentially, the sociocultural current is the STSE answer to such indictments of western science.

The socio-ecojustice current is the current that focuses on “critiquing and solving problems through human agency and action” (Pedretti & Nazir, 2011, p. 17) when the traditional science education and other STSE currents do not extend to educate students about socio-political arenas (Bencze & Sperling, 2012, Hodson, 2003; Roth, 2002). Mueller and Zeidler
(2010) also view traditional Western science education as: “Historically, for the most part, traditional science teaching corresponds to the notion that science should not involve ethical, political, and social judgments” (p. 112). With reduced opportunities to involve social issues in science classroom, activities could instead be designed to inspire students to think critically, analyze information and come to an agreement to solve an STSE-based problem. Pedretti and Nazir (2011) present two different approaches that can be used to apply this current in the secondary science classroom. These two approaches in socio-ecojustice current are: 1) combining place-based education with STSE issues-based orientation, and 2) encouraging students to confront social and environmental problems with student empowered activities.

Place-based education (Smith, 2007) seeks to develop in young people a sense of affiliation with the places in which they live (Gruenewald, 2003; Smith, 2007), and enhance “young people’s familiarity with what is beautiful and worth preserving in the territory they call home” (Smith, 2007, p. 192). As a site for place-based integrated learning, urban outdoor education centers (OECs) for example, are often characterized by a center’s woodlot, rivers or streams and encroached by local community. Though these natural ecosystems may enrich students’ senses as a place for learning, the outdoor education centers can become places that create possibilities for children to derive context in learning and caring for the environment, leaving it intact for future generations (Ayyavoo & Pedretti, 2010). Supporting the idea that the natural ecological setting becomes a site for place-based education, Pedretti and Nazir (2011) further endorse “the idea that learning is most effective when learning material is derived from the immediate context of the learner” (p. 17). Employing an ecological context for learning, the natural outdoor environment becomes a site for place-based education where students learn and care for the environment while voicing their opinion in class discussions and sometimes by
expressing their concern through written publications (see for example, Ayyavoo, Duchen, Savage, Shrumm, 2004).

Outdoor learning sites are opportunities available to connect STSE issues emphasizing environmental events where part of students’ learning experience occurs in the outdoor setting which provides the context for learning. According to Smith (2007):

Since the mid-1990s, an educational approach that embraces both human and nonhuman communities has been attempting to achieve just this. Called place-based education, its proponents have been striving to make the boundaries between schools and their environs more permeable by directing at least part of students’ school experiences to local phenomena ranging from culture and politics to environmental concerns and the economy. (p. 190)

When boundaries between schools and their environments are made more ‘permeable’, students learn about the environment and begin to critique society’s influence on the state of ecosystem. Researchers like Smith (2002) and Mueller with Zeidler (2010) also advocate that issues relevant to their local environment strengthen learners’ willingness to acquaint themselves with problems where they can voice their opinions. The cultivation of critical analysis and activism are the central challenges of placed-based education (Smith, 2007). To move students into seeking justice and equitability, issues and challenges of activism need to be addressed in schools, and more time is required in schools to capitalize the pedagogical opportunities.

The second approach to the teaching of the socio-ecojustice current of STSE-based education encompasses student activities that further social and environmental issues. In this current, students explore problems that originate from science and technology and become active in addressing issues of ecojustice in their communities to make a real difference in solving these problems. Loynes (2004) presents a framework to understand outdoor ecological education as relying on a transformative practice through the *generative paradigm*. The generative paradigm is understood to be about radical practice, or as Loynes (2004) says “it incorporates actions based
on the experiences inspired by learners choosing for themselves how to make a difference. The individual moves through the role of participant and narrator, and becomes an agent in their world” (p. 122). As an agent, students participate and engage in a transformative learning venture. The characteristics of this paradigm, thus, extend beyond just process oriented or outcome based activities. It drives the ideas of community and the environment through the political engagement of all participants in environmental education. For example, this means that high school science students would do more than pick up garbage in their local ravine on Earth Day. Rather, Earth Day would compel students to become active in speaking up in their local municipalities about issues connected to environmental degradation in their parks and ravines.

Other educational researchers (see, Pedretti & Nazir, 2011) believe that eco-sensitive student activities that concern students can originate from certain kinds of science and technology curriculum activities. These researchers state that eco-sensitive activities, such as measuring lichens on trees as pollution indicators or identifying macroinvertebrates in water systems as water pollution indicators (Ayyavoo, 2004; Eick, Deutsch, Fuller, & Scott, 2008), empower students to take charge and lead with democratic choices. The specific student actions may be in the form of designing an action plan, lobbying for change, promoting environmental wellbeing, raising funds for environmental cleanups or planting trees or conducting student run environmental stream study and pollution research (Ayyavoo, 2004; Ayyavoo, Duchen, Savage, Shrumm, 2004; Eick, Deutsch, Fuller, & Scott, 2008). Students are inspired to engage in relevant socio-environmental activities both at kinesthetic and cognitive levels.

The logical reasoning current is “one of strongest currents in the STSE continuum” (p. 13) that is used as a basis for gathering knowledge and employing decision making’ skills in controversial issues (Pedretti & Nazir, 2011). In this dissertation, I am particularly interested in
exploring the logical reasoning current (the sixth current in Pedretti and Nazir’s 2011 paper) in STSE-issues based education and understanding how this current is influenced through computer-mediated online discussions. According to Pedretti and Nazir (2011), logical reasoning is one way in which STSE-issues can be utilized for discussion in the science classroom to “enhance student understanding and/or decision making about SSIs by encouraging [students] to think ‘the way scientists do’” (p. 12). Even within this current, there are several substreams of thought about what constitutes enhancing student understanding and/or decision making skills. Pedretti and Nazir (2011) discuss this dilemma:

While some groups consider enhancing student understanding of the complexity of issues a suitable endpoint, others insist that in addition to promoting understanding students must be encouraged to make decisions about issues. The aim of science education in this current reflects a citizenship and civic responsibility emphasis through the transaction of ideas. As such, the dominant approaches are cognitive and reflexive. (p. 12)

Discussion of issues provides opportunity for students to understand and arrive at a decision on a problem or issue. Such articulation and argument of ideas is the aim of science education as it encourages reflection on citizenship and civic responsibility.

Osborne, Eduran and Simon (2004), for example, introduce the idea that “learning to think is learning to argue” (p. 998). These researchers explain how Toulmin’s argumentation pattern represents the rhetorical elements of argumentation and its use can therefore encourage thinking about issues in a systematic way. This is one way of understanding the logical reasoning current. Osborne, Eduran and Simon (2004) describe Toulmin’s argumentation patterns as:

… the essential elements of argument are claims, data, warrants, and backings. At the base of all arguments is a claim—essentially an unwarranted assertion that a proposer believes has the status of a universal truth. Arguments, however, normally rely on evidence or justifications that consist of data related to the claim by a warrant. Warrants, in turn, may be dependent on a set of underlying theoretical presumptions or backings, which are often implicit. (p. 998)
This model of argumentation is suggested as a guide for helping students develop higher order argumentation and reasoning skills. The model identifies a series of steps that begins with observations or data related to the claim with support that arrives to a conclusion. Teaching strategies that scaffold argumentation steps during class discussions seem to support students in developing reasoning skills (Pedretti & Nazir, 2011). Similarly, Simon and Richardson (2009) identify lessons with structures that support higher order reasoning:

…this structure offers more opportunities for students to compare ideas with each other, counter-argue, and reflect on and improve their own reasoning. It is therefore more likely to help students develop higher-order argumentation skills such as evaluation, counterargument and reflection. (p. 45)

As a result of structured lessons for argumentation, students may begin to reflect, evaluate, and prepare for counter argumentation in a face-to-face in-class activity or in an online computer-supported context.

As described earlier, the logical reasoning current has an important place in this dissertation study. STSE-issues based discussions require students to be competent in cognitive tasks which involve critical thinking skills (Pedretti & Nazir, 2011) and a computer-mediated online approach may be one means to support the development of these needed cognitive skills.

Researchers such as Garrison, Anderson and Archer (2000), underline this emphasis on the value of the cognitive task and identify it as Cognitive Presence in their paper on ‘text-based environment and computer conferencing in higher education’:

This term [cognitive presence] here is taken to mean the extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication. Although this is far from unproblematic even in traditional face-to-face educational settings, it is particularly worthy of attention when the medium of communication changes, as in the adoption of CMC for educational purposes. Cognitive presence is a vital element in critical thinking, a process and outcome that is frequently presented as the ostensible goal of all higher education. (p. 89)
A number of researchers accept the phrase ‘cognitive presence’ to encompass critical analysis, reflection and discourse in order to construct personal meaning through sustained communication and collaboration (De Leng et al., 2009; Ennis, 2008, 1991; Garrison, Anderson & Archer, 2001; Schrire; 2006). In my thesis, this current of logical reasoning is particularly suited for inclusion in computer-mediated STSE-issue based discussions and provides an opportunity for science students to be cognitively involved in socially-related science discussions. The next section will introduce issue-based education in science programs.

2.3 Issues-based Science Education

Issues-based education in science is an active approach in science learning where science content is situated within a social context which motivates and initiates ownership of learning (Bodzin & Mamlok, 2000; Klosterman & Sadler, 2010; Nunongchalom, 2010; Pedretti, 1999; Sadler, Barab & Scott, 2007). It differs from STSE education in that issue-based education is the larger umbrella (Penick, 1989) under which STSE can be considered as one sub-section. Penick (1989) maintains that “teaching must go beyond mere content to emphasize observing, problem identification, creativity, and use of community resources. Students will thus apply their knowledge, learning more as they go” (p. 2) In Penick’s explanation, therefore, issue-based education is not limited to STSE-based issues, but encompasses a wider variety of issues in society where students can engage in classroom discussions.

Researchers have identified that science in a social context engages students to deliberately use scientific ideas to engage in dialogue and discussions (Klosterman & Sadler, 2010; Nunongchalom, 2010; Sadler, 2009; Zeidler & Keefer, 2003). The added element of the controversial nature of issues requires some additional effort of reasoning and often surfaces the evaluation of social and ethical concerns in arriving at a resolution of socially-embedded science
issues. The intent is for students to develop meaning while engaging in issues that matter to them. Issues-based science requires students to search for evidence and provides a context for understanding scientific information. Nuangchaler (2010) adds:

Students do not just learn about science or complete science activities; they become more broadly enculturated into science and come to appropriate scientific practices. While scientific practice include conceptual understanding and skills, commonly promoted in science. Exploring scientific controversies is one pedagogical approach that allows students to critically evaluate and debate competing scientific claims. (p. 36)

Critically examining and evaluating claims in issues-based science allows students to develop the ability to extract information and make connections to science in a social context. Zeilder and colleagues (2011) add that changes in learners’ views are supported by “argumentation and debates [that which] are necessary elements in socioscientific issues-centered classroom” (p. 277). Indeed, debates and discussion, in the context of doing STSE in science, are instrumental in allowing students to formulate their own personal understanding and informed opinions about controversial issues.

The extension of reasoning and problem solving skills learned in school, particularly in a science class that uses STSE issues, become applicable in everyday work places. Greenwood (2000) identified in nursing practice that critical thinking skills in the workplace are required to deal with problematic situations in hospitals beyond everyday patient care situations. With this example, Aikenhead (2005) addresses nurses’ knowledge-use as:

…it would be helpful to know what conceptual content in physics has a role in everyday nursing, given the abundance of measuring instruments and physical procedures utilized by nurses. It would also be helpful to the nursing profession to know if there is a common core of concepts of evidence used by nurses as they engage in critical thinking [and] problem solving. (p. 244)

Aikenhead adds that critical thinking in life-threatening situations in hospitals provide a real life context to solve problems. Such problem-solving skills in conjunction with critical thinking
activity can be enhanced by science education that prepares people for the workplace (Nuangchalerm, 2010). Researchers refer to science classrooms as places where socially-related issues can be posed as model activities for students but may face “challenges in scientific knowledge, technological creativity, environmental situation, and social concerns” (Nuangchalerm, 2010, p. 36; Zeidler et al., 2011). When novel pedagogy (such as issues-based science with controversy) is introduced, experienced teachers and students become resistant to the comfortable and known teaching and learning expectations and strategies in their class (Zeidler et al., 2011). Hence, the dynamics of issues-based education in science is likely to challenge traditional science classroom norms and practices. In this case of using STSE issues specifically in the classroom, teachers not only challenge traditional norms, but also help students to understand the real-life application of science to their own lives and to their social world. This adoption of STSE-based issues in the classroom is not without its challenges. In the next section, I will discuss some of the challenges of bringing STSE-based issues in secondary science education.

2.4 Implementation Challenges of STSE in Secondary Science Classrooms

This section of the literature review is concerned with addressing the challenges of implementing STSE-based discussions at the secondary level. Teachers at the secondary level face a number of challenges in using STSE issues in their science classrooms. The first and second challenge resides with teachers’ understanding and implementation of issues-based science education. Teachers’ resistance to issues-based science education encompasses both their comfort level with STSE topics and their lack of understanding of what constitutes STSE-based science pedagogy. The third challenge is concerned with ideological differences about what constitutes an STSE-based issue, as well as teachers’ and students’ perceptions of STSE-based
issues as “soft science” instead of “hard science” (these terms are later explored in detail). In
general, the barriers to STSE education are pedagogic (e.g., pure vs. diluted science concepts,
overloaded curriculum), systemic (e.g., large class size), and philosophical in nature (that is,
teachers’ belief constraints or variations in ideological orientations) (Hodson & Bencze, 1998;
Mansour, 2007; Pedretti & Little, 2008). The fourth challenge concerns student attitudes, values
and understanding of STSE-based issues in science courses particularly student perceptions
about STSE education and their motivation to engage in learning science with issues-based
science education. Finally, there are systemic challenges that include an already over-loaded
curriculum and time restraints. Each of these STSE education constraints is discussed further in
the next pages.

There are numerous opportunities to utilize socially-related scientific issues in science
teaching, yet STSE-issue based topics seem to be scarce in science classes because teachers are
often uncomfortable introducing controversial and debatable social issues rooted in science
areas. Teachers and students are often resistant to an issue-based education within conventional
science pedagogy (Hughes, 2000) because STSE-based issues require knowledge beyond the
science content base. For example, if a teacher wanted to explore genetically modified corn from
an STSE-based point of view, he/she would not only be teaching the scientific knowledge behind
gene manipulation in food products, but would also have to consider the impact on health,
environmental, and social-economic issues, for which he/she may not have adequate training or
comfort level to do so. In other words, teaching STSE-based issues requires adopting an
interdisciplinary perspective to teaching science, where the overlap between scientific concepts
and society is acknowledged and explored.
Since the introduction of STSE-based issues in the Ontario science curriculum in 2000, STSE-based issues have become a popular label for certain activities in school science, however these activities have been found to often lack a meaningful connection to those social issues within the actual context of learning science concepts (Sadler, 2009; Zeidler, Applebaum & Sadler, 2011). For example, informal discussions of global warming or genetically modified foods or solar panels for the third world countries are often only presented as independent research projects, with no plan for action afterwards. They may be presented as broad topics, and the specifics of how they are relevant to students’ lives are often not explored. As such, these activities lack the necessary depth of investigation of a social issue meaningfully rooted in science concepts. In-class activities that are labeled as STSE-based have been used ineffectively by both teachers and students who lack the skills to engage with such controversial issues (Hughes, 2000; Pedretti et al., 2011, Sadler, 2009). From the results of such critiques (Sadler, 2009; Zeidler et al., 2005), it appears that STSE-based activities have become widely used but their socioscientific meaning has often become diffused into simple science activities that merely address issues superficially.

Teaching STSE-based issues within science courses is also neglected due to the large corpus of traditional content knowledge that teachers that need to understand and be confident about addressing in science courses (Aikenhead, 1994; Hodson & Bencze, 1998; Mrazek, 2004; Pedretti, Bencze, Hewitt, Romkey & Jiwani, 2008b). The fear of diluting the abstract body of scientific knowledge contributes to science teachers’ reluctance to incorporate socioscientific issues into their classes. Hughes (2000) suggests that teachers become apprehensive when there is extensive coverage of social scientific issues which they fear may devalue the pure science content within the science curriculum. Hughes adds: … the abstract scientific “body of
knowledge’ is associated with able students and by implication the socioscientific with less academic students” (p. 436).

Among science teachers, the value of abstract scientific knowledge is privileged and seems to be associated with academically-able or high performing students. Meanwhile the perception of socioscientific topics as diluting science content is associated with less academically-able students. By contrast, Aikenhead (1994) claims that in STSE-based education, science content is not watered down but is embedded in a meaningful context which actually enriches student learning. The potential enrichment of science knowledge with the STSE education occurs through the encouragement of healthy debates that raise questions about the production and ownership of knowledge (Hughes, 2000). With healthy debates, teachers’ fears of diluting science may be potentially diminished when science is shown to intertwine with the values of the social world (Kolsto, 2001; Pedretti et al., 2008; Sadler, 2004; Zeidler et al., 2005; Zeidler et al., 2009).

Nevertheless, incorporating socioscientific issues conveys the perception of science as “soft science”, while science without the social issues is often seen as “hard abstract science” (Hughes, 2000). Simms (2011) further defines the dichotomous views of science as:

Broadly, the hard sciences are concerned with physical entities while the soft sciences are concerned with living entities. The identification and measures of their subjects and the phenomena that influence these subjects typify the extant hard (natural) sciences, such as physics and chemistry. Inexact identification and measures of their subjects and the phenomena that influence these subjects typify the extant soft sciences, such as life and society. The ubiquitous phenomena of gravity and energy have been identified, described and measured in physics. In the soft sciences, the ubiquitous causes of living entities’ behaviour have not been adequately identified, described and measured. (p. 40)

This perception of “hard science” often remains unchallenged, thereby creating barriers to students’ opportunity to debate, analyse, reflect and make new decisions in new situations where socially-related issues in science are considered (Simms, 2011).
The notion of science as an abstract subject with a discrete knowledge base is implicit to students (Hughes 2000), while the idea of science as tentative and debatable is less understood because it is less practiced in the classroom. As such, introducing STSE-based issues in the science classroom can be a challenge for teachers when students have a certain fixed perception of what science is, and why science and social science are two different subjects and not an integrated course in school. However, if ideas in science are presented as disputable and tentative knowledge, then students’ interpretation of ideas can become a valid form of learning (Osborne, et al., 2004; Kolsto, 2001; Sadler & Fowler, 2006). When learners perceive science as disputable and debatable, then the teacher’s task of STSE implementation becomes easier. When teachers provide opportunities for the class to view and understand different students’ beliefs and opinions, students’ learning becomes less of a barrier especially in locating everyday science in STSE issues (Hughes, 2000). By highlighting social issues, learners connect with classroom science concepts (Zeidler & Sadler, 2008). However, because of the departure from traditional views of the nature of scientific knowledge, these classroom discussion opportunities to develop argumentation skills and to critically analyze issues through reflections and collaborations are often lacking in the science classroom.

Ideological differences that students hold about the value of discussing STSE-based issues in the classroom can also be a challenge to the teacher who wishes to implement STSE topics. STSE based-issues dealing with water, agriculture and global warming may seem inspiring to some students, particularly those who live in non-urban centres. Other students may question the value of introducing social issues in the science classroom and may want to focus exclusively on “hard” science concepts. Conversely, “soft” science includes STSE based issues that includes socially controversial topics such as “Embryo selection for tissues typing”.
Levinson (2006) adds other causes to the list of reasons why socioscientific issues are challenging: “lack of interest, lack of understanding why the issue is deemed to be important, and irrelevance of the school context to the issue in the outside world”.

In my own teaching experience with socially-related science topics, I have encountered such a challenge. In a grade 12 biology project where students designed water pollution and stream studies called ‘Measuring River Pollutions’, students took on the role of ‘researchers’ and used macroinvertebrates (aquatic larvae and insects in the stream bottoms) as indicators to assess the ecological health of the Don River – a large river in Ontario (Ayyavoo, 2004). Despite the fact that this project invited students to apply their knowledge of the physical environment to the social context of their community, I encountered and answered students’ typical question about the relevance of this activity to the science curriculum, namely, ‘Why should we care about social issues in science courses?’ This question came up despite the fact that the Ontario curriculum clearly states that the overall expectation in each content strand in the grade 12 university biology course should, “focus on relating science to technology, society, and the environment (STSE)” (Ontario Science Curriculum, 2008; 2000). While it could be argued that students are unaware of what is in the science curriculum at the ministry level, this example points to the larger issue which is that students struggle with making connections between science concepts and their own lives. This underlines an ideological difference between course expectations and students’ understanding of the value of applying STSE-issues in their classroom activities.

Garrison and colleagues (2000) suggest, in contrast to these students beliefs, students can derive meaning and value from discussing social concerns, particularly when these issues are connected to their experiences. Zeidler and Sadler (2008) agree that students’ epistemological
beliefs may change when they see the value of science in making decisions. For example, students may consider the implications in such things as the increased trend of obesity in the West, sexual controversies such as same sex marriages and sexual orientations, and issues around the mandating of ‘Gardasil’ inoculations to prevent cervical cancer in teenage girls. As examples of STSE issues, these social dilemmas are often avoided in science classroom content issues that might in fact provide opportunities for democratic dialogue.

Many educational researchers endorse the application of socioscientific issues as a way of providing context to examine science connections to students’ lives and to the society broadly (Driver, Newton & Osborne, 2000; Mueller & Zeidler, 2010; Sadler, 2004; Yager, 2007; Zeidler et al., 2009; Zeidler, Sadler, Simmons & Howes, 2005). New scientific issues, for example those related to genetically modified foods, may result in the introduction of new content in biology courses. The process of using genetically engineered molecules that include human genes injected into bacteria in order to harvest insulin protein or other pharmaceutical products may yield unforeseeable problems. These newly discovered biotechnological concepts in sciences, such as genetically engineered molecules with human hormones or genetically modified crops that are pest resistant, may have immediate benefits on the crops, but have delayed effects on health and associated environmental matters requiring socially responsible steps to be taken. Thus, understanding genetic manipulation in commercial food products introduces students to current social problems.

By participating in discussions about these controversial issues, students may become increasingly informed and ultimately be involved in responsible decision-making about the products they purchase and consume (Albe, 2008; Mueller & Zeidler, 2010; Sadler, 2006, 2004). Social and cultural issues provide opportunities for students to put on their ‘thinking caps’ as
they connect the science concepts from their textbooks to issues in their own lives and in the broader culture as they attempt to better understand socioscientific matters.

Issues-based class discussions are also not without systemic challenges for teachers. Having large class sizes, over-crowded curriculum and managing new curriculum content are some of the challenges faced by teachers in high school classes who desire a discursive science class (Hughes, 2000). Large class sizes minimize the opportunities for students to voice their opinions and views. In such large classes, there is less opportunity for all students to communicate their views even when the teacher facilitates and encourages students to participate in discussion (Levinson, 2006). Discussions that focus on a sensitive issue for some students in terms of religion such as the evolution-creationism debate (Levinson, 2006) in biology may be too controversial or be so absorbing that they end up impinging on curriculum time.

The comfort level of teachers in addressing controversial social issues rooted in science also needs to be considered. Indeed, the definition of STSE is not fixed, but flexible and dynamic and while this provides a great freedom in interpretation and exploration, it also means there is a lack of clarity in teachers’ minds of what constitutes an STSE-based issue in science. Consequently, STSE-based issues can be often neglected or marginalized in science classrooms (Hughes, 2000, Mrazek, 2004). Therefore when a teacher decides to present these issues, he/she may be met with resistance from students who perceive science courses to be about accumulating a body of knowledge. Finally, systematic challenges connected to curriculum delivery, pacing of courses to complete the curriculum materials, and class sizes (which impact participation), can contribute to the difficulties teachers face when addressing STSE-based issues in class. Understanding what these challenges are may prove helpful in explaining the different opinions that teachers and students have about STSE-issues discussed in schools.
2.5 Benefits of In-Class STSE Science Education: Developing Reflective Thinking Skills

The potential value of discussing STSE issues in the science classroom and the connection with rich context for exploring sciences to develop cognitive skills cannot be underestimated. Yager points out that science courses typically concentrate on developing knowledge in terms of learning new concepts, and have little room for creativity in thinking and challenging points of view and/or debating (Yager, 2007). The incorporation of STSE issues in the science classroom allows for the application of science concepts in examining real-world issues, and this in turn allows for the development of cognitive skills. Zeidler and Keefer (2003) and Abd-el-Khalid (2003) agree that socially-based issues in science engage students and encourage moral and ethical considerations while promoting holistic development of learners including cognitive levels. Yager (2007) highlights the importance of cognitive development via creative thinking skills suggest that “if students can apply and use the concepts and skills on their own in new contexts, this is real evidence of learning” (p. 387).

Indeed, the Ministry of Education in Ontario recognizes the importance of STSE issues in the science curriculum because it has added STSE as an overall expectation of every strand of the science curriculum. An examination of the science curriculum, for example, reveals the importance of STSE in the curriculum for the development of cognitive skills by making it the first overall expectation in each strand. The Ministry of Education guidelines state:

The first overall expectation in each content strand focuses on relating science to technology, society, and the environment (STSE). These expectations and their related clusters of specific expectations are positioned at the beginning of the strands to better align the curriculum with the optimal approach to teaching and learning science, and to emphasize the importance of scientific, technological, and environmental literacy for all students. The STSE expectations provide the context for developing the related skills and conceptual knowledge necessary for making connections between scientific, technological, social, and environmental issues. The STSE expectations often focus on aspects of environmental education. (Ontario Science Curriculum, 2008, p. 8)
The Ministry expectations make it clear that the STSE issues provide the context for developing the related skills in science, and as such this potentially ensures that students make connections between science and the real world. This leap from concept to connection is what Yager (2007) identifies as being evidence of real learning. Similarly, Abd-el-Khalid (2003) addresses the real world events as valuable and relevant learning situations in science:

By bringing socioscientific issues into the science classroom, science educators hope to engage learners in the sort of “real world” problem-solving in which scientific knowledge and ways of thinking are brought to bear on discussing, and making decisions regarding, issues that are immediately relevant to students’ lives. (p. 43)

Yager (2007) claimed that, “If students can apply and use the concepts and skills on their own in new contexts, this is real evidence of learning” (p. 387). Contextual factors linked to learning scientific concepts promote learning of independent scientific concepts. Zeidler and colleagues (2011) emphasize that social issues used as a context becomes personally relevant and accessible to the student. Further, social issues employed in science also encourage understanding of principle concepts as a group of learners in a class which, according to Klosterman and Sadler (2010), ultimately promotes informed citizenship.

Integrating STSE issues in the science classroom results in students asking more questions which in turn suggests that students are developing their cognitive thinking skills. In classrooms that employ STSE issues as teaching strategies, students ask questions, arrive at decisions, and make evaluations. Cognitive activities that address social, economic and environmental elements go beyond acquiring information (Teed, Zandvilet & Ormond, 2011) which is identified as lower order thinking but these other activities (according to Newmann, 1990) can be considered as higher order thinking activities:

Lower order thinking demands only routine, mechanistic application of previously acquired knowledge; for example, repetitive exercises such as listing information
previously memorized, inserting numbers into previously learned formulae, or applying the rules for footnote format in a research paper. In contrast, higher order thinking challenges the student to interpret, analyse, or manipulate information, because a question to be answered or a problem to be solved cannot be resolved through the routine application of previously learned knowledge. (Newmann, 1990, p. 44)

Higher level thinking using socially-related issues in science classroom can further develop cognitive thinking skills (Yager, 2007). For example, in his Iowa study he compared the traditional classroom with the classroom that employed STSE issues and found that the STSE classroom is dominated by student questions, including higher-level questions. The fact that students are asking higher level questions and are outnumbering their teacher in the number of questions they are asking demonstrates that the discussion of STSE issues excites students, makes them curious, and thus promotes the development of their cognitive skills because they continually seek to learn more. Yager’s comparison between the traditional classroom and the classroom that uses STS is detailed as follows, “traditional classes resulted in practically no student questions; in contrast, STS classrooms were characterized as being structured by student questions. Furthermore, student questions outnumbered teacher questions. Student questions in the STS classrooms were ‘higher level ones’ ” (Yager, 2007, p. 388) and students in socioscientific discursive learning approaches develop positive attitudes and creative thinking skills in addition to other cognitive skills.

When students critically analyze and decide on their views to ascertain a goal, it appears that they are grappling for reasonable arguments, and as such are developing their cognitive thinking skills. Smith (2003) elaborates further that thinking is a mental exercise that utilises one’s knowledge and intellectual capacity to arrive at a certain goal. A good thinking process, supported by knowledge and experience is continually re-enacted across different facets of students’ personal lives, from selecting movies to watch, to buying their favourite music CDs.
and to selecting fashionable clothing for certain occasions. Similarly, when students grapple with different perspectives in science in order to create an argument, discursive lesson scenarios present opportunities for them to be challenged to articulate, clarify their arguments and hence develop critical thinking skills (Huitt, 1998; Furberg et al., 2008).

Higher level thinking questions, which are the result of STSE discussions, reveal the development of critical thinking skills. According to Ennis (2008), the everyday usage of the term ‘critical thinking’ refers to the process of identifying “the truth or the most reasonable approximation of the truth” (p. 4). Students exposed to thoughtful situations, where there are effective persuasion and resolution of disputes, learn to think critically. De Leng and colleagues (2009) argue that such controversial lessons in science enable students to reflect and analyze issues and to arrive at understanding of situations.

Several researchers insist that it is important for students to participate in discussions in their science classes as this supports them in developing moral and ethical judgments (see for example, Sadler & Zeidler, 2003, Sadler, 2004; Walker and Zeidler, 2007; Zeidler, Osborne, Erduran, Simon, Monk, 2003). These researchers have reviewed the connection between teaching reflective, critical thinking skills and addressing social issues in science courses. Sadler (2004) emphasizes that socially and politically invested participants employ technology and science to understand the mechanism of the Nature of Science. Sadler (2004) presents the components of Nature of Science to include “the efficiency of data and its analysis, the evolutionary and revolutionary nature of scientific epistemology and the social embeddedness of scientific progress” (p. 41). The implication is that, when students are exposed to STSE issues in science, they may engage skills such as reflection, reasoning, discourse and argumentation using evidence during their face-to-face interactions. Walker and Zeidler (2007) show that
socioscientific issues in science courses do promote discourse and enable students to examine, recognize and reflect on scientific literacy in their lives.

The use of STSE issues in the classroom encourages students to think about science as a multidisciplinary field, and not simply a concept-based area of study. For example, in my grade 11 chemistry class, students started to investigate the effects of everyday tea drinking, which this led them to explore the presence of leucocyte cells (white blood cells) in urine samples, which in turn led to an investigative project looking at the connection between white blood cell production and the body’s immune system. The students in this group have continued in their exploration of this issue, and are now starting to think about what the social implications of their findings could be. This in turn has led students to consider the health implications of the social activity of tea drinking. This shows how unknown events and situations may invite inquisitive students to ask penetrating questions to uncover weakness and doubts. In the example of my students, the questions and doubts their project is uncovering concern whether green tea does really have an effect on leucocyte cell (white blood cells) production. It is the unrelenting thinker, such as the students in my example, who pursue to know biological facts of leucocytes who are most likely to make logical connections to other broad areas in society.

Indeed, according to Sadler (2004) and Zeidler and Sadler (2008), the reflective thinking process amalgamates the understanding and cultivation of reasoning skills in multidimensional contexts including moral and ethical dimensions. Sadler (2004) suggests that science concepts and ethical issues cannot be compartmentalized in society, but rather should be combined to deliver a well-informed and reasoned decision. Then, reflective thinking in socially-related science issues can become a purposeful and student-relevant activity that could relate to moral, ethical or other dimensions. Encouraging the reflective thinking-process may help students to
create meaning from their experiences while exploring new student-relevant socioscientific events with complex discussions. Bell and Linn (2000) have identified that more complicated issues involve more complex arguments that utilize more evidence and thus warrants increasing time needed to think about social issues within the realm of science. Unfortunately, recent research shows that complex rigorous thinking skills are deficient among high school and college graduates entering society’s workforce (Casner-Lotto & Barrington, 2006). Gambrell (2004) and Larson with Murray (2008) also highlight the need to further develop thinking skill acquisition in high school. Thus this dissertation focuses on finding ways to increase reflective thinking processes in high school science, in part by using an online discussion forum as a medium to promote critical thinking skills.

Explanation and self-regulation are core components of the reflective thinking process. Explanation is defined as providing a holistic picture of thinking that involves evidence, concepts, criteria and context to build reasons for an argument. The data, claims, warrants and evidences of the arguments are re-examined and double-checked through self-regulation processes (Facione, 2010; Simon & Johnson, 2008). Facione describes this concept of ‘self-regulation’ as the monitoring of the cognitive skills used in validating and correcting the proposed results. Self-regulation also describes knowledge about one’s thinking that involves monitoring and control of one’s cognition (Flavell, 1979), or metacognition, which is crucial in examining controversial events in STSE issues. Re-evaluating possible views helps students develop critical thinking and allows students to explore STSE topics from a multitude of viewpoints. The metacognitive processes of explanation and self-regulation potentially can increase student sensitivity towards possible influences of societal views. In this context, peer
contributions reflect socio-cognitive processes and group discussions create a sense of belonging as a locus that can support meaning creation (Norman & Garrison, 2005).

By using critical reflective thinking skills through STSE-based activities, higher-order cognitive actions involving argumentation and discursive practices in group settings can potentially be fostered. Geerstein (2003) defines higher-order thinking as going beyond everyday thoughts by employing critical and reflective thinking that exemplifies a more disciplined and systematic approach to problem solution. The systematic approach to gathering information through various forms of direct and indirect observations is a central tenet of the National Science Teachers’ Association (NSTA) position about the nature of science (NSTA, 2000).

One key premise required to understand the nature of science is that scientific knowledge can change with new research: “Scientific knowledge is simultaneously reliable and tentative. Having confidence in scientific knowledge is reasonable while realizing that such knowledge may be abandoned or modified in light of new evidence or reconceptualization of prior evidence and knowledge” (NSTA, 2000). Newmann (1990) adds that awareness of the changing ‘nature of science’ facilitates higher-order thinking when learners interpret, analyze and re-examine (or experiment) to resolve and arrive at consensus in relation to socially-related issues. Other researchers support the notion that there is no single answer where STSE issues are concerned but rather that using STSE-based issues allows a broader discourse using a distinct way of thinking reflected through reasoning (Reis & Galvao, 2004; Teed, Zandvliet & Ormond, 2011). Hence, a wide range of social-political-cultural-economic issues emerging from any subject specific science domains shapes good reflective thinking.
With the need to further stimulate students’ cognitive skills, we now look at the research on using online discussions by secondary physics students to critically think and analyze STSE-based issues in the Ontario science curriculum.

2.6 STSE Education in Ontario Context

This section explores how STSE education is situated in the Ontario science curriculum enhancing critical thinking skills. Situating STSE education in science as a way to develop reflective thinking skills is reflected in the revised Ontario science curriculum (2008) as one of the major goals of science education. According to this (2008) document, one of the roles of the science teacher is to:

… provide numerous hands-on opportunities for students to develop and refine their Investigation skills, including their problem-solving skills, critical and creative thinking skills, and communication skills, while discovering fundamental concepts through inquiry, exploration, observation, and research. The activities offered should enable students to relate and apply these concepts to the social, environmental, and economic conditions and concerns of the world in which they live. Opportunities to relate knowledge and skills to these wider contexts will motivate students to learn in a meaningful way and to become lifelong learners. (p. 9)

Providing opportunities for students to solve problems through critical reflective thinking process is an area that is often considered by educators. In light of increasing opportunities for students to reflect and think on social issues in science, the Ministry of Education has broadened the content in the Ontario science curriculum (2008) to include socially-related issues including environment and economics in science and these issues are also being included in the curriculum for the e-learning platform (Ontario’s E-Learning Strategy, 2006).

Between 2000 and 2008, the Ontario Ministry of Education (2007, 2008) increased the emphasis on STSE-based discussions in the science curriculum at both the elementary and secondary levels. The STSE emphasis indicates an increase in government support and policy for teachers to integrate socioscientific issues into their secondary science classrooms. Because
secondary students studying science are not gaining critical thinking and problem solving skills (Sendag & Odabas, 2009) one intervention to correct this imbalance is the implementation of STSE issue-based topics in science education.

Several researchers (Develaki, 2008; Zeidler et al., 2005) suggest that students’ critical analytical skills can be developed through the use of social dilemmas related to science. Identifying the need to nurture social consciousness in students’ lives, both Kolstø (2001) and Zeidler (2009) and her colleagues suggest an intensive intervention to boost critical thinking skills in sciences. In Ontario, the Ministry of Education’s emphasis on STSE education provides an effective avenue to nurture critical thinking. In the earlier 2000 science curriculum documents, the ministry had placed some emphasis on STSE by identifying it as one of three specific expectations rather than as part of the overall expectations. With the most recent recommendations, however, the Ministry of Education has further emphasized the importance of STSE issues in Ontario science education by adding three specifically STSE revised curriculum goals (Grade 9 to 12, Ontario Science Curriculum, 2008). The three goals of the science program for the Ontario Science Curriculum are (p. 4):

1. To relate science to technology, society and the environment,
2. To develop the skills, strategies, and habits of mind required for scientific inquiry,
3. To understand the basic concepts of science.

The aim is to establish a broader socio-political and economic context for students, in an age-appropriate way, to understand and learn to consider critically the role of science with STSE influences in their everyday life.

In this study, the aim is to show how cognitive presence can be enhanced through an online STSE-based discussion carried on in science courses. To reiterate, cognitive presence
describes students’ aptitude to critically analyze, reflect and discuss through collaboration and
discourse to develop meaning (see section 1.3). In an e-learning context, Garrison et al. (2003)
describe the potential for developing critical thinking as a vital part of the educational
experience. The challenge is to understand changes in the reflective thinking process developed
through meaning-construction after the community of learners engage in discourse and
reflection. Learners participating in a reflective process, through a blended approach, may be
engaging in critical, reflective thinking. Such reflective thinking is considered to be synonymous
with the skills of inquiry (Garrison et al., 2000; 2001; 2003). Garrison and colleagues’ (2000)
Practical Inquiry (P.I.) Model tries to capture the details of this process by linking higher-order
thinking with the different phases of inquiry skills. Accordingly, the higher-order thinking
mentioned in the P.I. Model includes reflection and discourse that displays creative, critical and
intuitive components.

2.7 Benefits of STSE Science Education Online: Developing Reflective Thinking

Recent investigations of the merits of online asynchronous discussions (De Leng et al.,
2009; Garrison et al., 2003; Schellens & Valcke, 2005, Williams & Lahman, 2011) indicate that
online discussion forums can promote active learning behaviours, self-reflection, authentic and
collaborative learning. Williams and Lahman (2011) also found that course instructors who use
online discussion in their teaching may, “encourage interaction and critical thinking” (p. 143).
These virtual online discussions may actively encourage reflective thinking skills (Garrison et
al., 2003). Garrison and colleagues (2003) claim that the use of computer-mediated tools may
motivate students to do research outside of class, as well as help them move towards asking more
complex questions and find solutions to the problems presented in the STSE-based issues raised
in their science classes. Similarly, other researchers (Arend, 2009; Garrison et al., 2003; Picolli,
Ahmad & Ives, 2001; Rau, Gao & Wu, 2008) agree that computer-mediated technology can support deeper thinking when used as a pedagogical tool. Hence, computer-mediated peer discussions may appeal to, and motivate 21st century learners, by providing them a familiar online venue which they already use in other aspects of their lives, in which to critically reflect on STSE-based issues.

Many higher educational institutes are adopting computer-mediated communication platforms to deliver blended and fully online courses (Arend, 2009; Garrison et al., 2003; Luppicini, 2002) as these courses provide greater flexibility to students and teachers. Computer-mediated technology as a pedagogical tool provides two important features to educational programs: availability (any place) and accessibility (any time) through text-based discussions (elaborated later in the section on text-based online communication). This ‘time and place’ flexibility, noted by several researchers, potentially permits learners who have family and work commitments to participate in higher education, an option that might otherwise be inaccessible to them (Brett, 2004; Brett & Nagra, 2005; Garrison et al., 2000; 2001; Hewitt, 2001; Rovai, 2003; Wishart et al., 2011). Similarly, accessibility to learning in high schools via computer-mediated learning is also gaining momentum in North America (Horn & Staker, 2011; Natale, 2011).

In Ontario, Canada, online learning is also becoming more prevalent in secondary school systems in both private and publically funded schools. Bennett (2012), for example, identifies in his study the growing number of private schools that offer virtual learning. For example, The Virtual High School (a privately funded high school in Ontario) website claims to offer an emphasis on collaboration tools (i.e. online learning platforms) and interactive exercises with a wide variety of assessments (Virtual High School, 2012). Students from the Virtual High School discuss virtual learning opportunities as allowing them to study at their own pace, improve their
text-based writing and as an alternative learning avenue that they enjoy (Virtual High school, 2012). Public schools in Ontario, such as the Independent Learning Centre, also operate virtual high school systems that allow students from any school to obtain credits online, even if their school does not offer those particular credits. This can be particularly useful to students in rural areas who may have more restricted subject choices within their schools.

Prior research indicates an increase in computer-mediated discourse in which online discussions are encouraging students to voice and engage in dialogue (Brett, 2004; Fauske & Wade, 2003; Gambrell, 2004; Hewitt, 2003; Rovai, 2003). Because of the reflective opportunities afforded by such discourse rich online environments, they may also offer a productive location in which to situate discursive STSE-based issues in science education. The challenge is to align the powerful peer interactions within online environments demonstrated at the higher educational level within the context of high school science and specifically to support deeper learning through dialogue over STSE-based issues.

The following sub-section will specifically address how a greater dialogue of STSE-based issues can be supported through written, text-based online communication. This section will also highlight some of the challenges of using text-based online communication to learn about STSE-based issues.

2.7.1 Advantages and challenges of text-based online communication. Before proceeding to online STSE text-based discourse, both advantages and challenges of computer-mediated communication need to be examined. Internet-based communication can facilitate learners to conduct research, obtain sources of information and communicate with online users. Communicating ideas and opinions online can occur through a variety of means, including email, blog, chat rooms and forum discussions. These computer-mediated communications are
available as either synchronous or asynchronous communications. Synchronous refers to communication where individuals interact in real time whereas asynchronous communication involves a delayed response as in the use of emails or discussion environments (Arend, 2009; Gaimeter, 2008; Garrison et al., 2003; Hewitt, 2001; Miller, 1999).

There are a number of benefits to synchronous text-based communication. Synchronous text-based communication exercise involves simultaneous posting of messages or responses as parallel communication. Researchers describe that such text-based communication provides synergy that enables simultaneous and collaborative learning in the online course (Lobel, Neubauer & Swedburg, 2002). Other benefits of synchronous discussions include providing immediate feedback, encouraging others to exchange their perspectives and strengthening social interactions (Park & Bonk, 2007; Schrire, 2006). Park and Bonk’s research (2007) indicates the stimulation of meaningful interactions particularly via fast feedback, social encouragements and the rich verbal elements can exist in synchronous discussions. Except for the immediate feedback, similar rich text-based elements of synchronous discussions can also be paralleled in asynchronous communications. Park and Bonk found that, in asynchronous online interactions among students and teachers, rich conversational elements and interactions were also observed in the online asynchronous discussions.

Beyond the rich interactive communication, one major advantage of asynchronous text-based communication is that it allows for an intentional time delay in responding to topics or discussions where simultaneous locale and time are not crucial. The time-locale boundaries in Luppicini’s (2002) research highlight an increase in online collaboration not seen in synchronous interactions. Another advantage that both Arend (2009) and Miller (1999) identify is that asynchronous text-based interactions provide a deeper level of thought without the on-the-spot
pressure of synchronous answers. That delayed response enables discussions to be evaluated and renders time to think, reflect and search for extended answers and extra information about the issues before contributing to the discussions (De Wever, Schellens, Valcke & Van Keer, 2006). The fact that these communicative elements in discussions are explicit through written messages enables the process of collaboration to be more transparent. According to Hewitt and Scardamalia (1998), ‘time to reflect’ situations provide a greater opportunity for students to clarify and refine ideas in their text-based communications. The availability of time to write their text–based messages has resulted in a higher degree of participant reflection identified by Luppicini (2002) particularly through delayed response via asynchronous communication. The gift of time and flexibility of delayed communication (possibly with increased reflection time), allow for a greater number of communicative exchanges than in in-class discussions or synchronous interactions.

However, one drawback of asynchronous discussion is the requirement for participants to be disciplined and to regularly login and participate in the online discussions. For online learners, it may also take longer to write a response after reflecting and considering numerous peer responses to read and share comments. A powerful solution to the difficulty of multiple responses in the asynchronous environment is the use of threaded discussion (Arend, 2009; Derier, 1999; Dringus & Ellis, 2004; Hewitt, 2001; Kear, 2001; Meyer, 2003), although, threaded discussions produce problems of their own particularly in terms of allowing progressive discourse to develop (Hewitt, 2001). The next section will explore the challenges and benefits of threaded discussions.
2.7.2 Threaded discussions in asynchronous communication. Threaded discussions in asynchronous communications are often used in higher education (De Leng et al., 2009; Garrison et al., 2003; Schellens & Valcke, 2005; Schrire, 2004; Williams & Lahman, 2011), although newer systems currently in use by School Boards such as Ontario’s Desire 2 Learn also contains such functionality. Asynchronous discussions have two distinguishing features: one that the discussions do not occur simultaneously, rather learners post responses at their own convenience; second, conversations are conducted through written text-based comments (De Wever, B., Schellens, T., Valcke, M., & Van Keer, H., 2006; Miller, 1999; Schrire, 2004). These asynchronous discussion tools organize online conversations where participants post entries, and their peers reply to each other’s entries in a webpage called a forum.

The amount of messaging on the forum can be one indicator of engagement in social activity and the value students place on their peers’ postings (De Leng et al., 2009; Schrire, 2004). According to Dringus et al. (2004), threaded discussions are a mechanism for high level interaction where participants post entries, while peers and instructors have the opportunity to respond. These different levels of communication include student-to-student, student-to-teacher, and teacher-to-student interactions. Derier (1999) sees beyond the delayed response and visualizes this asynchronous response as an attribute for promotion of ‘interaction trajectories’ – defined as interactions that occur over a period of time. Macknight (2000) and Meyer (2003) believe threaded discussions are a promising method of encouraging critical thinking where more reflective learning can occur over time. The delayed interactions in the electronic environment can motivate students to develop deeper understanding of issues, in part, because they spend more time on crafting responses, thus spending more time on the material which in this case is
the socioscientific issues in science education. STSE issues seem to offer a fertile ground for such interactive reflective discussion and negotiating ideas especially with the extended time to develop deeper and more reflective thinking in this asynchronous environment. Furberg and Ludvigsen (2008) argue that time to reflect and negotiate issues leads to the construction of knowledge and that extended period of time is provided through web-based discussions.

The dynamic nature of online discussions does pose challenges in both higher education and secondary school education. For example, discussion threads are dependent on the content, and quality (including relevancy) of previous responses (Schellend, 2005), so if one student has not accurately labeled an issue, each subsequent student that may respond to her/his thread may continue that label. Kay (2006) notes in his study that the age of learners also needs to be considered in relation to the quality of ideas developed online. He states the following about his own online study of 13 to 15 year old students, “the level of knowledge and processing may be concentrated at the concrete operational stage (Piaget, 1954; 1974). In other words, some students may not have developed the ability to think at a metacognitive or abstract level (Kay, 2006). Schellend underlines Kay’s point in his own study where he further notes that, if students lack content knowledge, then they will be challenged in learning new materials via an online forum. In terms of the nature of threaded discussions, useless or irrelevant postings may interfere with the flow of ideas and thus disrupt the learning process. Schellend (2005) defines irrelevant postings as non-task-oriented messages that seem to be social in nature and deviate from the main theme being discussed.

Other issues pertaining to the use of technology-based discussions particularly in secondary schools is the fear of marginalizing those students who are already struggling in education due to economic, social, and cognitive limitations. These students may not have, for
example, access to technology, computer skills, good reading abilities, organizational skills, and abilities to follow deadlines or follow instructions online while simultaneously learning course content (Harrington, 2010). Some of these challenges can be addressed through the instructor’s awareness and proper guidance (Bouchat, 2007), and in the case of a blended or hybrid approach, the additional face–to-face interactions may alleviate some online drawbacks.

2.8 Blended Approach: Interactive Online and Offline Process

Researchers, such as, Bonk, Kim, and Zeng (2006), Brew (2008), and Garnham and Kaleta (2002) describe a hybrid course as one containing both the interactive online and face-to-face transactional processes within classrooms. Blended learning can enhance classroom learning while increasing opportunities for diversity of learning experiences for learners, including online discussions and computer-based instructions or technology-assisted learning objects (such as simulations, or designing storyboards). According to Rovai and Jordan (2004), a blended approach offers students flexibility and convenience where the online component becomes a natural component of the classroom learning. Face to face learning incorporating online asynchronous discussions offers a robust educational experience (Larson et al., 2008; Rovai & Jordan, 2004). Data from University of Central Florida shows that students in hybrid courses achieve better grades and have better course retention than face-to-face courses (Garnham et al., 2002). Another study conducted by Brew (2008) describes how instructors reflect and modify the course with feedback from students, while students find the access and interaction with their instructors helpful. The teacher-student interactions mentioned in these research studies, (Garnham et al., 2002; Larson et al., 2008) and in Brew’s (2008) with secondary teachers and students, also demonstrate the effectiveness of blended approaches in high school.
The effectiveness of a blended learning approach using the Internet is dependent on reasonable time commitments and convenience of access to computers for both teachers and students (Larson & Murray, 2008). When computer-mediated and face-to-face approaches are blended in an appropriate fashion, students demonstrate learning benefits. As Vaughan and Garrison (2005) note:

Blended learning designs reach beyond the benefits of convenience, access and efficiency. The true benefit of blended learning is in integrating face-to-face verbal and online text-based exchanges and matching each appropriate learning task. A high level of learning needs intelligent integration of both spontaneous and reflective communication [enhance by the blended approach]....There is every reason to believe that a blended learning design could be used to create cognitive presence and facilitate inquiry [while building a community of learners to extend in the exploration of ideas]. (p. 4)

There appear to be clear benefits to the blended approach, especially with the additional time beyond class period to enable reflective communication. Verkroost and colleagues (2008) suggest that, with science, technology and society-related issues, students need to be stimulated to ‘think outside the box’ with structured instructions. In the context of the virtual classroom, the roles of teacher and student are clearly defined. The teacher posts questions and problems, which the students discuss with their peers through online threaded discussions. In the context of these discussions, the teacher’s role becomes that of a facilitator, adding comments and probing with further questions where needed, thus supporting the student in developing her/his ideas. Blended learning courses can be a socially motivated activity (Park & Bonk, 2007). However, Vonderwell (2003) argues that developing the social interaction skills necessary to establish a sense of community in class first is vital to enabling students to open to each other and be able to participate in the kind of social interaction required for online learning success.

Achieving success in the blended approach particularly the online segment requires awareness of the value of collaborative meaning construction. To develop meaning from
socially-related science issues discussed through online environment needs time. The search for
time. The search for meaning is enhanced through making time available for peer collaboration online. In particular,
the virtual environment can provide a context for cognitive discourse or cognitive presence
achieved through peer collaboration. With regard to online student conferencing, Lee,
McLoughlin and Chan (2008,) discuss the online-mediated collaboration which they witnessed in
their study of undergraduate students:

Instead of using the technology to merely deliver content, the authors advocate greater
student control and ownership of the technology, and its use as a means for encouraging
collaboration. Podcasting also holds great potential for allowing students to articulate
their understanding of ideas and concepts, and to share the outcomes with an audience
they value, such as their peers as in the present study. Second, students may not always
realise that the actual processes of interactive dialogue and collective problem solving are
essential to knowledge creation, and may become overly focused on the technology—this
makes it important to scaffold cognitive behaviours and encourage collaborative
discourse by establishing a shared goal, highlighting the importance of sociocognitive
dynamics and emphasising the supportive role of information and communications
technology as a mediating artefact. Students need to become increasingly aware that
knowledge is not constituted simply by individual effort but collectively. (p. 518)

In this context of knowledge and meaning creation, student to student interactions may
need to be organized with structure or constraints for online discussions (Garrison & Cleveland-
Innes, 2005; Verkroost et al., 2008). One approach to creating such structure is manifested
through the Practical Inquiry Model (Garrison et al., 2003; Garrison et al., 2001). The P.I. Model
of cognitive presence set in an e-learning environment is used in this thesis as a framework to
help investigate science meaning construction.

In the section that follows, I will provide an overview of the main tenets of the
Community of Inquiry framework (Garrison et al., 2000) and will provide a detailed discussion
of the Practical Inquiry model (P.I.), which supports the development of cognitive presence. This
next section will describe the conceptual background of the Practical Inquiry Model and its
relation to the Community of Inquiry framework (Garrison et al., 2001).
2.8.1 **Community of Inquiry Model.** The Community of Inquiry (CoI) framework has become a prominent model of teaching and learning in an online environment (Akyol, Arbaugh, Cleveland-Innes, Garrison, Ice, Richardson, & Swan, 2009). The nature of the CoI framework is reflected in the interrelated and developmentally progressive nature of three presences, namely *Cognitive Presence, Social Presence* and *Teaching Presence* (Garrison et al., 2000; 2010). *Teaching Presence* defines the role of the educator in the classroom who provides the design and organization of the course, facilitates online class discussions, and provides instructions. *Social Presence* describes the degree to which the group (being students and teachers) feels socially and emotionally connected online. The emphasis with online social presence is on feeling group cohesion and a sense of community. Finally, Garrison et al.’s (2000; 2008; 2010) CoI model also includes a component called cognitive presence. *Cognitive Presence* conceptualizes how students use text-based communication to highlight a problem, discuss and debate ideas in relation to the problem, and work towards an understanding by challenging the ideas of their peers. After reacting to the ideas of their peers, students integrate their peers’ ideas with their own and arrive at a new resolution, which is based on the reflection and collaboration they did online.

These three main components provide a structure to understand the online learning environment, community and experience. According to Garrison and colleagues (2010), this framework suggests that social presence is the mediating variable between teaching presence and cognitive presence. Others researchers see teaching presence as the most significant mediating factor in creating and maintaining online social and cognitive presence (Garrison et al. 2010; De Leng et al., 2009; Schrire, 2005). Teaching presence is hypothesized to maintain the association
between teachers and the learners, through the course structure (e.g., design of the online
course), leadership (direction of the course) and coordination (facilitation of the course). The
teacher’s presence online helps to facilitate the course and through this facilitation can assist with
supporting higher-order thinking (Garrison et al., 2010; Meyer, 2003). Social presence is
hypothesised as important in helping learners view these online interactions through personal
characteristics projected into the community via the collaborative text-based interactions. In this
dissertation, the significance of the teacher’s role was to encourage STSE-based discourse by
supporting cognitive presence. Indeed, researchers such as, De Leng and colleagues (2009)
summarize that:

Garrison’s ‘Practical Inquiry’ model appears to be a viable instrument for procedural
facilitation of online discussions about basic science concepts among small groups of
students engaged in busy work placements at different training sites. An e-learning model
integrating this ‘Practical Inquiry’ model in concerted facilitation by a human moderator
and a program for asynchronous communication appeared to be successful in establishing
a dialogue among an expert and a group of students. The structure of the e-learning
model was useful in facilitating a sustained on-topic discourse involving critical thinking
in a group of peers. (p. 12)

The P.I. Model has been found to be relevant and suitable in analyzing the different cognitive
dimensions of knowledge construction during online discussions. Both this dissertation and
Akyol and colleagues (2009), focus particularly on the cognitive presence aspect of Garrison et
al.’s (2000) framework, as articulated through the Practical Inquiry (PI) Model which is a sub-
component of the larger CoI framework.
2.8.2 **Practical inquiry (P.I.) model.** The Practical Inquiry (P.I.) Model was used as a lens with which to better understand the online interactions in this study. Garrison and colleagues’ (2000) two dimensional Practical Inquiry (P.I.) Model shown in 2.1, is used as the core framework for this case study research. The first dimension has an action – deliberation continuum. This first axis is grounded in the pre- and post-reflective phase.

![The two dimensional Practical Inquiry Model](image)

*Figure 2.1 The two dimensional Practical Inquiry Model (adapted from Garrison, Anderson and Archer, 2000)*

For this study, the action- deliberation dimension reflects the critical thinking phase identified as cognitive presence (Garrison et al., 2000). The second dimension is between perception – conception where the transition is between the concrete and abstract world. This second axis includes the assimilation of information and the construction of meaning.

Together, the two dimensions constitute the shared (external) and personal (internal) world of learners (Garrison et al., 2000; 2003; 2004). The internal constructs identify reflection and monitoring while the external constructs are collaboration and discourse. Using internal
constructs, the purpose of my research is to observe STSE discussions that promote a variety of levels of cognitive interactions through a blended educational experience for both the in-class and e-learning context.

In a study done by Verkroost, Meijerink, Lintsen, and Veen (2008), the blended approach provided the opportunity to set up the context for students to produce a high level of content analysis, problem solution and a freedom to write responses in their own time. Hence, integrating e-learning with face-to-face learning may provide a variety of measures of pedagogical and technical components that supports the whole learning process.

2.8.3 P.I. Model: Cognitive reflective phases involve higher-order thinking.
Research by Garrison and Kanuka (2004) and Garrison et al. (2001) supports the finding that higher levels of learning can occur in text-based asynchronous communications. However, Gerbic (2010) also notes that text-based discussions require more effort in reading, thinking, and writing in order to produce better discussions. Producing good discussions from group problem solving problems is a goal-oriented activity that draws upon and integrates a range of higher-order thinking skills including idea generation, making interpretations, and judging and managing the problem (Kirkwood, 2000). Regardless of the nature of the communicative context, group problem solving involves identifying and building facts, evidence, events, ideas and concepts. With these cognitive features of communication identified in the first dimension of the P.I. Model, learners are expected to identify, construct and reconstruct, evaluate and confirm meaning cycles of discourse. Cognitive presence or critical thinking processes (concepts frequently recognized as synonyms among the text-based communications researchers e.g., De Leng et al., 2009, Garrison et al., 2003; Kakuna et al, 2007; Schrier, 2004) are identified through the Practical Inquiry cycle (see Figure 2.2).
The four interrelated phases of cognitive presence are: the Triggering event, Exploration, Integration and Resolution (Garrison et al., 2001; 2003). These four phases are discussed in greater detail within the P. I. Model below. However, recent researchers (De Leng et al., 2009; Schrier, 2004) have identified issues that students have in attaining the last two phases of cognitive presence which this dissertation will attempt to address.

**2.8.4 Four phases of the P.I. model.** The first phase of the P.I. Model of Cognitive Presence is called the ‘Triggering event’ found in the lower left quadrant of figure 2.2. In this initial stage, the teacher may construct an e-activity (online activity) such as an issue derived from students’ experiences, or one that may create a state of dissonance or simply an issue that has garnered much media attention. For example, an e-activity could include discussions on ‘designer babies’ or ‘cloning of pets’ as a futuristic reproductive technology of the future. The

![Practical Inquiry Cycle with four phases for cognitive presence](image-url)
The teacher can structure this stage to elicit students’ questions around the topic. The e-teacher’s role is to initiate the inquiry, frame the issue by eliciting questions, present the problems in the issue and evoke innovative ideas. One approach is to commence with a simple question, shown here as an example: *Today, couples are seeking to create designer babies by selecting a child’s gender and screening for genetic defects. Will these couples someday be able to decide and select ‘brains and beauty’ too?*

The second phase of the P.I. Model deals with ‘Exploration’ found on the upper left quadrant of figure 2.2. Garrison et al. (2004; 2000) explain the second phase as involving a search for information, knowledge and alternatives to use in understanding the problem. Students can explore the issue by developing questions or ideas through both synchronous and asynchronous text communication. Students’ ideas about the ‘designer babies’ issue might attempt to address ethical questions encompassing current scientific and ethical knowledge coupled with society’s moral norms. For example: Should we protect our humanity from genetic enhancement? Or, what effects would genetic manipulation have on human society? Group collaboration could be initiated with brainstorming activities. The teacher might also suggest an individual and group literature search on the topic. The information from the group can then be shared, reflected upon and explored through the community discussion. The aim is to elicit prior knowledge, gain new understandings and, to clarify and develop steps to solve the situation.

The third phase is ‘Integration’ which involves a synthesizing stage of meaning construction shown in the upper right quadrant of figure 2.2. For example, students can attempt to explain the issue in their own words to capture a clearer understanding of different (e.g., ethical) issues in ‘designing babies’. At this reflective stage, ideas are filtered out based on certain decisions, along moral, ethical, scientific or technological dimensions. Learners can
engage in critical discourse that may help them shape their own ideas more deeply as well as leading them to understand the bases for the scientific decision in the problem. This challenging stage involves deep cognitive processes that encompass analysis of the discussions, developing meaning, and seeking confirmation through reflective feedback. By writing responses, students can learn how to integrate, resolve, explain and critique their own theories and the theories of their peers. In this stage, there is an opportunity to synthesize solutions from the group discussions.

The fourth phase of the P.I. Model deals with ‘Resolution’ of the issue or problem (shown in the lower right quadrant of figure 2.2). The focus of this stage is to locate scientific, ethical and technological understanding in both the personal and group views as a way to close the gap between the different views. Activities performed in this stage include: developing a meaningful concept, unraveling a complex issue and developing a contextually specific solution to a complicated problem. The resulting insights help learners identify and articulate the best explanation for a given issue.

These four stages represent a process for seeking and monitoring solutions in real life events. Garrison et al. (2001; 2003) view the P.I. Model as an analysis of collaborative knowledge-building in text-based communication where learning occurs in a group setting. The final two phases (Integration and Resolution) are considered higher levels of critical thinking by several researchers (De Leng et al., 2009, Garrison et al., 2001; 2003; Kakuna et al., 2007; Schrier, 2004). Inevitably, the resolution phase which is considered to be in the highest level of critical thinking may generate a new cycle of inquiry thereby stimulating continuing learning and growth. In a study by Schrire (2006) using the P.I. Model as both a design method and data analysis, high levels of integration (phase 3) and resolution (phase 4) were identified in students
online threaded responses. In another investigation by De Leng et al. (2009), the P.I. Model appeared to be instrumental in generating and sustaining critical thinking and dialogue amongst students.

In this dissertation, the P.I. Model is used to analyze online discourse involving STSE-based issues in secondary science education by applying the reflective thinking indicators to the different phases of the P.I. Model (described in the analysis section of this dissertation).

In my research, I examine STSE-based issues in a senior physics course through the use of technology-mediated communication where reflective critical thinking is encouraged through the teacher’s structure of the online discussions. Many of today’s students are digital natives (Adams, 2008; Prensky, 2001) who are comfortable with the use of technology within and outside schools. Utilizing their technical skills, I examine their critical reflective thinking and inquiry skills while they worked in a blended classroom setting. The intention is to explore students’ thinking, collaborative and other emerging skills in the computer-mediated environment. I have used the P.I. Model as a framework to study the nature of students’ STSE-based discourse in both the online and offline activities.

In the next chapter, I briefly describe the qualitative case study method employed to study student interactions in a secondary senior physics course in an Ontario high school. I outline my methodology for answering my three research questions of the online STSE-based discussions.
CHAPTER III
RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, I describe and explain the rationale behind my methodology, I outline my study design, and I discuss the method I deployed in analysing my data. In this thesis, I use a qualitative approach in analysing a singular case study of an Ontario urban high school physics class. In this class of 23 students, nine students formed a focus group that participated in pre- and post-study semi-structured interviews, while all 23 were observed in both the offline and online class settings. In this chapter, I include discussion of my rationale for using a singular case study, as well as, description and analysis of my data. In my analysis, I include discussion on both the online and offline learning environments and how this connects to STSE-based education in physics. Issues related to validity, reliability, replicability, and ethics are considered.

3.2 Overview of Research Questions and Methodology

This research was guided by three research questions pertinent to my singular bounded case study:

1. What are secondary science students’ experiences as they engage in STSE-based education?

2. What is the nature of science students’ online discourse in the context of STSE education?

3. What are the students’ perceived benefits and challenges of learning about STSE subject matter through an online environment?
The goals of these specific research questions are to examine the online learning environment in a physics class and to investigate the opportunities the online learning environment provides for high school physics students to engage with STSE-based materials. Recall that STSE-based science education is one of the three major goals of the Ontario secondary science program (2008). I employ a qualitative method to investigate these research questions.

In this chapter, I provide a detailed description of how I went about answering my research questions, which were informed by a pilot study. My pilot study was conducted prior to my case study and helped me formulate my three research questions. My method included:

1. Recruiting both a physics teacher and her 23 physics student participants;
2. selecting nine students to form a focus group from the class of 23 physics participants;
3. collecting data through pre- and post-semi-structured interviews (with the nine focus students and the physics teacher) on the topic of STSE-based discussions;
4. observing the in-class STSE-based discussions of the whole class of 23 students;
5. collecting data from the online STSE-based interaction transcripts of the STSE-based discussion of the whole class of 23 students;
6. analyzing the data from the three major artefacts (pre- and post-semi-structured interviews, online STSE-based discussion transcripts, notes from in-class observations) using a qualitative data analysis approach; and
7. discussing issues related to validity, reliability, replicability and ethics.
3.3 Rationale for the Qualitative Approach

In this thesis, I employed a qualitative approach in gathering my data in connection to STSE-based discourse in an online environment. In this section, I will discuss the strengths of a qualitative approach, and include a discussion of my rationale for employing such a qualitative approach in a singular case study of an Ontario urban high school Physics class.

Qualitative research genres are typically used in social sciences and are increasingly employed in education to explore learners’ daily behaviour (Marshall & Rossman, 1999) and recently studied by online educators (Bassett, 2011; Gerbic, 2010; Kirkwood, 2010). A qualitative approach to educational research recognizes the impossibility of researcher and participant neutrality. In fact, Hara (1995) and others (Silverman, 2000; Trochim, 2006) argue that researchers’ viewpoints are crucial and value-judgments are deeply connected to research. Educational researchers (see Denzin & Lincoln, 2005) emphasize the value-laden nature of inquiry seeks to explore social experiences providing meaningful construction.

In my case study on the nature of physics students’ experiences of computer-mediated activities of STSE-based discussions, I employed a qualitative approach in analysing the following data:

1. Pre-study interview transcripts with the physics teacher and the nine focus participants regarding their perceptions of STSE education, the nature of science students’ online discourse in the context of physics-based STSE, and the benefits and challenges that they perceived with using the online forum to discuss STSE;

2. In-class observation notes from the high school physics class discussions with 23 students in connection to STSE-based discussion;
3. Online observation and analysis of the threaded discussions of the physics teacher and all 23 student participants, which includes 114 text-based discussion posts;

4. Post-study interview transcripts with the physics teacher and the nine focus student participants addressing their experiences of STSE-based discussions, the nature of online discourse regarding STSE, and the benefits and challenges they experienced discussing STSE-based issues through an online forum.

As illustrated, my use of a qualitative research approach means I collected a variety of data for analysis. A rich description of data gathered and analysed is included in sections 3.10 and 3.11. These analyses illustrate the value of a qualitative approach in STSE-based research.

De George-Walker and Keeffe (2010) identified a similar richness of data when they used a qualitative method to study blended learning design with communication technologies. One of the strengths of qualitative data analysis is the opportunity to examine the socio-psychological dynamics in the classroom situations, where ideas are constructed through interactions that may be missed in quantitative studies where the focus is on correlational and causational variables and using data collected through more standardized measures. Breuer and Schreier (2007) argue that qualitative styles of research can encompass both holistic and situational-opportunistic method practices. Hence, a qualitative approach provides a deeper understanding of social phenomena (Silverman, 2000).

Pare (2002) has identified a number of strengths inherent in qualitative research which I have correlated with my case study. Pare suggests narrowing one’s research question to a case study as this will help the researcher focus on a specific population and hence support the validity and consistency of the research. In my case study, I apply Pare’s principle by using a singular case study of a high school physics teacher using STSE-based discussions in an
asynchronous online approach with her 23 physics students. Furthermore, Pare outlines the importance of crafting one’s own research instruments and protocols that allow for multiple data collections. For my case study, I developed pre- and post-study semi-structured interviews for the physics teacher and nine focus participants, and I collected data from both offline observation notes of the 23 class members and online transcripts of all 23 student participant interactions. This variety of qualitative research data strengthens the grounding of theory by triangulation of evidence.

Denzin and Lincoln (2005) expand upon Pare’s (2002) identification of the strengths of qualitative research. Denzin and Lincoln (2005) suggest that, when the researcher acts as a field observer and data collector, he/she can take advantage of emergent events and themes. As a researcher in an Ontario urban high school physics class, I was able to observe the interactions between students in both an offline and online setting and their discussions on learning about STSE-based issues in an online environment. Denzin and Lincoln (2005) also highlight that an advantage of a qualitative research approach is that the researcher can make adjustments to his/her data collection process in response to unexpected events. This applies to my case study where I had recruited nine students to be a part of the focus group. In the pre-study semi-structured interviews I had nine focus students, and following these semi-structured interviews, one student chose to leave the focus group. I was able to replace this participant with another member of the class, and this student also participated in the post-study semi-structured interview. Finally Denzin and Lincoln (2005) state that a qualitative approach allows for the researcher to identify unique case features where the rich descriptions of the social world directs attention to the specifics of the particular case. This becomes apparent in my case study where I
observed spontaneous social peer compliments in the online STSE-based discussions, one of the unexpected themes that emerged.

A number of researchers identify the advantages of a qualitative approach in a small case study, as this allows the researcher to observe the dynamics of interaction. In particular, Breuer et al. (2007) suggests that research within qualitative studies grounds itself in a specific focus, as situational practices or experiences. In my research, the specific focus is a case study, dealing with STSE-based physics discussions in an online context. Stake (2005) suggests that the use of singular case studies in qualitative research can provide a method by which a deeper understanding of issues and dynamics of interactions can be explored. Because I employed a singular case study, I was able to observe and identify all interactions within each of the offline and online environments, and the interactions between these two learning environments. The goal of a blended teaching approach (an approach that uses both online and offline learning environments as in this case study) is to build a holistic understanding of how students tackle STSE-based issues through peer rapport, trust and collaboration. My use of a singular case study means that I was able to observe this rich peer interaction, as well as observe how concepts are learned in the two learning environments.

The next section will discuss my rationale for choosing a singular focused case study as the particular qualitative method with which to explore STSE-based issues in an online environment for an Ontario urban high school physics class.

3.4 Rationale for a Singular Case Study Method: Exploring STSE-Based Online Discussions

A case study is an appropriate method when an in-depth investigation (as in this research to explore STSE-based online and offline science discussions) is required to reveal a rich and
holistic account with details and various viewpoints about each situation to expand the readers’ or learners’ experiences in construction of knowledge (Hammersley & Gomm, 2000; Tellis, 1997; Vonderwell, 2003). Although the case study is an in-depth investigation which shares similar reasoning with value of qualitative research, an in-depth, singular bounded case study explores further into an intensive study of a single unit (bounded phenomena) to elucidate peculiarities and unique complex interactions and experiences (Stake, 2005; Yin, 1998). Stake (2005) suggests that case materials parallel actual experiences that seem to feed into a number of fundamental processes of awareness and understanding of case study events. In this bounded case study research, I explored how senior physics students and their teacher use the blended (i.e., online and offline) communicative features within the STSE context to address my research questions.

In my singular bounded case study, my central interest in the computer-mediated STSE-based discussion attempts to satisfy the tenets of qualitative method through: describing, understanding and explaining phenomena anchored in student collaborative text-based interactions. Examples of case studies on qualitative research are numerous (see for example, Tellis, 1997; Stake, 2000a; 2000b; Yin, 1989) and reflect a number of systemic approaches to viewing events, collecting and analyzing data. These studies articulate different rationales about the strengths of the case study approach. For example, some researchers believe that case studies empower teachers in their classroom by illuminating and improving their practice (Koutselini, 2008; Macpherson, Brooker, Aspland & Cuskelly, 2004). Stake (2005) suggest that case studies “provide insight into an issue” (p.445) and thus have an instrumental as well as descriptive function. A particular case may provide depth into the context and its related ordinary activities. In fact, a single case study is justifiable if the case is rare or unique or serves as a revelatory
purpose (Yin, 1989). This singular case is also referred to as the ‘bounded phenomenon’ case study by Gerring (2007). This applies to my case study where I examined the asynchronous text-based discussions of STSE-based issues in an Ontario urban high school physics course with 23 students. According to Stake (2005), bounded phenomenon studies delve deeper into a relatively bounded (or singular) unit of investigation such as a single-outcome case such as this high school physics course described in this dissertation.

Furthermore, the use of a singular bounded case study in my research was advantageous in highlighting the unique interactions between teaching methodology in a blended approach (online and offline), student interactions in a blended learning approach (online and offline), and interactions between participants and the STSE-based content in an online approach. The STSE issues within secondary science courses are often neglected (Aikenhead, 1994; Hodson & Bencze, 1998; Hughes, 2000; Pedretti, Bencze, Hewitt, Romkey & Jiwani, 2008b), and thus a detailed description of changes in the pedagogy when STSE is used in this technology-enhanced way may serve as a useful illustrative example for the field. A teaching repertoire that involves online and offline STSE discursive pedagogy in this bounded case study may serve to illuminate teachers’ practice (Koutselini, 2008; Macpherson et al., 2004); open doors to [STSE] issues identified by participants in the singular case (Stake, 2005; Yin, 1989); illuminate how students engage in critical thinking skills, in online platforms (Arend, 2009; Facione, 2010; Gambrell, 2004; Garrison et al., 2001), provide insights into STSE discursive issues conducted via online, and inform how it plays out within the larger classroom context.

My study may be referred to as bounded case study because it delves deeper into the singular unit of investigation of STSE-based discursive issues in an Ontario urban high school physics course. This case study examines, in an in-depth way, the uniqueness of this blended
teaching approach with single-outcome (that is, to understand the nature of online discourse of STSE-based discussions) in secondary physics education in Ontario. In this bounded case study, the STSE-based dialogue was analyzed on a deeper level that included the four levels of the Practical Inquiry (P.I.) framework (see Section 3.3). As discussed by Stake (2005), researchers use instrumental case studies because of an intrinsic interest that may later produce a change in the system and this particular case study, making reference to STSE-based education in science courses, has the potential to influence curriculum development in science courses across Ontario high schools. Before setting up my study design, I present an overview of the preliminary classroom study that I piloted before designing the asynchronous (online) STSE-based discussions.

3.4.1 The pilot study: Secondary science asynchronous discussion forum. STSE-based issues are a component of the Ontario science curriculum (elementary and high school), yet Canadian and Ontario educational researchers (for example, Aikenhead, 2006; Hodson, 2003; Hodson & Bencze, 1998; Pedretti & Little, 2008) claim that secondary students studying science in Ontario are not gaining the critical thinking and problem solving skills that might be developed from using STSE-based socioscientific issues in the science curriculum. Based on these findings, I decided that one potentially valuable intervention to explore in a pilot study was the use of an online discussion forum to potentially supplement the science class with rich discussions about STSE issues.

Accordingly, I conducted a pilot study using the online platform of my school board with my grade 10 science class in 2009 (see appendices I and J for the screen-shot and instructional details utilised for the online discussions). This class consisted of 30 students in an urban Ontario high school. Classes were run primarily in an offline approach, and as part of my pilot
study, I incorporated online text-based discussion to incorporate STSE issues. Each student was given a login and password, and when they entered the board’s online platform, they could see the STSE-based question that I had posted and were invited to type a response within a set of parameters. In addition to responding to the question, students were also asked to respond/comment on at least two other peer responses of their choice (Appendix J).

Since the advent of the e-learning facility within this large urban Ontario school board and as an online Chemistry teacher within this board, I had first-hand knowledge of the workings of the discussion forum on this platform before designing the pilot study. The board’s e-class activities suggested that digital learning might be a fresh venue with which to enhance and to study online science pedagogy. To continue supporting the board’s teachers in utilising online communication, an e-class platform was established for collaboration and communication amongst all board stakeholders especially for its teachers and students.

In this pilot study, the board’s discussion forum was selected for two major reasons. The first was that the board’s managed discussion forum provided a safe and Board-sanctioned cyber environment for teachers and students to interact. Second, the school board provides easy access to technical support available on-line and by calling a help desk number.

Reading the online discussions produced during the pilot study suggested the blended online science classroom transformed the context in which students expressed their own identification and analysis of social issues embedded in a science course. Many of my science students discovered opportunities to express a wider range of ideas and voices while extending into cyberspace for evidence to support their argumentative claims. As their science teacher, I maintained online interactions with my students as they progressed with their threaded
discussions by responding to their questions and commenting/encouraging them to continue their discussions.

From this pilot study, I formulated my overall research question for the main thesis study which was to understand more deeply the impact of their engagement in an online forum and its relation to their learning and engagement in STSE issues. These cyber interactions with my students inspired both content and situational reflection leading to a desire to develop assessment strategies for my students’ threaded discussions as predicted by many online educational researchers (see Arend, 2009; Dringus & Ellis, 2004; Gaimster, 2008; Jeong & Joung, 2007; Kear, 2001). Having observed the dynamics of my grade 10 science students’ interactions particularly through the board’s online environment with the STSE based discussions, my intentions were to observe an urban Ontario senior secondary science course and teacher who might be engaging in similar computer-mediated STSE-based discussion groups in high school.

To reiterate, my pilot study showed that the online discussion forum plays an important role in STSE-based issue discussion in a high school secondary program. In the online platform, the threaded posts showed that students were involved in discussing STSE-based issues, participated without apparent inhibition, posted their own questions and thoughts spontaneously, and interacted with one another more than in the offline classroom environment.

3.5 Study Design

In exploring the answer to the research questions set out in Section 3.2, I employed the following research design, which I will first outline and then discuss in detail. My research design includes:

1. Recruiting of high school participants, including a physics teacher, her senior physics class of 23 students, and a focus group of nine students selected from the group of 23;
2. Conducting pre- and post- semi-structured interviews with the nine focus group members and the physics teacher;

3. Observing and collecting data from the online environment of the physics class with regards to the STSE-based discussions in the same urban Ontario high school physics classroom;

4. Observing and collecting data of the offline learning environment with regards to the classroom STSE-based discussions.

3.5.1 Recruitment of teacher and student participants. Within this bounded case study of blended (offline and online) learning, I employed purposive sampling to identify study subjects. Purposive sampling allows the researcher to seek out participants who are best positioned to inform about the phenomenon under investigation (Panacek & Thompson, 2007). In this bounded case study this meant using students and their teacher who were already pursuing the online discursive science approach. According to Panacek et al. (2007), Schrire (2006) and Stake (2005), the purposive sampling technique enables researchers to select the participants who meet specific criteria (introduced earlier in this section).

The purposive recruitment for this case study includes one secondary science teacher and the class selected from an urban Ontario secondary school. The criteria for teacher selection included: familiarity with the online teaching strategies and use of a blended teaching approach in science, willingness to be observed while pursuing the teacher’s current blended online discursive STSE curriculum embedded in science and be a permanent member of the secondary science panel. In order to focus on the use of STSE-based issues in this bounded case study, one secondary science teacher with an average class size (25-30 students) was required. This was to ensure that multiple participant perspectives of the online approach could be observed. The class
selection criterion was based on the teacher’s use of the board’s asynchronous computer-mediated communication, namely the e-class shown in appendix J, and that teacher’s use of online STSE-based discussions in their classroom.

The method I deployed in recruiting the high school science teacher and his/her students, involved sending out an e-mail on the board’s site asking for volunteers, reading the responses, and selecting a teacher who was not only willing to participate in my research, but whose teaching pedagogy included the aforementioned criteria. Through this approach, I had one teacher reply that was familiar with STSE-based education and online pedagogy. This teacher was employed in an all-girl high school in a large urban Ontario school board. I selected this high school science teacher and her senior physics class of 23 female students as my participants and in particular I observed and analyzed the online threaded discussion posts of this group.

From this group of 23 students, I selected a focus group of nine female student participants. This group completed all activities of the online and offline discussions, as well as, both the pre- and post-study interviews. The selection criterion for the focus students was identified by me to encompass a diverse academic ability within the class. The teacher identified the students who had volunteered to be in the focus study group to be of varied academic ability and from this group I formed the focus group of nine female students. The teacher informed me that the group consisted of students whose academic averages in the physics course ranged from 50-90%.

3.5.2 Pre- and post-study semi-structured interviews. As part of my pre- and post-study, I conducted a 20-45 minute semi-structured interview with the nine focus science students. The physics teacher was involved only in the post-study semi-structured interview as she had already been selected to be a part of the study, whereas the pre-study semi-structured
student interviews were designed to help inform my understanding of student knowledge of
STSE-based issues in science prior to the blended STSE-based class discussions.

In structuring the interviews I abided by Berg’s (2009) guidelines, which outline how to
conduct a semi-structured interview for the purpose of a qualitative research approach. The focus
students were interviewed before starting the STSE-based issues in the physics curriculum. Both
student and teacher participants were presented with a similar interview protocol so as to obtain
comparable responses (Berg, 2009). The interview questions were designed to obtain the
demographic information of the students; their baseline understanding of the STSE topics in
science; their knowledge of, and issues with, with computer-mediated discussions; and their
understanding of the strengths and challenges of learning about STSE issues with technology
(questions are shown in the appendices A and B). The interview protocols were developed from,
and based on, validated reports from Dringus et al. (2004), Garrison and Anderson (2003) and
Garrison and Kanuka (2004). The interview questions requested little personal information other
than the participants’ names which were then replaced by pseudonyms and kept confidential. An
analysis of the semi-structured pre- and post-interviews appears in Section 3.11.1.

The next section of this thesis outlines the method of research conducted with the
computer-mediated settings (online learning environment)

3.5.3 **Online asynchronous computer-mediated conferences in senior physics.**

The physics teacher posted discussion questions for students to respond to online through the
board’s online platform. Students were required to post a response to the STSE-based online
questions that their physics teacher posted within a week. In addition to responding to the teacher
question, students were required to post two threaded responses to their peers.
The first STSE-based online conference occurred at the commencement of the semester when the classroom teacher introduced the online discussion platform. This online discussion revolved around the theme of Friction in Tires. In class the students had been learning about the concept of friction, and through the online discussion they applied their knowledge of friction in answering an STSE-based issue that involved physics. The teacher posted both a physics concept question and an application of physic knowledge that dealt directly with STSE-based issues. The posted questions were as follows:

1. **Physics content question:**
   a. Name one difference between the Formula One tires and All-season tires and explain why there is this difference?

2. **Application questions:**
   a. How does this factor help a racing car win a race?
   b. Why is this design feature not used in a passenger car?
   c. How does the mass of the car and type of tire affect the acceleration of the car?

3. **STSE-based issue questions:**
   a. Should Ontario follow Quebec’s lead and make snow tires mandatory in winter months?
   b. How would you convince your parents to invest in snow tires for the winter months? (Refer to Appendix K for screen shots with instructions)

This question generated a total of 56 posts which included 19 initial posts and 37 threaded peer postings (See Chapter 5 in Table 5.1). I provide an analysis of the discussion and threaded posts that ensued from this posting in Section 3.11.2.
The second STSE-based discussion conference was observed in the same physics course around a different theme and a different physics concept. The reason for repeating the conference using a different topic was to better access any new viewpoints (Yin, 1989) not observable in the first attempt. This second round of data collection was on the Use of Green Energy. In class students had been learning about the concept of energy use, and through the online discussion they applied their knowledge of the physics concept of energy to socially relevant physics issue. Once again, the teacher posted a knowledge based question, as well as, application questions and STSE-based issue questions. Students were once again given a week to reply to their physics teacher’s question, and to post two threaded responses to their peers. The posted questions were as follows:

1. **Physics Questions:**
   a. What does it mean: ‘electricity is the most versatile form of energy’?
   b. Provide the name of your energy source you researched and state the cost analysis you found for your energy source.

2. **Application Questions:**
   a. We use energy for many purposes. Let’s see if the class can come up with 10 different purposes. Give one (1) way in which we use energy.
   b. Should Canada continue to use coal to generate electricity? Is it ethical for Canada to so?
   c. Your classmates have presented alternative energy technologies. Which alternative energy technology did you agree with the most? Why?
3. **STSE-based issue questions:**

   a. We as a society tend to look at cost analysis to determine which energy source to use without looking at the overall effect to the environment. What is more valuable? Explain your reasoning.

   b. Is it fair for rich developed countries to force poor developing countries into using expensive renewable sources of energy? Should the developed countries assist the developing countries in developing renewable sources of energy? (See Appendix L)

A notable difference in this conference post, as compared to the first conference post on the topic of Friction in Tires, was that the teacher assigned that students make a PowerPoint presentation on the topic of Green Energy prior to them discussing and posting their responses in the online platform. Students presented their PowerPoint project in class and this generated discussion around the topic of Green Energy, which was later also discussed in the online discussion platform. This means that students entered the online platform with some prior knowledge and discussion on the STSE-based issue discussed online. This question generated a total of 58 posts, which included 20 initial posts and 38 threaded posts (see Table 5.3). I provide an analysis of the quality of the discussion and threaded posts that ensued from this posting in Section 3.11.2.

The teacher’s instructions and threaded message constraints [requirements] for students was also carefully scanned through the transcripts looking at participant text-based conversational exchanges for the second conference. Jeong and Joung (2007) postulated that the technique of placing constraints on messages by the instructor helps mark the function of each
message and identifies any themes that could surface. Endorsing constraints on the computer-mediated communication tends to facilitate the analysis of the sequential nature of exchanged messages which accentuates both reflective phases three (Integration) and four (Resolution) of the Practical Inquiry Model of cognitive presence, which is further discussed in my results chapters (see Chapters 5 and 6). Accordingly, it enables using the process-oriented approach to understand students’ online discursive interactions through the two systematically similar conferences conducted over a short period of course time. Other computer conferences that direct the threaded class discussions have been similarly instructed or monitored by teachers in other studies (Godwin-Jones, 2003) to guide students’ online task based activity.

This observational case study involves collaborative dialogue and group learning (De Wever, B., Schellens, T., Valcke, M., & Van Keer, H., 2006). According to De Wever and colleagues (2006), collaborative dialogue through asynchronous computer-mediated technology supports the potential for co-construction of knowledge with deeper thinking when text-based messages or posts are used. Deeper thinking in text-based responses provides students’ time to reflect before writing the peer discussions of a relevant topic and this is discussed in the results chapters (see Chapters 4, 5, and 6).

3.5.4 Offline classroom setting. As mentioned in the recruitment section 3.5.1, the physics teacher selected was already familiar with the urban Ontario high school’s online settings and was already employing an STSE issues-based pedagogy in her science classes. The offline environment provided a means to observe the discourse of STSE-based issues in the physics classroom also, and observing the class discussions provided me with an understanding of student identities and peer-relationships. In addition, I was able to observe the patterns of
discourse and the nature of engagement in class STSE-based physics discussions for later comparison with the online environment.

During the research period, my classroom visits varied with at least three visits per STSE discussion. This means I visited the classroom a total of six times during the time period when the two physics topics (the Forces Unit and the Use of Green Energy Unit) were discussed. Each classroom period is 75 minutes in duration and I was a non-participating observer during the six visits.

The teacher and students’ comments and questions around STSE-based issues were observed and recorded during my in-class visits. I organized my notes recording according to who responded, what was being said, where in the discussion the comments were made, when in the discussion the comments were made, and how the teacher and peers responded to any particular activity. During my visits, I observed the interaction between the teacher and her students, as well as amongst students. I also noted the teaching strategies (for example, the teacher’s class debate designs and class set-up with instructions to guide students to discuss STSE based-issues). I kept a journal to record oral student interactions and used a digital voice recorder to further capture discussions conducted in small group and whole class activities.

I collected data from February to June, 2011. These data included class observations, the online and offline discussions and from the semi-structured participant interviews conducted in February and again in June. The physics teacher and I collaborated in organizing the schedule of dates for my visits during the offline STSE-based discussions.

3.5.5 Physics course with offline STSE-based class discussions. The teacher in this study was committed to her blended approach using technology-mediated discourse to incorporate STSE-based physics. Throughout the in-class observation period, the physics teacher
in the case study was enthusiastic and engaged using a variety of teaching strategies to support STSE-related discussions in physics.

The physics teacher incorporated discussion in the traditional classroom mainly through the Socratic approach, but also through cooperative learning experiences. In one particular class the students were studying Energy Transformation as a topic. I audio recorded and took notes from the group interactions of this class. I observed the teacher as she provided instructions and outlined the activities to the class. To explore this topic, the teacher divided the class into small groups of 2-3 students. Each group was given a strip of paper with a physics related problem. Students were asked to work collaboratively in addressing the problem. The teacher’s instructions were, “I’ll give you a strip of paper. You are going to describe the motion and the energy transformation [related to the stated problem” (Ayyavoo, In-class Recorded Observation, April 2011). The teacher stated that students would have two minutes to discuss and work collaboratively in coming up with an answer to the one written question connected to a physics problem. Each group was given a different problem connected to the unit on Energy Transformation. Group One for example, was given the following problem, “A stuntman falls and lands safely on a trampoline” (Ayyavoo, In-class Recorded Observation, April 2011) and asked to identify the motion and energy transformation. As an observer, I recorded excerpts of student group discussions and noted comments and questions asked in the group activity. At the end of the allotted time, students were asked to present their problem and answer to the whole class, and a whole class discussion ensued regarding the physics concepts being addressed.

3.6  Research Timeline

In November 2010, one ethical review request was sent to University of Toronto for the acceptance and approval of the study. Following the university’s approval, a second request was
sent in January 2011 to a large urban Ontario school board’s ethical review committee for approval to conduct the online case study at a school in this board. Please see appendix C, D, F and H for the sample consent documents for the selected school principal, teacher, students and their parents. I recruited a physics teacher and observed her senior physics class from February to June 2011. My data was analyzed during the summer and fall of 2011. My analyzed data was submitted for presentation at the World Educators’ Research Association held in Taiwan during December of 2011 and later at the Canadian Society for the Study of Education Conference in Waterloo, Ontario in May of 2012. Table 3.1 is a timeline of my data collection schedule.

Table 3.1

*Steps to Research Investigation and Data Collection Schedule*

<table>
<thead>
<tr>
<th>Date</th>
<th>Details</th>
<th>Research Data Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>Find participants for study</td>
<td>Meet teacher and student participants</td>
</tr>
<tr>
<td>2011</td>
<td>Establish contact with one science teacher</td>
<td>Present information regarding the study to teacher and student</td>
</tr>
<tr>
<td></td>
<td>and her/his grade 11 students</td>
<td>participants</td>
</tr>
<tr>
<td></td>
<td>Set dates for pre-study interviews</td>
<td>Provide and collect research consent forms from study</td>
</tr>
<tr>
<td></td>
<td></td>
<td>participants</td>
</tr>
<tr>
<td>March</td>
<td>Conduct pre-study interviews with teacher</td>
<td>Record audio data from semi-structured interviews with teacher</td>
</tr>
<tr>
<td>2011</td>
<td>and nine focus students</td>
<td>and focus students</td>
</tr>
<tr>
<td>April</td>
<td>Weekly classroom observations</td>
<td>Record teacher-student verbal in-class interactions and other</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td>details in researcher notes and audio</td>
</tr>
</tbody>
</table>
May 2011

- Observe two STSE-based discussions offline
  (in-class) participant interactions
- Observe two STSE-based discussions online
  - Observe offline participant interactions
  - Observer online participant interactions
  - Retrieve online transcripts from teacher

June 2011

- Conduct post-study interviews
  - Record audio data from post-interviews
- Debriefing and closing visit
  - Transcribe all audio data

3.7 Summary: Offline and Online Learning of STSE-Based Issues

In both the asynchronous online and synchronous in-class offline learning environments, the objective was to record student-to-teacher and student-to-student interactions with STSE-based discussions. In the four discursive sessions for online and offline situations (that is, with two different physics-based STSE topics for each online and offline environment): distinct patterns related to factors such as instructor’s moderation of the STSE topics; structuring of instructions (or constraints); student interactions (including responses to the topic); and emergence of student-to-student interactions with respect to the discussion threads were monitored through transcript analysis of the online interactions obtained from the physics teacher’s online forum.

The in-class monitoring also included recordings of the participants’ voices and the researcher’s notes on any unique events that occurred during the teacher and student and class
interactions. The in-class observations included factors that triggered students’ reflective thinking in the learning situations which the teacher formulated. With respect to teaching methods, notes were kept on any special teaching strategies that were implemented in the asynchronous (online) and synchronous (offline) student discussion groups, and noted any potential influences of the hybrid (blended) teaching and learning approach on the online component of the STSE-based social-scientific dialogue.

3.8 Researcher’s Role in the Case Study

In order to understand the socioscientific aspect of students’ secondary science curriculum, my main intention as a researcher is to observe a high school science teacher and the students in the online learning environment for the semester. To enhance the technology-supported discursive activity, I acted as a researcher and occasional technician in this study.

My part in this study can be explored from both the perspectives of taking a specialized role as a researcher and as my role as a technician. According to Kemmis and McTaggart (2005), this specialist role with an additional specialized function is described as someone:

With some special expertise that may be helpful to the group in its endeavour. … to see the doubleness of the role in terms of a specialist role and functions in critical tension with processes of cultural, social, and personal reproduction and transformation that aspire to achieving self-expression, self-realization and self-determination recognizing the individual (p. 594)

As my dual-role of a researcher (an observer/interviewer) and occasional technician with specialist in science curriculum leadership in high school, I was available for technical guidance to members of the case study with respect to the e-learning platform. In the technical moderator role (Garrison & Anderson, 2003; McPherson & Nunes, 2004), I collaborated with the teacher on the use of the discussion forum and, according to Kemmis and McTaggart (2005), to support a collaborative enterprise in engaging participants in exploratory action. In both offline (the classroom venue) and the online (computer-assisted platform) discourse, the researcher’s and
teacher’s role was expected to diminish over time during the hybrid (blended) teaching and learning approach for all participants in the study. I noticed that students asked fewer questions in class about operating the online forum by the end of second week of observation of the STSE-based discourse and hence, neither the teacher nor the researcher was asked about the technology-mediated setup. The objective was to promote greater student interactions in the STSE-based discourse and minimize teacher involvement in the technical details so not to stray away from the goals of the case study.

In my technical role, I was available for queries about discursive interactions and to provide support on the software issues. Within the first two weeks of the study, I collaborated with the teacher on embedding pictures in the forum and with setting up instructions for the threads. At no time during the case study were students able to see my presence online since I accessed the material through the teacher’s site to review students’ online activities. I neither participated nor corresponded online with the teacher or the students in her class. The teacher continued to have a major role in managing the class discussions.

As a researcher in this study, my role was to collect data from various sources both from the online and offline discussions and semi-structured interviews. After my initial interviews with the teacher and the students, I commenced my STSE online and offline discursive case study observations. In all the online observations, students were unaware of my presence in their computer-mediated discussions. In the offline and online discursive observations, the teacher’s role was pertinent in monitoring the dialogue and negotiations amongst the participants in both online and offline environments as discussed next.
3.9 Teaching Presence: Teacher’s Role in the Computer Conference

Garrison and Anderson (2003) postulate that high levels of online participation are rooted in topic interest and in the discourse structure designed by the instructor. There is an inherent requirement for the instructor to be an architect in designing, directing and sustaining the online cognitive and social transactions. In addition to these components of teaching presence, Anderson (2009) further postulates three important roles for teachers to increase their effective teaching presence. First, the teacher’s role is critical in designing and organizing the overall learning experience for the students. Second, teachers can design and implement activities to explicitly encourage discursive interactions between students and students, as well as teachers and students. Finally, beyond moderating the students’ learning experience, the teacher can participate by sharing her subject matter expertise through student interactions in both the online and offline environments. This is an enormously imposing task for instructors in both an e-learning and face to face context (Garrison & Anderson, 2009).

3.10 Data Collection: Three Major Artefacts

Three major artefacts were collected during this research: interview transcripts, participants’ online and offline discussion transcripts and the researcher’s field notes. Each of these artefacts are described in Table 3.2 and discussed in greater detail in this section while providing the rationale for their use in this study.
<table>
<thead>
<tr>
<th>Research Questions to Address Data Source</th>
<th>Instruments and Artefacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are secondary science students’ experiences as they engage in STSE-based education?</td>
<td>1. Conducted semi-structured pre- and post-study interviews and collected transcripts of the interviews</td>
</tr>
</tbody>
</table>

As described later in this chart, the data source for this question (#1) comes explicitly from the interviews with the participants (students and their teacher) about their perceptions of STSE-based education using the online and offline learning and teaching strategies. The objective was to observe two online and two offline STSE-based topics presented by the teacher and retrieve students’ views of STSE-based education from these experiences. Essentially, the offline STSE-based discussions required several in-class visits and observations; commencing with observing the teacher’s initial instructions and the in-class discussions.

A group of nine focus students were interviewed twice; once for the pre-study (prior to class STSE-based discussions) and second for the post study (subsequent to offline and online STSE-based discussions). These focus students were identified by the teacher to encompass a diverse academic ability within the class prior to the study. The instruments for data collection involved the stimulus pre-study interview questions. The stimulus questions provided me with demographic information, an understanding of the students’ baseline understanding of STSE topics, as well as, an understanding of their prior knowledge and viewpoints of online discussions.

In the post-study interview, the stimulus questions were designed to gather information (artefacts) about the influence of computer-mediated technology on particularly, the students’ learning of physics and STSE-based issues using computer-mediated discussions, offline discussions, and learning with technology.
2. What is the nature of science students’ online discourse in the context of STSE education?

The online transcripts were used to examine the nature of discourse that occurs when the participants (teacher to student and student to student) interact online with respect to the context of STSE-based topics. The rationale here was to identify the nature of their discourse online with respect to learning about STSE-based issues.

3. What are the students’ perceived benefits and challenges of learning about STSE subject matter through an online environment?

From both the pre- and post-study interview questions, the responses were transcribed and used to address the research questions.

Both the pre- and post-study interview sessions with the students were conducted at a pre-arranged time in their school but organized outside their class period to avoid interruptions to their curriculum instructional periods.

2. Transcripts from the threaded online discussions

Two different STSE-based issues were explored in two separate online discussion conferences. I retrieved the transcripts from both of these online discussion conferences from the teacher’s online folder. The reason for repeating the conference observation was to better access any new viewpoints (Yin, 1989) not available in the first attempt. These two different conferences revealed the number of postings, individual responses to the STSE-based topics and the teacher’s role in facilitating the discussions. At the end of the study, all online responses were retrieved through the teacher’s online discussion board for data analysis.

3. Researcher’s Field Notes and Interviews

From the researcher’s notes, the STSE class discussions and participant interactions including both the teacher’s and students’ responses were recorded and noted. The researcher’s field notes were used to identify any discrepancies during the in-class discussion sessions and influences in the online components. Most of the answers to this research question (artefacts) were analyzed from the pre- and post-study interview transcripts.
Post Study Teacher Interview:
At the end of this bounded study, arrangements were made
with the teacher to complete the post-study interview
which brought closure to the research activities for the case
study.

3.11 Data Analysis: Three Major Artefacts
My data were analyzed using the content analysis method (De Leng et al., 2009; Garrison
et al., 2000), which involves an iterative process of data analysis and interpretation of qualitative
data described in Schrire (2006). I worked through the data transcripts systematically identifying
specific characteristics found within the texts which are described in the following paragraphs.
The subsequent sections show how each of the three data sets were analyzed in order to address
my three research questions.
3.11.1 Analysis of semi-structure interview transcripts. The interview responses from both the teacher and students were used to gather data about the participants’ views and understanding of STSE-based issues in physics and their perceptions of online learning. The classroom students’ interviews produced information about the students’ background information on learning physics, on learning physics through STSE-based issues, using computer-mediated technology in online discussions, and learning with technology. The teacher’s interview produced information about her experience teaching secondary physics, teaching physics through STSE-based issues, and her experience using online technology for teaching. These interview transcripts were carefully scrutinized through content analysis (De Leng et al., 2009; Garrison et al., 2000) which involved my reading, and reading the participants interview responses and looking for themes.

From reading these interviews, I further identified re-current patterns or themes in relation to learning through STSE-based issues and learning online. Examples of themes include using STSE-based topics to support learning and making connections of physics concepts in society (see section 4.3). With respect to the discussion analysis, researchers (Rourke & Anderson, 2003; Stacey & Gerbic, 2003) have suggested using schemes that have been developed and tested in previous research studies, and Garrison’s and Anderson’s (2003) reflective thinking indicators were used here. But these indicators were more valuable in the online discussion transcripts described in section 3.11.2. Garrison, Anderson and Archer (2001) and Meyer (2003) support the idea of measuring the discussion progression through the different Practical Inquiry (P.I.) Model phases. Hence, Garrison and Anderson’s (2003) critical, reflective thinking indicators were used to examine discussion progression through the content analysis as shown in Table 3.3.
3.11.2 Analysis of STSE-based discussions: Online discursive transcripts. From the online data transcripts, the text-based discussions were analyzed through content analysis grounded in the four phases (labelled as P1 to P4) of the P.I. Model (discussed in Chapter 2). Such content labeling and analysis coding systems have been successfully used in e-learning models by many researchers (De Leng, Dolmans, Jöbsis, Muijtjens, & van der Vleuten, 2009; Jeong, 2005; Jeong & Joung, 2007). Drawing on the literature from De Leng and colleagues (2009) on analysis of student discussion postings in addition to the coding established by Garrison and colleagues’ (2001), the current case study participants’ online interactions from their logged postings were also analyzed. The quality of interactions between the participants was assessed through analyses of threaded response sequences identified by coding levels, across Phases 1 through 4.

Furthermore I applied De Leng et al’s work (2009) to this current study. These researchers found that the P.I. Model phase and checklist seemed to parallel aspects of the critical reflective thinking process, and that critical reflective stages were found specifically to be related with the developmental phases of P.I. Model. Other researchers (for example, Kanuka et al., 2007; Schrire, 2004) have indicated that Phase 3 and 4 - Integration and Resolution, respectively represent synthesis (drawing conclusions) and application (drawing an action plan). The exploration Phase (P2) is the phase in which students develop questions around a topic and focus their area of research. In this dissertation the reflective thinking indicators shown in Table 3.3 were employed to examine reflective critical thinking and discourse in the STSE-based online discussions.
<table>
<thead>
<tr>
<th>PI Model Phases (Codes) with Descriptors</th>
<th>Reflective Thinking Indicators</th>
<th>Sample Question Checklist</th>
</tr>
</thead>
</table>
| Phase 1: (P1) Objective/ Triggering     | Recognizing problems, concepts and issues, Identifying relevant elements and asking relevant topic related questions. | - Are the physics students cognizant (aware) of STSE issues?  
- Can the problems or issues be identified? |
| Phase 2: (P2) Exploration               | Information/exchange/ suggestions/brainstorm, Exploring Contradictory ideas and concepts, Seeking out specialized information. | - Are there questions asked or statements made to analyse the problems?  
- Are there clarifications made to seek more information? |
| Phase 3: (P3) Integration               | Synthesis /solutions and drawing conclusions, Building on ideas, providing rational, justification and offering solutions. | - Do students make suggestions or provide advice or comments on the identified issues?  
- Do students make connections to current knowledge and theories? |
| Phase 4: (P4) Resolution                | Applying, testing, defending, critiquing and suggested applications. Deciding on the action to take. | - Are students applying their current knowledge?  
- Does it lead to reasonable resolutions?  
- Are new suggestions made to solve problems? |

**NOTE:** PI Model Phases and Reflective Thinking indicators (Descriptors) were adopted from Garrison and Anderson (2003) and the checklist adopted from De Leng et al. (2009).

In summary, Phases 1 and 2 (Triggering and Exploration, respectively) were considered to emphasize both the content level reflection – which entails acquisition of relevant details, and exploratory information – which builds on researching skills (Dringus et al., 2004). Phases 3 and 4 (Integration and Resolution, respectively) entailed developing problem solving abilities and deciding on the action to pursue.
To further delineate the interactions, the online discussion and interactions between participants were measured at both macro and micro-levels (Schrire, 2005). At the macro-levels, discussion threads were analyzed according to the number of student postings of the teacher’s discussion questions, peer responses to other peers’ postings (using text-based computer-mediated postings). While the micro-levels included the quality of the STSE content analysis of the students’ threaded discussions that achieved higher order thinking. At the micro-levels while analyzing the quality of responses, higher-order thinking manifested in Phase #3 Integration and Phase #4 Resolution of teacher suggested STSE-based issues were identified with the different phases of the P.I. Model. I looked to see if student responses reflected the P.I. Model phases by identifying instances of students’ transformation from the lower cognitive presence Phases 1 & 2 to higher-order thinking Phases 3 and especially Phase 4, the Resolution phase. Dringus and Ellis (2004) identified this level of thinking as a process level reflection. This important and demanding learning encompasses analyses and evaluations of the solutions which Garrison and his colleagues (2003) believe to involve higher level thinking.

3.11.3 Analysis of STSE-based discussions: Offline (in-class) discussions. To analyze the offline (in-class) discussions, I used my field notes of the whole class discussions and of the individual group discussions. The field notes were used to enhance my data and to resolve any discrepancies noted during the in-class discussion sessions. The objective of the analysis of the in-class discussion is to offer insights on students’ perceptions of STSE education and to answer the research question: What are secondary science students’ experiences as they engage in STSE-based education?
The amount of time allocated to in-class discussions, teacher to students and student to student interactions time, the number of students involved in the open discussions are a few of the observations that were analyzed. Similarly, time allocated for online discussions, the number of participants involved in the peer-to-peer interactions were also compared with online discussions. Besides the time factor, any significant similarities and particularly the differences between online and offline discussions were used as the basic unit of analysis. Moreover, the text-based asynchronous online interactions were observed for the type and number of responses that the teacher required and that were imposed on students to respond. The in-class discussions were regulated by the curriculum period of 1 hour and 15 minutes. As such, the amount of time provided for responding to issues was the same as that allowed in the online component of the STSE-based discussions.
3.11.4 Analysis of researcher’s field notes. I analyzed my observational notes of ‘who, what, where, when and how’ of the STSE-based discussions of both the Friction in Tires and the Use of Green Energy topics as they occurred in both the offline and online environments. In relation to the ‘What’ question, the type of emerging patterns and themes during the discussions were identified in relation to the phases of the P.I. model. The ‘when’ and ‘how’ questions dealt with the supplementary activities or teaching strategies implemented during class in relation to the STSE-based discussions. My questions addressing ‘where’ dealt with recognizing and correlating to events that could have generated ideas as to where the problem originated. My questions looking at ‘what’ involved analyzing what generated discussion in the offline environment. In terms of ‘who’ these questions focused on who was involved in creating the responses and especially if the student motivated the discussions.

These field notes enabled further insight into the teacher’s activities and students’ learning outcomes with respect to the offline and online activities. Of interest was whether the online learning activities had changed the nature of STSE-based discussions in terms of the amount or kind of interactions with other students or the teacher. Other areas of observations encompassed the accessibility of participating during in-class interactions and activities compared to the opportunity to access the computer-mediated discussions of STSE-based issues.

In conclusion, multiple data sources were compared. In addition, the various data collected in the researcher’s notes provided opportunities to triangulate (Stake, 2005; Yin, 1989) the findings.
3.12 Issues of Validity, Reliability and Replicability

Stake, (2005) and Yin (1989) make a point that validity of a study is based on the investigator showing a multiple constructions of reality which gives the case study high internal validity. One of the important features of internal validity is triangulation (Stake, 2005; Yin, 1989). Triangulation of the data using multiple sources can increase confidence in our interpretation of the findings in this case study. Stake (2005) postulated that qualitative casework of “triangulation is considered as a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation” (p. 454). In this case study, two different iterations of online discussion were used, about two different topics. For this study, additionally, multiple sources of data were collected: the pre- and post- semi-structured interviews of the nine focus participants including the teacher’s interview, observation of class discussions of STSE-based issues from the grade 11 physics curriculum, and the online written text-based synchronous discussion transcripts.

Qualitative measures were used initially to develop strong internal validity. Internal validity comes from having necessary data present and being measured in this study the number of threaded postings or the level of cognitive processing. The different data sources from this single case study research enabled triangulation of the data. The offline component brings the view of the physics classroom peer and teacher interactions on particular STSE-based issues. The online component using computer-mediated interactions demonstrates secondary students’ comfort in virtual discussions of socially-related science issues.

3.13 Ethical Issues

On receiving the approval from University of Toronto’s ethical review board and the urban Ontario school board’s ethical review committee, all of the potential case study participants namely, the grade 11 physics students and their classroom teacher were contacted
and consent forms were received for the bounded case study. Information consent letters outlining the scope of the research, research approaches, participant responsibilities, and the ability to withdraw at any time were drafted according to the requirements of each institution. Protocols concerning confidentiality, privacy and anonymity were strictly enforced as according to institutional guidelines. A sample copy of all required documentation can be found in Appendices C to H.

3.14 The Integrated Result and Discussion

In Chapters 4, 5 and 6, I will present a combined result and discussion chapters to address each of the three research questions respectively for this case study. According to Henrich (2011), the results and discussions are the heart of a report and should provide a concise and clear presentation. This research dissertation is designed to address issues regarding the specific data and interpret the findings as an integrated review in evidence-based practice (Whittemore & Knafl, 2005). Hence, each of the Chapters 4, 5, and 6, in this evidence-based bounded case study will begin with an overview, introduction, results and discussion of the data, and a conclusion.
CHAPTER IV
RESULTS AND DISCUSSION – PART 1
Secondary Students’ Experiences of STSE-based Education

4.1 Overview and Introduction

This chapter explores the first research question about students’ experiences of STSE issues-based science education. This first question was aimed at characterizing students’ involvement with STSE: What are secondary science students’ experiences as they engage in STSE-based education? In section 4.2 of this chapter, students’ perceptions of and experiences in engaging in STSE-based issues in their senior physics course are examined. The two main data sources for this section come from student interview responses and the online discussion transcripts, with emphasis placed on the nine focus students. This study reveals that all nine focus students in the class of 23 physics students enjoyed STSE-based issues. In this case study high school students engaged in STSE-based physics topics primarily through the online discussion platform. The experience of students doing STSE online is of particular interest to this dissertation, but it will be later analysed in detail in Chapter 5. This chapter is focused on examining students’ views of what constitutes STSE and their experiences in doing STSE-based issues in physics curriculum.

The physics teacher developed two STSE-based online discussion conferences corresponding to two units in the curriculum, namely, the Forces unit and the Energy and Society unit of the Ontario Physics Curriculum (2008). The overall theme which emerges in both the interviews as well as the online discussion transcripts, as explored in detail in 4.2 is that students said that discussing STSE-based physics topic allowed them to understand the application of physics concepts in their own lives. Furthermore students’ responses indicated how using STSE topics in physics allows them to make more accurate connections with physics concepts and
provided them with a more sophisticated understanding of physics in STSE topics, and consequently, application of science concepts to society and making connections with socio-political-ethical issues.

Four key themes emerge in relation to student experiences of doing STSE-based work in their physics course. These themes reveal that students are able to make connections between physics and several aspects of their own lives. Specifically, the themes which emerge, and which will be discussed in detail in section 4.3 of this chapter are:

I. STSE informs learning about physics concepts;
II. STSE helps students to apply physics to their personal lives;
III. STSE allows students to make connections between physics concepts and the physical environment; and
IV. STSE allows students to make connections between physics and socio-political-ethical issues.

Before the four main themes are discussed, summary data are reported in the next section which reveals an overall positive attitude towards STSE-based discussions.

4.2 Students’ Impressions of STSE-issues in their Physics Course

Science is embedded within socially-related issues and, according to Zeidler and colleagues (2011), can motivate participation in discussions that “‘unearth’ personal connections and relationships to contentious scientific issues” (p. 300). In my bounded case study, I found that class discussions presented multiple opportunities for students to engage in learning about physics and to connect their learning to contemporary issues. It is precisely this application of physics to current events/issues that entices students and excites them about learning. In an attempt to view the interconnectedness between science and social sciences in this research, the
nine focus students were interviewed and data were transcribed to explore students’ perceptions of STSE matters. The following are questions relevant to this issue that were asked during the interviews:

I. How did you feel about having STSE-issues incorporated into the science curriculum?

II. Please provide examples of what you have done in science classes.

II. What did you like or not like about having STSE-issue discussion in your science class?

In response to these questions, students provided a number of reasons as to why they liked STSE-based discussions in physics and not just how they felt about the issues. In fact, all nine of the focus students (100%) from the physics class expressed that they liked STSE-based issues discussions and none of these students noted any dissatisfaction nor dislike towards STSE-issues based physics discussions. Figure 4.1 shows a summary of physics students’ experiences with the online STSE-based physics discussions in response to the interview questions.

![Figure 4.1: Summary of students’ experiences with the online STSE-based physics discussions.](image-url)
The nine focus students responses to the interview questions suggested they had a positive experience using STSE-based discussions in their physics course because the socially-related physics discussions engaged and helped them connect science concepts to their personal lives instead having to learn science in a traditional teacher-directed and decontextualized approach. Excerpts from all nine focus group participants have been included in this section to illustrate not only their enthusiasm for STSE-based discussions in physics, but also to demonstrate the reasons behind their positive responses. It is important to note that pseudonyms are used to identify students’ comments. The following is a list of all responses from the focus group to the first interview question regarding how students feel about having STSE-issues incorporated in the science curriculum:

- I liked involving it [STSE] because it was more application not learning knowledge. (Esther)

- It [STSE] makes it a lot more interesting because you can actually apply what you are learning to real life. (Veronica)

- I enjoyed it [STSE] because it does bring awareness of what’s going on in your world. (Holly)

- I felt that the STSE discussions wasn’t a drag but connected to science and society. (Violet)

- I like it [STSE] because it’s more like, it’s not just equations and stuff, it’s applied. (Daisy)

- [STSE] was pretty good because you explore and apply science to normal life and Future. (Rosa)

- I think that it [STSE] was a good idea because it’s [about] everyday issues. (Dahlia)

- With STSE questions, it felt good to say what you thought, like energy and Canada. (Flora)

- I am interested in science related topics [STSE]. It was nice to voice an opinion on stuff. (Azilia)

(Focus Students, Interviews, June 2011)
As noted above, students’ comments indicate positive attitudes towards STSE course-related issues with terms such as “I like involving in it, more interesting, brings awareness, not a drag, good idea” (Ayyavoo, Personal Interviews, June 2011). Wishart, Green, Joubert and Triggs (2011) also note (in a study on developing ethical arguments in science) similar positive attitudes of students’ toward science and society discussions. These researchers note that students show motivation and enjoy the opportunity to be challenged by linking science to socially-related research projects (Wishart, Green, Joubert & Triggs, 2011). Similarly, in my case study I found that all nine focus students support and favour the use of STSE-based discussions in physics. Indeed, the data indicates that these physics students feel empowered from STSE-based discussions in their class and believe that including social-techno-scientific issues in their course means the real application of physics in their lives. For example, in the interviews students used terms such as, “aware, explore, apply, connect and voice” (Ayyavoo, Personal Interviews, June 2011) showing that they were learning science by applying science to everyday life. Zeidler, Osborne, Simon and Monk’s study (2003) show a similar positive response to STSE, where they reveal the positive attitude displayed by millennium students towards STSE-based topics, and concluded that learning science content with practical application and implications makes science relevant to student lives (Zeidler, Osborne, Simon & Monk, 2003).

According to Roehling and colleagues (2010), Millennium Generation students (born between the 80s and mid-2000s) have a low tolerance for boredom and require a high level of stimulation with discussions. This is of particular relevance to this dissertation, as all participants in the case study are Millennium Generation students born in the 1990s. With an increased digital presence in students’ lives, technology invites students to come to their own decisions as evidenced in the interview comments. For example, one focus student said “STSE-based
discussions connect science to society” (Veronica, Interview, June 2011) and another suggest that STSE discussions provide opportunities “to voice out [their] opinions” (Azilia, Interview, June 2011). This voicing of opinions suggests that students are actively engaged in learning and that they are critically thinking about what they are learning in their physics course. This level of critical thinking may indicate that students actually want to understand, explore, dialogue and challenge each other to seek solutions to real world events (Duncan et al., 2010; Mrazek, 2004).

In exploring students’ STSE views in this study, several interesting re-current themes surfaced from student interviews and these will be discussed in the next section of this chapter.

4.3 Themes that Emerge from Doing STSE-based Discussions in Physics

Four central themes emerge from an analysis of the interview transcripts and online discussion transcripts of the nine focus physics students in this bounded case study. These themes reveal that students explored and understood physics in connection to STSE-based issues. These STSE-based discussion connections to physics were as follows:

1. STSE - learning about physics concepts;
2. STSE - applying physics to their personal lives;
3. STSE - connecting between physics concepts and the physical environment; and
4. STSE – connecting between physics and socio-political-ethical issues.

Each of the above themes is discussed in detail in the sub-sections that follow.

4.3.1 STSE - Learning about physics concepts. The students involved in this bounded case study revealed that they enjoyed learning about STSE-based issues because this allowed them to learn physics concepts. This section provides an analysis of the interview transcripts to illustrate how STSE was described by students as a means to learn concepts in physics. Veronica for example, states in an interview:
In this interview excerpt, Veronica reveals that the STSE-based physics discussion on F1 Tires (Formula 1 Tires) discussions is not only interesting but one that produces an opportunity to build on physics concepts she studies in class. Indeed later on in the same interview, Veronica states, “It [STSE discussions] makes it a little bit easier to understand the physics concepts, I find, because some of them are pretty abstract” (Veronica, Interview, June 2011). It was important to Veronica to understand the value in learning about the physics concepts in relation to practical world views. Veronica particularly expressed the physics concepts that she had learned by discussing friction and surface area of racing car tires. Veronica identified the application of physics concepts embedded in the STSE issue and how they relate to real life and enable her to learn about physics. Several researchers support this notion that learning science content and concepts is enhanced with socially-related issues discussed in science (Sadler, Barab & Scott, 2007; Sadler, Chambers & Zeidler, 2004). Indeed, several researchers describe that students transfer their understandings developed in a socially-related science context to their learning about science concepts (Sadler, Klosterman & Mustafa, 2011; Sadler, et al., 2007). This occurs by way of ‘socio-scientific reasoning’ (Sadler et al., 2011). This concept of reasoning is explained below:

As a means of framing transfer relative to SSI, we proposed a new construct, socio-scientific reasoning. Socio-scientific reasoning (SSR) was designed to capture the practices in which citizens can be expected to engage across multiple SSI. That is, socio-scientific reasoning was developed as a means of understanding student practices relative to the invariant features of SSI. (Sadler et al., 2011, p. 46)
By using socio-scientific reasoning, learners interact with social issues and become aware and better prepared to manage and negotiate the different scenarios of social issues. Sadler and colleagues’ (2011) concept of socio-scientific reasoning is evidenced in my interview with Veronica, who highlights this type of reasoning when she states:

I think discussing STSE issues made it a lot easier for me to remember concepts. Like I said before, how abstract they are, because if you are writing a test or a quiz or something and all you see is letter and numbers, you are just like, ‘this isn’t very applicable, how to do I memorize this.’ And all you think about is memorization. Whereas when you actually have the backup information with STSE, you can remember certain scenarios, certain articles that you’ve have read, certain bits of information that actually help you probably a lot better, because not only are you memorizing the data, but you are understanding it…So…yeah. (Veronica, Interview, June 2011)

In this excerpt, Veronica explains how STSE discussions informed her understanding of physics concepts. Engaging in STSE based discussions meant that Veronica did not rely on memorization of physics concepts to study for tests, but rather was able to recall STSE-based scenarios from class discussions to understand physics concepts. In her interview response, Veronica uses physics concepts to explain how STSE informed her learning, “We talked about friction with the tires, and that really helped a lot because it helps you to remember how they’re either inversely proportional or not” (Veronica, Interview, June 2011). Veronica is using the term ‘inversely proportional’ to link friction and tire treads, which are terms she learned in physics, and is making connections to STSE.

In my own teaching experiences, I have seen the benefits of students learning concepts by understanding instead of relying on rote memorization. Geertsen (2003) supports the use of scenario based learning and points out some medical schools are increasingly relying on problem solving learning as opposed to memorization. Geertsen explains:

Many medical schools now have switched to a problem-based curriculum where the emphasis has shifted from memorization and problem solving learning is organized around medical cases that cut across specialty boundaries (learning across the
curriculum) and thinking skills (analysis, synthesis, transfer) in an effort to check excessive specialization in medicine. (p. 15)

Likewise, the emphasis in the physics classroom shifted from memorizing physics concepts, such as coefficient of friction, frictional force versus normal force (Ontario Science Curriculum, Grade 11 Physics Strand C – Forces, 2008), to using STSE-based scenarios to reinforce the learning of such concepts. Similarly, Dahlia explains how STSE-based discussions influenced her understanding of physics concepts. She states, “It helped us with the first one [first STSE based discussion on Friction], with the tires. And the second one [the STSE based discussion on the Use of Green Energy], it helped, I guess again, with physics and chemistry with the gases that are emitted” (Dahlia, Interview, June 2011). Dahlia reveals that STSE helped her learn not only physics concepts, but she also shares how STSE provided her with an interdisciplinary understanding of chemistry concepts. Azilia too, highlights how the STSE-based scenario helped her understand the concept of friction when she states:

I actually didn’t know what the grip lines on tires [are]…I didn’t actually think it [tire grip lines] did much. I didn’t think it made a difference and stuff, but after this, I realized that you actually have different tires for winter and different seasons depending on the friction. (Azilia, Interview, June 2011)

In this example, Azilia is exploring the grip lines on tires and making connections to the concept of friction in physics. Her comment demonstrates that using the STSE-based discussion on winter tires possibly gave her a clearer understanding of the concept of friction.

In summary, both Veronica and Azilia learned about physics concepts of Friction using STSE-based scenarios. Veronica and Azilia talk about their conceptual understanding of physics concepts developed in a socially-related science context to their learning about science concepts (Sadler, Klosterman & Mustafa, 2011; Sadler, et al., 2007). The use of STSE-based issues to learn physics concepts is supported by Pedretti and Nazir’s study of STSE currents (2011). Pedretti and Nazir (2011) highlight the application/design current as being one where students
apply their knowledge of science concepts to design new technology or solve a problem. In my study, students learned concepts by studying problems, and as such, demonstrated the physics application aspect of the application/design current discussed by Pedretti and Nazir (2011). However, a key difference which emerges is that the dominant approach in my study was cognitive, and not one in which students actually created a new product. In other words, they learned about concepts by studying socially-related physics problems (such as winter tires). Hence, using STSE-based scenarios not only supports students in learning about physics concepts, but also reveals that they are applying physics concepts to their own lives. This application of physics to their personal lives will be discussed in the following sub-section.

4.3.2 STSE - Applying physics to their personal lives. In this case study, the interviews and the online discussion transcripts both revealed that students made connections between physics and their lives, as a result of engaging in STSE-based discussions. In addition, the online threaded discussions on STSE issues reveal that students made particular connections between physics concepts on Friction in tires and the Use of Green Energy in their personal lives. These findings are discussed in detail in this section.

In my interview with Esther, she began by discussing how STSE issues helped her understand concepts in physics and then went on to connect these STSE scenarios to her own dreams of being a nurse. Esther’s comments follow:

I guess like I said before, it made me think more of the real life application side of science, because when you’re in school and a lot of the time, especially in elementary school, when you learn science, you are just taught terms, you’re taught definitions and equations and you’re sitting there and you think ‘okay, this is all I’m going to need for the rest of my life.’ And then, when we did these STSE questions online, it sort of made me go ‘oh, science is applicable to real life.’ I’m going into nursing, so I’m sitting there thinking…especially when I’m in chemistry now, I’m looking at it and I’m saying, ‘okay, Solutions Chemistry, how is it relevant to nursing.’ So it makes me think more about how it’s relevant to real life. (Esther, Interview, June 2011)
Esther states that the STSE-based scenario helped her understand the application of science to her future dreams of entering the nursing profession. Furthermore, Esther makes connections between physics and other courses, in this case, chemistry, as a result of her experience using STSE-based scenarios. Her exclamation of “…oh, science is applicable to real life” reveals her deeper understanding of concepts as well as an interdisciplinary understanding of science.

In another excerpt from a student named Violet, she explains how science (particularly physics concepts) could be used in her daily life, but expresses her struggle with implementing the concepts. She says, “I’d say we could use science in our daily lives, but I never knew how to actually do it. For the energy product, now I’m thinking if I have my own house, I want to use solar panels, because it’s a really good energy saver and also [about] the developing countries” (Violet, Interview, June 2011). In this short excerpt Violet expresses her desire to use solar panels after understanding the energy saving benefits that she learned from the STSE-based discussions. In fact, Violet begins her reflection by thinking about the application of physics to her personal life and extends her thoughts to ideas about problem solving for developing nations.

In excerpts from the online threaded discussions, both Dahlia and Veronica express their views of how Ontarians should follow Quebec’s lead to make snow tires mandatory in winter times. Dahlia connects the positive values of such decisions in terms of road safety in her own life and discusses how she would like to talk to her parents about buying snow tires as a result of learning about friction and its application to snow tires in the STSE discussion. Dahlia states:

I would convince my parents to invest in snow tires for the winter months by telling them all of the positive factors about them [snow tires].I would tell them how it is proven that winter tires improve breaking by 25 percent. I would also remind my parents that they have a family, and that it is important to know [how not] to put anyone’s life in danger. (Dahlia, Online Discussion Comment, May, 2011)

In this excerpt from the online threaded discussion transcript, Dahlia makes a connection between physics and her personal life by expressing her intention of wanting to convince her
parents to invest in snow tires during winter months. In this example, she intends to use her knowledge of physics which she gained from the STSE discussion to share with her parents. In particular Dahlia intends to use the information she learned, namely the fact that winter tires improve breaking by 25 percent. Her intentions are to focus on her family’s safety and the safety of others on the road.

Veronica expresses a similar application of physics to her own life in the STSE-based discussion on snow tires. Like Dahlia, Veronica is concerned about snow tires being made mandatory in Ontario. In positioning the value of snow tires during winter she points out both her understanding of reduced friction in tires and also addresses the safety concerns on winter roads. Veronica’s text-based online discussion reads:

I believe that Ontario should indeed make snow tires mandatory in winter months. This is because automotive accidents are at their apex during the winter. This is due to ice/snow reducing the amount of friction on the roads. With less friction, this makes controlling the car much more difficult. Since treaded tires increase the amount of friction, this will compensate for the slippery roads. The best way to convince my parents to invest in snow tires would be inform them of the hazards of driving in winter without snow tires. I would take into account that they are very expensive, however no monetary value could ever compare to the safety and wellbeing of one’s family.

(Veronica, Online Discussion Comment, May, 2011)

Veronica is concerned about safety on the road during the winter months. She further reiterates her understanding of how snow tires reduce friction and the importance of this in relation to being able to maneuver cars during winter conditions. Interestingly, her approach to convincing her parents stems from sharing her comprehension about the hazards of driving without snow tires. She realizes the expense involved in buying winter tires but prefers to convince her parents to be safety conscious and care for wellbeing of family members as important criteria for making democratic decisions on buying winter tires.
Veronica’s reasoning reveals a value centered approach (Pedretti & Nazir, 2011), as she discusses making decisions about socio-scientific issues by through consideration of her values. In this case, Veronica reveals that safety is of utmost importance to her and that she values safety above any monetary cost. STSE-based discussions, as in this case study, recognize that science education may encourage more positive view of the concepts of science which can be used to resolve conflicts and recognize the democratic decisions that citizens can make (Albe, 2008; Sadler, 2004).

Using STSE-based scenarios not only supported students in learning about physics concepts, but also encouraged them to apply physics to their personal lives. Both the interview transcripts and the online discussion data also reveal that besides applying physics-related STSE discussions to their personal lives, students also discuss STSE topics in relation to their physical environment. This will be discussed in the following sub-section.

4.3.3 STSE - Connecting between physics concepts and the physical environment.

Students were able to make connections between physics concepts and the physical environment, when engaged in an STSE-based discussion focused on the topic of the Use of Green Energy. Specifically the teacher asked students to make connections between physics and the concept of the Use of Green Energy, as opposed to non-renewable energy sources, for example, coal. In this conference, the topic of the Use of Green Energy necessitated a discussion on the physical environment. However, it is worth noting that the teacher’s questions shaped the outcome of students’ thinking and their connection of physics (in terms of the Use of Green Energy) to the physical environment. In this STSE-based discussion, the teacher thus scaffolded the questions by presenting both physics concept application questions and then STSE-based questions. These questions merit being repeated:
1. STSE-based issue questions:

a. We as a society tend to look at cost analysis to determine which energy source to use without looking at the overall effect to the environment. What is more valuable? Explain your reasoning.

b. Is it fair for rich developed countries to force poor developing countries into using expensive renewable sources of energy? Should the developed countries assist the developing countries in developing renewable sources of energy? (Appendix L)

Student responses to the above questions reveal a connection between their understanding of how physics concepts are related to both the physical and social environment. Indeed, students often discussed both the physical and social environment in the same responses. In this section, I will provide an analysis of student responses to both Parts A and B of the STSE question set out by the teacher on the topic of the Use of Green Energy. I will also include a discussion connecting my findings to Pedretti and Nazir’s (2011) value centred and logical reasoning currents. To reiterate, STSE education is conceived as currents or collection of ideas, principles and practices that tend to constantly change with different situations where ideas from earlier discussions may simply dissolve or merge and develop into new waves of ideas (Pedretti & Nasir, 2011).

In the two excerpts below from the online threaded discussions, both Esther and Veronica express the connections made between physics concepts of non-renewable and renewable energy and the physical environment. Both Esther and Veronica present different viewpoints using different value systems connected to students’ own values, beliefs and experiences. In this question, they were asked to respond on how our society tends to look at cost analysis to
determine which energy source to use without looking at the overall effect to the environment.

Esther comments through an online discussion response:

The overall effect to the [physical] environment is ethically more important. While economically, cost analysis seems to be the more important aspect to be looked at, a price cannot be put on the effects that some energy sources have on the environment. For example, the negative effects of coal seriously outweigh the cost, whereas wind power has little to no negative effects on the environment. The repercussions that accompany some forms of energy are more important, as they affect us and our future. While money can be made, our world is delicate and needs to be taken into high consideration.

(Esther, Online Discussion Comment, May, 2011)

Esther’s comment focuses on environmental degradation when coal is used to generate electricity. She prefers wind power as an alternative form of energy source to that of a coal dependent energy source in generating electricity. She stresses that by switching to wind power fewer negative effects are produced on the environment as compared to using coal to generate electricity. Esther places more emphasis on environmental care than economical cost to generate cheaper energy, and as such reveals her decision making process as being centred on her own personal moral reasoning (Pedretti & Nazir, 2011). Similarly, Zeidler and Sadler (2008) promote that classroom scenarios are important for students to present their ideas, their own values and also genuinely express their critical discourse associated with their own values system which is more meaningful to them.

Comparing Esther’s and Veronica’s value system, one can identify differences in values in relation to the question on the decision of whether to use renewable or non-renewable energy as shown in the excerpt. Veronica explains in her online forum:

Given the fact that I am not very knowledgeable, nor experienced in financial and environmental matters, my opinion on this topic may not be entirely sound. I personally believe that even though both sides to this argument [i.e., financial versus environmental] weigh equally heavily in my mind, I lean more to the economic concerns. It is easy to say that one should not put a price on the well-being of the planet Earth, but what about its inhabitants? Global warming is an issue of the future, poverty and human rights are issues of the present. I believe that more philanthropic action needs to be taken and that money should be spent on efficient energy that is affordable for people who are
financially unstable. If people can’t even afford basic human necessities in this world, then their government should direct their financial concern appropriately. (Veronica, Online Discussion Comment, May, 2011)

Veronica’s views are based on a different value point from Esther’s stress on environmental matters. Veronica places her emphasis instead on humanity and considers the immediate needs of the citizens in impoverished parts of the world. Veronica’s viewpoint values humanity while Esther’s values the state of the environment. Both examples reveal how incorporating STSE-based discussions in the curriculum allows students to present their values (Pedretti & Nazir, 2011) in relation to socioscientific issues. Opportunities to discuss STSE issues through text-based discussions, as in this case study, enable students to freely choose and defend their personal values for each issue. Researchers (for example, Bell & Lederman, 2003; Hodson, 2003; Sadler, 2004; Zeidler et al., 2005) claim that human values and emotions are intrinsic part of citizens’ decision making skills and that science education is laden with values which are often not adequately explored. Pedretti and Nazir (2011) explain that:

The value-centered current seeks to address this gap by highlighting science as a value laden enterprise. The focus is on enhancing student understanding and/or decision making about SSIs through an explicit consideration of ethics and moral reasoning. 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. 14)

The differing viewpoints of Esther and Veronica hinge on their conceptualizing of STSE-based issues in relation to their own personal and moral decisions. Students use their knowledge of science concepts and connect with their physical environment using different value systems that rely on different cognitive knowledge, moral development and experiences. Thus, science students who express a diversity of values tend to identify meaningful contexts which can further be developed by considering socio-political—ethical issues—the subject to which we now turn.
4.3.4 STSE - Connecting between physics and socio-political-ethical issues. A final theme which emerged in my analysis of both the online discussion transcripts and interview transcripts is the connection students made between learning physics concepts and socio-political-ethical issues in their lives, as triggered by STSE-based discussions. The data here are rich with description, as students elaborate on Canada’s ethical responsibility in helping developing nations support and develop renewable sources of energy. Specifically, students answered the following question from their teacher, “Should Canada continue to use coal to generate electricity? Is it ethical for Canada to do so?” (Classroom physics teacher, Online Discussion Question, May 2011). This section highlights the importance of STSE-based scenarios in the science classroom, by exploring the interdisciplinary points of view presented by students in relation to topics connected to physics. In this section, I also connect students’ discussions (both interviews and online responses) to Pedretti and Nazir’s (2011) discussion of currents in STSE, specifically focusing on the socio-ecojustice current and the value-centred current.

Bencze (2008) argues that science cannot be considered in a ‘closed system with scientists making decisions freely without influences’ (p. 302) and thus separated from socio-political-ethical viewpoints. This view of the interconnectedness and influences of various factors affects not just one sector of the globe but all areas of the world. Two students express such views in the global context as they claim:

Canada should not continue to use coal to generate electricity because it releases a lot of gases which contributes to climate change. Especially because Canada is one the countries which uses the most energy, coal can contribute greatly to the climate change of not Canada but the whole world. It is not ethical for Canada to bring down the whole world because of the burning of coal. (Dahlia, Online Discussion Comment, May, 2011)
I think Canada should not continue to use coal as we ourselves do become upset at the amount of pollutants in the atmosphere. We shouldn’t put it to the side and blame others when we ourselves do not treat the earth correct. No, I don’t think that is ethical for Canada to do so. This is because we need to help other countries with helping our earth. As it is, ‘our’ earth not one specific country. (Flora, Online Discussion Comment, May, 2011)

Both these students consider the closed system of our planet earth where the action of each country impacts another. These students believe that Canada should not be a contributor to the pollution that affects the whole world. These students believe that the action of Canadians is having an impact on other countries and that Canada needs to stop using coal powered generating power plants. However, it is interesting to note that students are not additionally suggesting that they be the agent to stop Canada’s role in global pollution. In other words, students identify the problem, suggest solutions, but then fail to see themselves as having an active role in implementing the solution. Hodson (2003) underlines this point by suggesting that students are not prepared for any sociopolitical action. He states that “schools need to overtly politicize forms of science actions” (Hodson, 2003, p. 653).

Despite students not showing any action plan to stop Canada’s role in pollution, the focus students in this study continue to show the intertwined interactions of the economy and its impact on ethical decisions. As Veronica states:

Canada being a very wealthy country has both the financial ability and the alternative energy source to sustainably and sufficiently wean off of coal. Having said that, … I believe that Canada should stop using coal to generate electricity. This is unethical to greedily abuse harmful resources when there is a viable, safe and renewable alternative energy. (Veronica, Online Discussion Comment, May, 2011)

Another student discusses health issues connected with the coal generating power plants.

Esther adds to the discussion of interrelated issues with coal generating power plants:

In my opinion, Canada should not continue using coal as a source of electricity. Not only is it a non-renewable resource (meaning it will eventually run out) but it contributes to the production of greenhouse gases, such as carbon dioxide. It is not ethical for Canada to be using coal to generate electricity when the repercussion of such will destroy our
environment as well as cause health issues in us. When there are so many alternatives available, Canada can change and use more ethical and renewable source of electricity. (Esther, Online Discussion Comment, May, 2011)

Here, Esther discusses not only the environmental impact of greenhouse gases, but also the health issues brought about by coal used to generate electricity. This student introduces the consideration of health issues to assessing the various impacts of coal operated power plants upon society. Esther, Dahlia and Flora seem to be aware of health issues produced by pollution but do not propose action or activist movement in solving the issues. Hodson (2003) highlights this lack of agency when he mentions that there is a “need [for] much more overtly politicized form of science education, a central goal of which is to equip students with the capacity and commitment to take appropriate, responsible and effective action on matters of social, economic, environmental and moral-ethical concern” (p. 653). Bencze and Sperling (2012) also recognize that more serious educational steps are required to encourage students to become citizen activists who can take social and personal actions associated with such issues.

4.4 Conclusion

In summary, the student participants felt that the computer-mediated discussions had promoted a greater opportunity to discuss STSE-based issues. The overall theme which emerges in both the interviews as well as the online discussion transcripts, as explored in detail in this chapter is that students feel discussing STSE-based physics topic allows them to understand the application of physics concepts in their own lives. Furthermore, students discuss how using STSE topics in physics allows them to make more accurate connections to physics concepts and provides them with a more sophisticated understanding of the role of physics in STSE topics, and consequently, to society as a whole.

As discussed in this chapter, four key themes emerge in relation to students’ experiences of doing STSE-based work in their physics course:
I. STSE to learn about physics concepts;

II. STSE helps students to apply physics to their personal lives;

III. STSE allows students to make connections between physics concepts and the physical environment; and

IV. STSE allows students to make connections between physics and socio-political-ethical issues

The data reveal that students are able to make connections between physics and their lives. In some cases, physics concepts themselves were better understood as in the case of Friction on Tires. In addition to learning concepts, using STSE-based discussions allowed students to make connections between physics and their personal lives, as well as physics and students’ own social-physical environment. Finally, as a result of the STSE-based scenarios presented, students made connections between physics and socio-political-ethical issues that were important to them. Their reflections, both in the interview transcripts and in the online threaded discussions, reveals an application of Pedretti and Nazir’s (2011) STSE-based currents, specifically the value-centred and socio-ecojustice current.

In the next chapter, my results and discussion will focus specifically on how the medium of the online forum supported students in learning about STSE-based issues. I will explore how the online forum provided students with the time and space for reflection, and I will connect my findings with Pedretti and Nazir’s logical reasoning current within their STSE model (2011) and the Practical Inquiry Model of Cognitive Presence (Garrison et al., 2000).
CHAPTER V
RESULTS AND DISCUSSION – PART 2
The Nature of Science Students’ Online Discourse in the Context of STSE Education

5.1 Overview
This chapter explores the second research question, which focuses on the nature of science students’ online discourse in the blended (online and offline) learning approach. The discussion transcripts are analysed at both the macro and micro level. At the macro level, I analyse the online transcripts for the number of online threaded discussions, number of postings within a one to five day timeframe, and compare the number of postings between the first and second STSE-based discussion. At the micro level, I analyse the text of the online threaded discussions in relation to the four different phases of the P.I. Model. Through my analysis of the threaded discussions I form a correlation between the message postings and the phases of the P.I. Model. Finally, I also include a brief discussion on the teacher’s role in facilitating the online STSE-based discussions.

The text-based threaded online discussions of STSE issues in physics are cognitively interactive opportunities which provide more time for students to become aware, search for detailed information, think and reflect on discussion issues before contributing to e-(electronic) discussions (Arend, 2009; Derier, 1999; Dringus & Ellis, 2004; Hewitt, 2001; Kear, 2001; Meyer, 2003). De Wever and colleagues (2006) further expand that all communication elements are made explicit in written text-based contributions, thereby making the process of communication more transparent. These online discussion transcripts are used in conjunction with the students’ post-study interviews to explore the critical reflective abilities of the grade 11 senior physics students.

In the next two sections of this chapter, the online discussions and interactions are
analysed at both macro and micro-levels (Schrire, 2005). I begin with the macro-level interaction in section 5.2 which describes the participant to participant discussions through the threaded postings. Later in the micro-level interactions, I describe the quality of participants’ threaded STSE-based discussions. The primary focus is to analyse the computer-mediated discourse transcripts to gain an understanding of the nature of science students’ online discursive behaviour.

5.2 Macro-level Online Discussion Transcript: Threaded Posting Patterns

At the macro-level of discussion threads, the quantity of STSE-based discussions is one indicator of students’ ability to reflect and use the STSE-based problems in the online discussions. In this study the two discussion topics were Friction in Tires and the Use of Green Energy. Observations included the number of student postings to the teacher’s questions and the number of peer threaded postings made within a one to five day period. In addition to this, students’ approaches to the threaded discussion content, and the type of peer postings with respect to the phases (Schrire, 2006; De Leng et al., 2008) of the P.I. Model were also analysed and discussed. The results with respect to the type of postings and the phases of the P.I. Model are shown in Table 5.1. The percentages that appear in each cell of Table 5.1 are calculated using the total number of students in the class of 23 students. For example in the first STSE discussion topic, 19 students posted in response to teacher’s discursive questions. The total postings were divided by 23 students in the physics class then multiplied by 100%. This indicated a response rate of 83% (i.e., 19/23 x 100%). A discussion of these data is included following the table.
Table 5.1
*Macro-level interactions identified from the two different online STSE-based Physics discussion topics*

<table>
<thead>
<tr>
<th>Individual Posting (Percentage) Number of Students</th>
<th>Threaded Discussion Postings (Percentage) Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posted to Teacher’s Discursive Questions</td>
<td>First Threaded Response</td>
</tr>
<tr>
<td>3 Postings within Same Day</td>
<td>Second Threaded Response</td>
</tr>
<tr>
<td>3 Postings within 5 Days</td>
<td>Total Threaded Postings</td>
</tr>
<tr>
<td>1st STSE Topic Forces and Technology: Tires</td>
<td></td>
</tr>
<tr>
<td>(83%) 19</td>
<td>(83%) 19</td>
</tr>
<tr>
<td>(57%) 13</td>
<td>(78%) 18</td>
</tr>
<tr>
<td>(26%) 6</td>
<td></td>
</tr>
<tr>
<td>19 + 18 = 37</td>
<td></td>
</tr>
<tr>
<td>2nd STSE Topic Energy and Society: Green Energy</td>
<td></td>
</tr>
<tr>
<td>(87%) 20</td>
<td>(78%) 18</td>
</tr>
<tr>
<td>(61%) 14</td>
<td>(74%) 17</td>
</tr>
<tr>
<td>(26%) 7</td>
<td></td>
</tr>
<tr>
<td>18 + 17 = 38</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* The total number of students (23) in class remained the same throughout the semester.
Total post for 1st STSE topic: Teacher’s Initial post + Total threads = 19 + 37 = 56 responses
Total post for 2nd STSE topic: Teacher’s Initial post + Total threads = 20 + 38 = 58 responses

Both STSE-based discussion conferences included the class of 23 students and their physics teacher. With reference to Table 5.1 (Macro-level Interactions), 4 students in the first conference and 3 students in the second conference did not fully participate in the discussion forum, as they did not respond to the teacher’s initial posting. Reading, understanding and responding to threaded controversial issues in the physics course outside of class time may require additional effort and time from students which may pose as an inconvenience. Many of these high school students may have secured part-time jobs after school or may be required to manage family and household chores. The excess online work or assignment may seem to be a
burden beyond completing other assignments, studying for test or writing essays in other courses. Daisy mentions in the post-study interview that, “I would forget to go online sometimes and it would take a while to remember” (Daisy, interview, June 2011). Forgetting to read and post online within a given timeframe (e.g., 1 week to post) could be an issue for busy students. This could perhaps be another obstacle that some students encounter with asynchronous online posting.

Besides accounting for the some students who may not post their views, most students manage to read and interact online through text-based responses. For the first forum, 19 students participated with their initial post to the teacher’s questions on the Friction on Winter Tires. A total of 37 threaded responses were found for these 19 participating students. Meanwhile in the second forum, 20 students participated with their initial post to the teacher’s discussion questions on the Use of Green Energy. A total of 38 threaded responses were found from these 20 participating students. In both forums, a common pattern that emerges is that some of the participating students posted less than 2 threaded messages each. In the next section, these results are analysed in more detail. This following section will also include a comparative analysis and the interpretation of the in-class and online participation levels of the two STSE-based discussions.

5.2.1 Interpretation of student postings on the discussion board. The results in Table 5.1 reflect the class interactions during the two STSE-based discussion conferences between the 23 students (including the nine focus students) and the teacher. In comparing both the STSE-based conferences, the total number of participants’ responses is fairly similar with 56 responses in the first STSE-based discussion and 58 responses in the second STSE-based discussion. If all 23 students had submitted their initial and subsequent two peer responses, the
theoretical number of threaded postings would have been $23 \times 3 = 69$ responses for the physics class. In this case however, full participation was not observed. As mentioned earlier, 19 students participated in the first STSE-based discussion and 20 participated in the second STSE-based discussion. To establish the total response percentage of participants, I employed a calculation based on the theoretical total number of possible postings. The following calculation was employed. If the current 56 student postings (in the first STSE-based discussion forum) were divided by 69 theoretical student postings and multiplied by 100%, then it would produce a fairly well attended result with 81% (i.e., $56/69$) for the first STSE-based online discussion responses. Similar occurrences of student postings were observed with 84% (i.e., $58/69$) for the second STSE online discussion responses.

The average 83% online participation level is compared to the in-class participation level. A higher percentage of students were involved in online dialogues (that is, between 81% and 84%) compared to the in-class discussions where 30% of the students (calculated from $7/23 \times 100\%$) were involved in the class discussions recorded from an in-class discussion observation. This figure of 30% is based on my observation of 7 out of the 23 students participating in the in-class discussion. It is also noteworthy that, during my in-class visits, of the 7 students who participated in the in-class discussion, only 3 were part of the focus group. Hence, a clear finding that emerges from this data is that there are a greater percentage of students participating in discussions in the online forum. Also noteworthy is the fact that there was a small increased overall participation from 83% to 87% from the first to the second STSE-based online discussions. It must be mentioned that these data are not inferential statements made about grade 11 physics students. Instead the data is presented to indicate descriptive numbers involved in this case study and to show student involvement in STSE-based discussion postings.
In both STSE-based discussion conferences, the teacher crafted the original problem and questions, posted this problem online, and requested that students participate by responding to the original post to create peer threaded responses (see Chapter 3 of section 3.5.2 and appendices K and L for computer screen shots). Students were provided with clear instructions as to the frequency of postings in threaded discussions especially online. They were instructed to post at least two threaded postings per STSE-based conference.

Since they were instructed to post a minimum of two, there were no students who had posted not more than two postings as required by their teacher. Students were given a timeframe of five days to respond to the teacher’s original post and to craft two peer threaded responses of their choice. Most students’ comfort level and familiarity with technology, in this case study, had directed the teacher to establish the timeframe (see, email communication with teacher in Chapter 6). This physics teacher was able to gauge students’ comfort level from her past experience with managing similar online discussions. Picolli, Ahmed and Ives (2001) and Gerbic (2010) are researchers who were able to identify high comfort level with students learning with computer-mediated technology. They found that students with more experience using technology in their learning tend to have a positive attitude and perform better in an online learning environment.

Bassett (2011) states that collaborative online discussion is valued by many students who use the virtual environment for information exchange. Bonk and Zhang (2008) add that with good teacher’s guidelines for the online discussions, many students favour virtual discussions. In this case study, the higher participation in the online class discussions versus the in-class class discussions was noted which can be attributed to the first and foremost the teacher’s instructions and coupled with other possible reasons. Some of today’s students are digital natives who are
‘thumb tribe’ communicators and as such are familiar and comfortable with using technology to communicate with their peers. Therefore, they adapted quickly to the structure of the online discussion forum and were comfortable using it. Rosa states, for example, “…when you’re on the computer, it’s more free and unrestricted, but in class it feels sort of pressured to speak out” (Rosa, Interview, June 2011). In this excerpt Rosa describes her comfort with conducting online text-based discussion. Several researchers suggest that today’s students are digital natives who are comfortable with the use of technology within schools and communication devices through texting in their personal lives (Adams, 2008; Basset, 2011; Prensky, 2001).

Computer-mediated communication enables students with the flexibility of time to rethink and analyze their thoughts (Basset, 2011; Furberg & Ludvigsen, 2008; Wang & Woo 2007).

According to Levinson (2006), thought provoking controversial topics inspire learners to link, for example STSE-based topics such as embryo selection and waste disposal, to science content. As in this case study, students are intrigued by the physics dependent STSE-based discussion topics where students have the time to reflect and conduct further research into topics that are relevant to their lives. Esther, for example, states, “Well, I read through the question and I tried to understand it and I tried to research it as much as possible, in connecting with my own knowledge of it” (Esther, Interview, June 2011). Two other focus students also addressed their knowledge and made a personal connection between the STSE-based topics and their own lives. Discussed in depth later in this same section, Violet speaks of relatives in Philippines while Veronica addresses her connection to family in the Third World countries in their interviews with respect to Use of Green Energy. The sociocultural aspects of science (Pedretti et al., 2011) are thought of and discussed by students when socially-related scientific issues are introduced in their physics course. Researchers, who are proponents of incorporating socially-related issues in
science, identify diversity of cultures and traditions as an important component to incorporate in courses to support learning and to create a meaningful context in science courses (Bencze et al., 2012; Hodson, 2003, Mueller & Zeidler, 2010). Hence, STSE-based topics encourage students to ask questions and may also pique their curiosity when they discover opportunities to discuss sociocultural aspects that are important in their own lives in relation to science.

To sustain participation in student discussions of STSE-based topics, asking questions regarding the science or issues related to science, in other words, inquiry is needed. Researchers identify that science students are not at ease and do not tend to independently formulate questions for arguments dealing with socioscientific issues (For example, Ekborg, Ottander, Silfver & Simon, 2012). Ekborg and colleagues (2012) explore how teachers need to develop strategies to increase student involvement in science. They found teachers in their study appreciated using socioscientific issues to increase students’ interest in school science. They all acknowledged student involvement as a key to engagement in, and understanding of, school science.

Likewise, my case study’s results rested in how the physics teacher’s facilitated online STSE-based discussions. In my study, teacher’s questions triggered and stimulated personal experiences that may elicit information or a higher-order reflective analysis of the situation (Meyer, 2003). Daisy highlights the role of the physics teacher in encouraging students to not only participate online, but to further develop their answers and post them online. She states in the post-study interview, “She [The teacher] pushed us to look at it [STSE discussion] and she pushed us to look at research and to look at readings, and to apply what we knew from it. So she [the teacher] was very helpful” (Daisy, Interview, June 2011). An example of the teacher’s online posts for the class is stated here:
Hi Everyone,

There was an article in yesterday’s newspaper (‘24 Hour’, a free paper) and the headline read: “Green Energy Act to cost Ontarians $310 per household”. The byline read: “50,000 jobs would cost $179,000 in subsidies each”. Do you think this is a negative stand on energy? Do you think it is ethical for media to portray green energy from one point of view? Let’s discuss.

(Teacher, Online Discussion Comment, June 2011)

The teacher’s response to the class encouraged some students to consider social issues in science (in their local newspapers) and to understand more than just the concepts in physics. Her questions framed with the words “do you think” guided students to consider ethical issues in science and may have encouraged some students to pursue further research on the topic of Green Energy being studied. These types of discussions between student-student and student-teacher might also trigger participants’ to respond to analyze, synthesize or evaluate text messages—levels of responses which are related to higher application levels of Bloom’s Taxonomy (Ertmer, Richardson, Belland, Camin, Connolly, Coulthard et al., 2007).

Several researchers’ studies of blended learning believe that asynchronous communication benefits learning and engagement while meeting the social and academic requirements of educational interactions (for example, De George-Walker & Keeffe, 2010; Wishart, Green, Joubert & Triggs, 2011; Garrison & Kanuka, 2004). The opportunity to interact online with student relevant STSE-based issues is effective because it complements the learning styles of both extroverted and introverted students in class. Other researchers propose that computer-mediated activities promote both self-directed learning (while instilling independence and responsibility), and encourage interaction with peers (De George-Walker et al., 2010).

In an attempt to understand student participation in the online discussions, I plotted a graph to compare the frequency of the threaded responses between the two different STSE-based physics topics (see Figure 5.1). The following calculation was employed to show the percentage...
of students who participated in the two STSE-based online discussions. Using the example of
initial student postings, the number of students posted were divided by total number of students
in class multiplied by 100%, that is, \( \frac{19}{23} \times 100\% = 83\% \). To reiterate, each student was
required to provide their responses to the teacher’s initial posted questions and subsequently was
required to respond to any two other preferred peers’ responses within five days.

![Figure 5.1 Comparison of Threaded Response between the Two STSE Topics.](image)

In Figure 5.1, the macro-level participation interactions depict interesting events with respect to
STSE-based issues. To reiterate, these data are not inferential statements made about the physics
student. Instead the data is presented to show descriptive numbers involved in this case study and
to show small increments depicting comparable results. Between the two initial online STSE-
based discussion postings, a small increment in the online class interactions with postings was
identified. Hence in comparing the two online STSE-based discussions, there is a small
discrepancy of students who did not participate by posting their responses. This is indicative of
several possible motivations underpinning the students’ posting rates.

To analyze why students participated the way they did in each discussion the focus group students were interviewed. The post-study interview question read: ‘Did you do anything differently in terms of responding to the two online conferences?’ Their answers revealed a variety of factors that account for the increased participation in the second STSE-based discussion conference. These factors include:

I. Confidence
II. Relevancy of the topic
III. Prior knowledge

Gaudry-Hudson and Yalda (2010) also identify similar factors in regards to the motivations for posting discussions. These factors encompass applying prior knowledge, developing confidence about the postings, reflecting on alternative perspectives, transferring knowledge and drawing connections to field and disciplines.

One of the factors that accounts for this improved participation is students’ feeling of confidence about going online and sharing their ideas especially during the second STSE-based conference. This idea of increased confidence was discussed by several students in the focus group. Violet for example states, “In the first discussion, I read other people’s responses before I responded. But for the second [STSE topic on the Use of Green Energy], I felt more confident to just put my answers up” (Violet, Interview, June 2011). In this example, Violet expresses that having already participated in an online discussion forum, her comfort level with the structure of the discussion had increased, and as such she felt more confident in sharing her ideas.

The relevance of the topic to students’ lives is second important contributing factor to the increased participation during the second STSE-based online discussion conference. When topics
related to the lives of students, they were more motivated to participate in the online discussions. Veronica for example, describes how she was more motivated to participate in the second STSE-based discussion conference because of her interest in the topic. She states:

The first one with the snow tires [first STSE-based discussion on Friction in Winter Tires]...it wasn’t really that much of a compelling argument. It wasn’t really an argument. There were really two sides to it and I pretty much just gave advice and added on to what they were saying. But with second one [second STSE-based discussion on the Use of Green Energy] I thought it was a little bit crazy that everyone said the same thing. ‘Oh yeah, the environment is very important, and we should only help them and we should force third world countries to spend their hard earned money on green energy as opposed to food for their children.’ So I was like, do they even understand what Third World countries go through? Can they actually put themselves in their shoes? Obviously, I live in a privileged society. Obviously I am privileged in that way. I have been to Third World countries. I have family living in Third World countries. I can be sympathetic and understand what it’s like and put myself in their shoes. So that kind of bothered that everyone just was looking at it from a more scientific point of view and looking at it as A+B=C, as opposed to realizing that maybe our priories aren’t the same as that of other countries. So that’s pretty much what I said to them, because I really wanted to make that clear. Maybe they didn’t understand that. (Veronica, Interview, June 2011)

In this example, Veronica explains that she was not as motivated to participate in the first STSE-based discussion around Friction in Snow Tires because the topic was not “compelling.” She expresses that there was little to argue and as such she illustrates the importance of choosing topics that are relevant to the learners. However, in reference to the second STSE-based discussion conference on Use of Green Energy, Veronica spoke at length about the topic. She expresses disdain at the position of her classmates on the issue, and she connects the STSE-based issue to her own experience of being in a Third World country. In Veronica’s eyes, the STSE-based issue of the Use of Green Energy did not have a rigid, correct answer, but rather was a debatable issue that depended on other societal factors (in this case poverty). Veronica’s answer encapsulates the importance of developing STSE-based issues that connect to students’ lives in an authentic way.
Holly, shares the same idea as Veronica in terms of the importance of the relevance of the STSE-based topic. Holly stated in the post-study interview:

If I knew and if I had an opinion on what they [peers] were talking about and if I felt strongly about it [STSE issue], it is easier for me to talk about it [STSE issues]. …if it was something than it was just ‘okay’ [little or no opinion]. … it is not that important to me. (Holly, Interview, June 2011)

In this example, Holly reiterates Veronica’s feelings that she was more motivated to discuss the STSE-based issue if she felt “strongly” about it. As Holly mentions, if there are socially embedded issues in science that have contextual relevance where she feels strongly about the topic, then she would contribute to class discussion.

Similar to Veronica and Holly, Violet also discusses the importance of the relevance of the topic in relation to her motivation. She stated in the post-study interview:

I actually liked it and the topics were interesting, and also because they were related to STSE [STSE-based discussion on the Use of Green Energy] because I really am now looking for solar panels in my own home. And I also have my family in the Philippines and they also have a farm, so maybe I’m going to ask them, ‘maybe you can try this?’ (Violet, Interview, June 2011)

In this example, Violet connects the idea of the Use of Green Energy discussed in the online STSE discussion forum to her family in the Philippines. This makes the topic relevant to her and because of this relevance she is more actively engaged in learning about energy use in society.

Some researchers (Gardner & Jones 2011, Hughes, 2000, Pedretti et al., 2011) support the idea of relevance of subjects as it engages students cognitively and empowers students to make democratic choices. Empowering students is the focus of Pedretti and Nazir’s (2011) socio-ecojustice current where students are encouraged to critique and attempt solving problems through human action. In the above example, Violet connects the STSE-based issue of Green Energy to her family life in the Philippines. The socio-ecojustice current can be seen in this example, where Violet discusses informing her family about the ecological advantages of using
Advocates of this STSE-based education current (for example, Bencze et al., 2012, Bencze, 2008; Hodson, 2003, Roth, 2002) believe that political and economic factors influence science education and can become an instrument to assist in transforming society. As such, students seem to desire to participate in discussing STSE-based issues that are relevant to them. Relevance of the topic becomes one of the most important motivations in this case study. Socially embedded issues in science motivate students’ involvement in class discussion. For example, Veronica’s strong views with Third World countries and the use of green energy (See excerpts from Veronica, Interview, June 2011). Indeed, in this bounded case study, the relevance of the STSE-based topic used in physics was overwhelmingly discussed as a key motivating factor in increasing participation in discourse.

Prior knowledge is the third key factor that influenced an increased participation in the second STSE-based discussion conference on the Use of Green Energy. For the second STSE-based discussion, the teacher assigned students to a PowerPoint presentation on topics relating to the different types of Green Energy. Examples of the Green Energy PowerPoint presentation topics include Wind, Tidal, Geothermal, and Biomass. When students entered the online discussion, they did so with prior knowledge on several topics related to Green Energy and their posts were richer. This is different from the teacher’s first STSE-based posting on Friction in Tires where she did not assign any prior activities related to the topic. Azilia commented on the assigned PowerPoint presentation project when she stated:

The first one [STSE-based discussion on Friction in Tire]...I was actually new to this, so I didn’t know what I was expecting, so I guess I just went into...when I responded it was more like, ‘I agree to all of your answers’ and that was about it. But then on the second one [STSE-based discussion on Use of Green Energy], I actually talked about what they said and one of them actually learned from one of my PowerPoints, so I said ‘I’m glad you learned from my PowerPoint.’ (Azilia, Interview, June 2011)
Azilia’s comments reveal how prior knowledge, whether it is acquired through a class project or through direct instruction, enhances student participation in the online forum. Prior knowledge also means that students have had time to think and reflect on a topic before posting an opinion or participating in a threaded discussion. Gaudry-Hudson and Yalda (2010) also underline the importance of prior knowledge in their study where they discuss how students were guided in their online studies through, “taking and applying prior knowledge” as well as, “transferring knowledge and drawing connections and relationships to other fields and disciplines” (p. 99). Gaudry-Hudson and Yalda (2010) further explain that this represents the ability in students to develop transferrable skills. These skills include, “applying and transferring knowledge, drawing connections, recognizing origin of knowledge, acknowledging the value and difference of information based on valid research and reliable references, learning to communicate effectively through written words, and learning to question purpose and meaning” (p. 99). These skills are present in the students who participated in the online discussion, and as such this indicates the relevance and need for online learning in STSE-based education.

A notable pattern that emerged in this case study was a delay in immediately responding by 26% of the students who participated in both the STSE-based online discussions. It was noticed that about 26% of the students required more time to post that is, within the five days of their first response for both the STSE-based topics (see Figure 5.1). To better understand the reasons for this delay, the following was asked through the post-study interview session: ‘Did you do anything differently in terms of responding to the two online conferences?’ Esther reflects:

I think in the first one [STSE topic on Friction in Tires], I read through a lot of them before I even answered my own, because it was my first online discussion and I wanted to get [to know] how people were doing it. And the second [STSE topic on Green
In this excerpt, the delay to the first STSE-based conference may be associated to confidence, but as Esther grows more comfortable with the online forum, the delay for the second STSE-based conference is in connection to her desire to reflect more deeply and prepare a well formulated answer. Violet also discusses taking more time to reflect and compose her answer with proper evidence prior to posting when she says, “Online if I were to post something, I usually don’t post it right away. I usually keep it for a day and then read others, and if something comes up, I add to it” (Violet, Interview, June 2011).

Likewise, Azilia comments on how the online forum afforded her more time to critically reflect on her ideas before participating by posting them. She states:

I guess when you’re in class the discussion is happening right there, but when it was online I got time to think about it, or maybe even research on the topic. And I had more time…like I typed up the physics [concepts], all the questions, but then I always left 30 minutes or something to think about what I wanted to say for the STSE, and how I really felt about it. (Azilia, Interview, June 2011)

Azilia also comments on how she delays in responding to the STSE-based discussion questions in order to have more time to think and compose her answer. Azilia tackles the content questions immediately and takes more time with the STSE-based questions. Hence, her comments reveal how doing STSE-based activities online, supports the development of reflective critical thinking skills in students. Several researchers stress in their research that there is a need to develop thinking and reasoning skills in high school, and that socially-based interactions can support the cultivation of such skills (Bell & Linn, 2000; Gambrell, 2004; Larson & Murray, 2008; Sadler, 2004; Zeidler & Sadler, 2008). According to Pedretti and Nazir (2011), the logical reasoning current of STSE-based education is one way to enhance student understanding and decision
making skills. In the above example with Azilia, the logical reasoning current is evident in the systematic way that Azilia approaches the STSE-based problem. In this above example Azilia discusses how she crafts a response, takes the time to assess her answer, makes changes and/or additions to improve her reasoning, and then shares her solution. Simon and Richardson (2009) support that students require time to reflect and improve their reasoning skills. In this case, Azilia identifies that she requires time to think and reflect before imparting her views online. Hence, the STSE-based activities conducted online did seem to encourage the development of reflective thinking processes. In this next section, I look at the criteria students used in selecting the posts to which they respond.

5.2.2 Criteria students use to select and craft online threaded responses. The interviews probed the students’ rationales for responding to their peer responses. The student responses were analyzed for both the two STSE-based physics issues, namely, Friction in Winter Tires and the Use of Green Energy. I am interested in exploring the factors that influenced the selection of which posts to read, and the criteria students established in responding to the posted issues. These analyzed online responses are displayed in Figure 5.2. This figure indicates factors that influenced reading and responding to peers’ articles.
Figure 5.2 Students and their motivation to respond to the peers’ comments.

Figure 5.2 illustrates students’ choices for selecting peers’ threaded asynchronous responses. Having similar or different opinions expressed within the message thread comments was one of the reasons for identifying peers’ message threads to be read or replied to. More than 66% (n=6) of the focus students responded to peer comments that had similar concepts and opinions to their own. These students took time to read and search for comments that were similar to their own. The following extract from Violet shows a student’s reason for selecting an entry expressing a similar opinion to which to respond:

If their answers were similar to mine and if I missed something, like if someone also said the biomass was something that they had preferred for developing countries, then I read theirs. It gave me more intrigue into it because I also said that answer, but it also makes me think what I didn’t miss, and what they said that I didn’t write. (Violet, Interview, June 2011)

Only one person responded by choosing peer replies that had different opinions from the student’s own response. Her selection criteria were to the identity different views with different explanations written by her peers. The following excerpt from Dahlia’s response exemplifies this
point: “...the ones that I actually wrote on [are the ones that] I disagreed. I guess it’s different so I just wanted to say what I thought” (Dahlia, Interview, June 2011).

While several students chose to read threaded responses that had a similar and/or different viewpoint then their own, Veronica describes choosing responses based on the structure of the writing, as opposed to the position on the topic. For Veronica, the peer responses were neither similar nor different to the student’s own perceptions but expressed with greater clarity and coherence, as described in Veronica’s excerpt:

The ones that were better written [were selected]. If I saw that what they had written were not making sense or is confusing, I didn’t really bother communicating on it. Because I don’t want to say that ‘you don’t make sense’. I don’t want to be mean! And ones that I saw that were better written and used complex language with coherent paragraphs, I commented on those.

(Veronica, Interview, June 2011)

Her selection criterion for choosing a peer post was based on the quality of writing in the peer responses. She also read articles from peer postings that enticed her to argue with them because she could relate to the issues. Veronica expands further in the excerpt shown:

Oh yeah, the environment is very important, and we should only help them [Third World] and we should force Third world countries to spend their hard earned money on Green Energy as opposed to food for their children. So, I was like do they even understand what Third World countries go through. Can they [her peers] actually put themselves in their shoes? (Veronica, Interview, June 2011)

Veronica’s response to her peers was emotional and reflects her passion for the issues. The online discussion forum enabled the views of Veronica and other students to be raised in a different way that would have been the case with verbal interactions which in class might have become more emotional. Despite some online arguments, there were also incidents that provided an opportunity compliment peers. This positive online community environment and peer compliments in particular, are discussed later in Chapter 6, section 6.3.4.
In summary, the nature of science students’ online discourse at a macro level relies on their motivation to participate, which can be attributed to the teacher’s instructions as well as their confidence online, the relevance of topics, and their prior knowledge on a topic. The teacher’s presence is also important in supporting the learners and in facilitating the learning activities and this topic will be further discussed in Chapter 6. The two STSE-based topics highlight the link between the physics content and sociocultural, socio-ecojustice, and logical reasoning currents in science education (Pedretti et al., 2011). These STSE-based currents (Pedretti et al., 2011) reveal how students identify and integrate topics such as Friction in Winter Tires and the Use of Green Energy situations to their own lives. Here, reflection on the socially-related physics topics dealing with the mandatory use of snow tires or providing opportunities to support third world countries, anchored students’ ideas and stimulated them to resolve perplexing and complex issues (Garrison, Anderson & Archer, 2000).

Baffling problems that require decisions for resolution can take students’ beyond the parameters of the classroom discussion; hence it is important for the socially relevant physics topics to be limited to the curriculum areas. These complex but relevant problems can encourage students to discuss and arrive at some resolution (De Leng et al., 2008). These resolutions are described in the next section. While seeking a productive insight and resolution, students identify the value of teacher’s presence both online and offline which seems to reduce isolation and create a community of learners (Duncan & Barnett, 2010). The value of teacher’s presence will be discussed at the end of Micro-level analysis of online discussions in section 5.3.4. The next section of the findings describes the nature of science students’ online discourse revealed through the micro-level discussion.
5.3 Micro-Level Analysis of Online Discussion: Quality of Threaded Discussions

The findings in the online student discussions can be grounded in the four different phases of the P.I. Model (Garrison et al., 2000; 2003). The different phases of the P.I. Model were used to rate the student text-based contributions (See, Table 5.2) from the different discussions. The content addressed by the phases ranged from Phase 1 (recognizing concepts, issues and problems with little time for reflection) to Phase 4 (defending, critiquing and extending argument with some rebuttal). The comments at the Phase 4 level are considered to involve more time to reflect and decide upon a decision. Examples of these different phases of the P.I. Model are shown in the Table 5.2.

5.3.1 Different phases of the P.I. Model. In this sub-section, students’ online threaded discussions and interactions are identified using the different phases of the P.I. Model and matched with the reflective indicators shown in Table 3.3. From the class of 23 students, the online student extracts of discussions are shown in Tables 5.2 and 5.3. These online threaded discussions are initiated from the two STSE-based discussions topics: Friction in Tires (first online discursive topic) and Use of Green Energy (second online discursive topic). The online peer responses or threaded discussions are scored according to the highest level of cognitive presence or levels of reflective thinking seen in Phase 4 (Resolution) to lowest level of the thinking levels Phase 1 (Triggering). The students’ written phrases in the online text messages (in Table 5.2 and 5.3) are used to distinguish the different phases (mentioned in Table 3.3 of the analysis section) of the P.I. Model.
Table 5.2
Exemplars of threaded online discussion extracts for STSE topic # 1 (Friction in Tires): Association of P.I. Model Phases with Reflective Indicators

<table>
<thead>
<tr>
<th>Phase 1: Triggering</th>
<th>I feel that winter tires are something every family should invest, in order to drive a vehicle safely during the winter months. It helps people to stop skidding, and it just helps the roads become a safer place for everyone to enjoy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicators:</td>
<td>Recognizing problems and Identifying relevant elements</td>
</tr>
<tr>
<td>Phase 2: Exploration</td>
<td>I agree with most of what you said. However, I have one dispute. Regarding snow tires becoming mandatory in Ontario, even though they are expensive, what if the government provided some sort of reimbursement? Or perhaps make it tax deductible? That way everyone’s safe on the roads.</td>
</tr>
<tr>
<td>Indicators:</td>
<td>Exploring contradictory ideas, brainstorming and suggesting ideas</td>
</tr>
<tr>
<td>Phase 3: Integration</td>
<td>I really agree with your answers. It is easy to understand with the help of your examples. However, my opinion on the enforcement of snow tires isn’t the same as yours. I don’t think snow tires are available to some families due to the cost of the installation and tires themselves. Although the safety of the passengers are very important, the possibilities of families and such being able to pay for the other important things like bills, food, etc. make the snow tires like the least of their worries.</td>
</tr>
<tr>
<td>Indicators:</td>
<td>Building on ideas, drawing conclusions and providing rationale</td>
</tr>
<tr>
<td>Phase 4: Resolution</td>
<td>I really do agree with you because I know how hard it is to get parents (in this case our fathers) to invest in winter tires and them saying that they don’t need it and all that jazz and how they’re good drivers and honestly my dad didn’t invest in tires until he actually got himself scared and get into an accident, and the day of (because of me scaring him even more) he got himself good expensive tires because of our van’s model.</td>
</tr>
<tr>
<td>Indicators:</td>
<td>Applying, suggesting applications and deciding to take action</td>
</tr>
</tbody>
</table>

Note: Excerpts taken from Online Discussion Comment, May, 2011)

In the above Table 5.2, the relationships between the phases of the P.I. Model and the comments
of students in their threaded online discussion on the STSE-based topic, Friction in Tires, are evident.

Table 5.3 provides an analysis of the thinking of students, in terms of associating the phases of the P.I. Model with their comments from the online discussion on the topic of the Use of Green Energy. Once again, student comments from the threaded discussions are correlated to the reflective thinking indicators of the P.I. Model (Table 3.3)

Table 5.3
Exemplars of threaded online discussion extracts for STSE topic # 2 (Use of Green Energy): Association of P.I. Model Phases with Reflective Indicators

<table>
<thead>
<tr>
<th>Phase 1: Triggering</th>
<th>Indicators: Recognizing problems and Identifying relevant elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>I began to think that solar energy sources as a reliable energy source for us Canadians. We do get a lot of sun! I also agree with your STSE answer. Developing countries do have a lot more to worry about that and what type of energy use. The thinking gone towards becoming an energy efficient country could eventually help those in poverty.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 2: Exploration</th>
<th>Indicators: Information exchange, exploring ideas, seeking information</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is obvious that the environment is more important than the cost analysis to energy crisis. I found it interesting where you talk about developed countries only being allowed to help developing countries once they learn to use renewable resources themselves, first. I found that a true and interesting point to bring up, though I hadn’t thought of it myself. I am also glad that I learned from the PowerPoint presentation on Biomass Energy.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 3: Integration</th>
<th>Indicators:</th>
</tr>
</thead>
<tbody>
<tr>
<td>I understand that from a Canadian's viewpoint, the environment is very important, and will be important for generations to come. However, from the viewpoint of some who can't even afford to feed and clothe their family, this is the least of their worries. If we were to go by the general consensus of the world's entire population (most of which are impoverished people), the priority of the underdeveloped countries would be to deal with the social and financial issues surrounding poverty, not wasting money on 'green initiatives'. I made up a quote: The cries of mother nature are quiet when the grumbling of your empty stomach is all you can hear.</td>
<td></td>
</tr>
</tbody>
</table>
Indicators: Synthesis, building ideas, providing rational, offering justification

<table>
<thead>
<tr>
<th>Phase 4: Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>I strongly agree ... because we should look more into the environment than cost. Yes cost would be expensive but if we take things step by step, the cost will not be as noticeable. The environment is very important and to help out and keep it clean we do need to take action in order to stop the pollution we humans are creating for the earth and use much more efficient resource that will into damage environment.</td>
</tr>
</tbody>
</table>

Applying, suggesting applications and deciding to take action

Indicators:

Note: Excerpts taken from Online Discussion Comment, May 2011)

With reference to students’ messages from Table 5.2 and 5.3, the text messages illustrate how Garrison and colleagues’ (2003) coding scheme was applied to students’ message postings. Some students recognized and identified problems which relate to the Triggering Phase #1 of the P.I. Model. For example, a student mentioned in Table 5.3 identifies the issue that “winter tires are something every family should invest, in order to drive a vehicle safely during the winter months”. This student recognizes the problem with safety issues relating to skidding, and making roads a safer place for commuters. Here the student identifies road safety problems and relevant elements of reduced friction in tires during winter time.

Similarly in the second STSE-based discussion on the Use of Green Energy (see Table 5.3), the student identifies “solar energy sources as a reliable energy source for us, Canadians”. She links the amount of sunlight to some developing countries and how these developing countries could capitalize the on renewable source of energy. In the Triggering Phase, each student is either able to focus on the problem of safety on the road or identify the availability of sunlight as a source of energy. In Phase 1, students’ text reflects the socio-cognitive process to understand the issue proposed by the teacher.

In both the topics, whether it is about mandatory use of snow tires during winter in
Ontario or the ability of developing countries to afford expensive renewable resources, the topics were designed to create dissonance in students. A notable difference with respect to the second STSE-based topic is that students entered the online forum with prior learning from the in-class Green Energy PowerPoint presentations. The interesting event to note is how the teacher’s introduction of students’ PowerPoint presentation prior to the online discussion provided most of the triggering messages. This would be Garrison’s Triggering Phase with knowledge support from the presentations.

In the Exploration Phase (Phase #2), there is a need to obtain information, exchange information, and seek out specialized information pertaining to the topic at hand. In the first STSE-based topic, the student explores a contradictory idea of mandatory use of winter tires in Ontario. She enquires by brainstorming if the government will reimburse the expensive proposition of winter tires for everyone’s safety on the road. In this response, the student explores an idea, brainstorms and provides a suggestion for reimbursement or tax deduction. In the second STSE-based online conference (i.e., the Use of Green Energy), the student identified in Phase 2 of Table 5.3 clarifies that solar energy is a reliable energy source and identifies the problem as to whether developing countries need to worry about energy efficiency or about poverty as a priority issue. The student in this phase is asking questions and seeking clarification to the problem. This is Garrison’s Exploration Phase where the socio-cognitive process of connecting and linking ideas is made evident.

Phase 3 of Garrison’s P.I. Model is the Integration Phase where students draw conclusions, build on ideas by providing suggestions or advice to the situation, and provide a rationale for their reasoning. The student’s message addresses about how Canada should not use coal but be more focused on environmental impact and cost analysis of renewable resources.
This student suggests that the world should be more conscious of the environment and provide support to developing countries. Both processes of suggestion and synthesis are valid processes of Garrison and colleagues’ Integration Phase. In Table 5.3, the Integration Phase can be seen where the student recognizes the problem, builds on ideas about the Canadian and global viewpoints connected to green energy, and provides justification for her position. Similarly in Table 5.2 the student provides a rationale for her viewpoint on snow tires which is based on her understanding of the costs of tires, law enforcement, and safety (hence she builds her ideas to come to a conclusion).

Phase 4 is the Resolution Phase of the P.I. Model and it involves taking action or providing a reasonable solution. In this phase (in Table 5.2), the student applies her knowledge of friction to the problem of safety in tires. The student is convinced of the need to take action on a problem of safe driving in the winter and provides a rationale to her father regarding snow tires. She is successful in defending her resolution—where her father takes the action of buying snow tires. These students’ online discourse (identified in Table 5.2) reflects socio-cognitive process of ‘testing and defending’ solutions which incorporates Pedretti and Nazir’s (2011) logical reasoning current. In this case, the student identifies the problem, syntheses a solution, provides rationale, and finally the action is taken (by her father).

In this section, the relationship between the phases of the P.I. Model and the comments of students in their threaded text-based discussion on the two STSE-based topics are evident. In further analysing the reflective thinking levels of students (in terms of correlating the phases of the P.I. Model) with their comments from the online discussion of the two STSE-based topics, the percentage of student postings are compared to the percent distribution of messages in the four phases of P.I. Model. This is discussed in the next section.
5.3.2. *Message distribution in four phases of the P.I. Model.* In further analyzing the quality of the threaded discussions of the two STSE-based topics, a summary of the distribution of the four phases of cognitive presence in the P.I. Model is recorded in Table 5.4. Here, I have identified the percentage of total student threaded postings that correspond to the four phases of the P.I. Model of cognitive presence.

Table 5.4

*The quality of threaded STSE-based discussions with respect to the four phases of cognitive presences (P.I. Model)*

<table>
<thead>
<tr>
<th>The four phases of the P.I. Model</th>
<th>Reflective Thinking Indicators of the P.I. Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Responses in 1st Online Threaded Discussion Friction in Tires: Total of 37 Responses (With Percentages)</td>
</tr>
<tr>
<td>Phase 1: (P1) Triggering</td>
<td>10/37 (27%)</td>
</tr>
<tr>
<td>Phase 2: (P2) Exploration</td>
<td>15/37 (41%)</td>
</tr>
<tr>
<td>Phase 3: (P3) Integration</td>
<td>11/37 (30%)</td>
</tr>
<tr>
<td>Phase 4: (P4) Resolution</td>
<td>1/37 (3%)</td>
</tr>
</tbody>
</table>

Total Number of Initial and threaded Postings

19 initial post + 37 threaded = 56

20 initial post + 38 threaded = 58

*NOTE:* A total of 114 discussion postings were analyzed for both the online STSE topics
Interesting patterns and differences emerge with respect to the two online STSE-based discussions and the P.I. Model. In the first STSE-based discussion on the topic of Friction in Tires, the greatest number of student responses is in Phase 1 (the Triggering Phase) and Phase 2 (the Exploration Phase), 27% and 40% respectively. This differs from the second STSE-based discussion topic on the Use of Green Energy where fewer student responses relate to Phase 2 (26%) than Phase 1 (29%). Specifically, the largest percentage difference in responses for the Exploration Phase 2 for the first STSE-based topic is 40% versus 24% in the second STSE-based topic. This difference in percentage respondents will be discussed in section 5.3.3 in relation to the reflective thinking process.

In the Use of Green Energy discussion, 16% of student responses achieve Phase 4 level comments whereas in the Friction in Tires discussion only 3% of student responses are in the Phase 4 category. This difference can be attributed to the prevalent factors in the patterns identified in the macro level discussion. In Section 5.2.1, the three major factors that accounted for increased participation in the online discussions were confidence, relevancy of the topic and prior knowledge, and the same three reasons emerge to support the evidence for cognitive processing in students and involvement in second STSE-based discussions. Firstly, the teacher’s requirement for a student-designed lesson to incorporate the PowerPoint exercise to bring increase awareness of the STSE-based topics on the Use of Green Energy prior to involving students in the computer-mediated discussions. This helped students acquire some relevant prior knowledge as mentioned in section 5.2.1. Secondly, with the increased student experience of using the online discussion forum in the second discussion there was greater familiarity and fewer technical hindrances to message postings and students were more confident about the format and procedures of the online discussion. This reflects in students’ increased confidence
and willingness to share their thoughts online. Thirdly, student relevant topic and discussion questions in the forum added to the difference in student online activity. In particular, the second STSE-based topic (Use of Green Energy) encompassed a direct sociocultural content where students were able to share different perspectives and utilize personal and academic experiences. As Veronica mentions in the post-study interview where she compares the two STSE-based topics:

The first one [STSE topic] was with the snow tires. It wasn’t really compelling an argument. There weren’t two sides to it [the argument] and I just added on to what they [students] were saying. But the second one [STSE topic on Green Energy], I [felt] that it was bit crazy that everyone said the exact same thing. Oh, yeah, the environment is very important and we should help the third world countries to spend their hard earned money on green energy as opposed to food for their children. Can they [fellow students] actually put themselves in their [third world citizens] shoes? (Veronica, Interview, June 2011)

It seems that Veronica was very interested in integrating her ideas and delivering a strong argument against the common views of the class. This student’s interview excerpt reveals reflection and critical analysis of issues, and situates her commentary at Phase 4 of the P.I. Model. In order to observe transformative learning experiences which may reveal the reflective thinking process, the integration of text-based learning (asynchronous) activities in this case supports face-to-face class interactions (Garrison & Kanuka, 2004). It appears that the online discussion provides the space and time for the students’ reflective thinking about the STSE-based physics topics.

5.3.3 Reflective Thinking Process and the Level of Cognitive Presence. In order to identify the various kinds of reflective thinking, the content of the online responses are analyzed using the coding schemes mentioned in the analysis section of this dissertation. The aim is to identify the various levels of cognitive presence in the P.I. Model (Garrison et al., 2000) in the
online STSE-based discussions. Researchers analysed the amount of critical reflective thinking evident at the different phases of the P.I. Model and I carried out a similar process in this study (for example, De Leng, et al., 2009; Garrison et al., 2000; Meyer, 2003; Schrire, 2006). The online discussions were categorized in the lowest level of cognitive presence (Phase 1 and 2) to the highest level of cognitive presence (Phase 3 and 4) (Schrire, 2004).

In this case study, student comments were categorized into the different phases which correspond to the different levels of cognitive presence (Garrison et al., 2000; Schrire, 2006; 2004; De Leng, et al., 2009). In the Triggering Phase (Phase 1), student text-based comments from both the STSE-based discussions were classified according to the reflective thinking indicators in Table 3.3. Of the total 75 (37 + 38) threaded student posts from both the STSE-based discussions, 26% to 27% of the text-based comments fit within the lowest category of cognitive processing, that is, in the Triggering Phase (Phase 1). For example Violet mentions, ‘I began to think that solar energy source is a reliable energy source for us Canadians’ (Violet, Interview, June 2011). Here, this student’s posting is identified as Phase 1. In this Triggering Phase, Violet reflects on the socio-cognitive process to seek and link the necessary information with the Use of Green Energy STSE-based topic. The sustained text-based interaction demonstrates acknowledgement of students’ information (i.e., solar energy) as well as possible ideas for exchange (i.e., a reliable energy source for Canadians) indicating the Triggering Phase of the cognitive process.

In this thesis, the data identifying Triggering Phase 1 and Exploration Phase 2 is comparable to findings from other previous research. For example, the percentages of student comments from Meyers’ studies (2003) showed 18% in the Triggering Phase and 51% in the Exploration phase. In this study the data from the first STSE-based discussion reveals 27% in the
Triggering Phase and 40% in the Exploration Phase. Other studies (Schrire, 2004; De Leng, 2009) that employed the P.I. Model also identify a higher percentage in the first two phase of the P.I. Model. For instance, Schrire (2006) found the bulk of the messages were categorised as Exploration (41%) similarly with De Leng and colleagues’ work found (40.9%) in the same Phase 2. It is apparent that the physics students in this case study identify issues and problems as a logical science thinker conducting a laboratory investigation. This coincides with Pedretti and Nazir’s (2011) logical reasoning current where STSE-issues can be utilized for discussion in the science classroom to “enhance student understanding and decision making by encouraging [students] to think ‘the way scientists do’ ” (p. 12). However, the message threads in this case study, identified in Phases 3 and especially 4, shows an interesting teaching and learning phenomena that is discussed next.

I categorize student text-based responses from the two STSE-based topics into Phases 3 and 4 of the P.I. Model. When classifying the text-based student responses within the Integration Phase, 30% respondent’s messages (for the first STSE-based topic) and 34% of the respondents (for the second STSE-based topic) fell within Phase 3 (See Table 5.2 and Table 5.3.). In De Leng and his associates’ (2009) study, these researchers categorised 27% of the responses to be within the Integration Phase (Phase 3). Similarly the results in this dissertation reveal 30% to 34% of the student text-based responses identified to be in the Integration Phase (see table 5.4). Also, and similarly to previous research, there is a drop in student messages categorised in Resolution Phase 4 (discussed in the next paragraph). It seems that some students stop their discussion as soon as they provide a solution, relevant information or opinions on the discussion topics. To advance further into higher order thinking, requires more reflective thought, further iterative cycles of commentary and possibly the moderator’s or teacher’s support.
Hou, Chang and Sung (2008) suggest that teachers could promote greater depth of discussion by promoting relevant articles for students to view, and while this prompting of new information at critical points in the discussion may have some effect, further cycles of discussion may be needed to actualize these higher phases of discussion amongst a greater proportion of students. The data from the current study and from other researchers (De Leng et al., 2009; Hou et al., 2008) confirms the limitations of curriculum, and in this case a high school science education system, where issues and problems of the natural world are presented artificially by the teacher providing insufficient opportunity for discussions (Garrison et al, 2000).

In this case study, an interesting finding surfaced relating to the teachers’ involvement in the online discussions while analyzing Phase 4 of the P.I. Model. The Resolution Phase (Phase 4) is the highest level of cognitive presence identified in text-based online discussions in several studies (Kanuka, Rourke and LaFlame, 2007; Meyer, 2003; Schrire, 2006; Vaughn & Garrison, 2006). These aforementioned researchers show the smallest percentage (about 1% to 18%) of text-based responses are categorized within the Resolution Phase (4). In this dissertation, about 3% to 16% of the text-based responses of the STSE-based discussions can be identified as falling within the Resolution Phase. On further scrutinizing the current dissertation research data, the first STSE-based discussion shows 3% of the students commenting on an action to pursue. In the second STSE-based discussion, 16% of peer text responses are focussed on the application of student ideas and hypotheses, partly facilitated by the teacher’s prior classroom intervention. The physics teacher’s change in teaching strategy by incorporating an in-class student-selected Green Energy PowerPoint presentations and discussions seemed to enhance the opportunity for deliberation over ideas and theories of physics of Green Energy into a meaningful discussion.

The physics teacher dedicated a week’s class time period to encourage meaningful
discussions about verifications of and resolutions for the PowerPoint materials on the topic of green energy. The teacher’s predicted outcome was to have some meaningful classroom discussion which might have an impact on the subsequent online discourse. Through those classroom PowerPoint presentations and discussion, students had the opportunity to listen to various Green Energy presentations, learn different energy concepts and address issues relating to ethical, political and social issues before their online discussing began. Other researchers have suggested that a sustained focus on the Integration and Resolution Phases (De Leng et al., 2009) can be effective in boosting these higher levels of thinking. The aforementioned researchers reported that by dedicating a greater amount of time to the Resolution Phase generated an increase in integration and resolution messages in their study. De Leng and colleagues (2009) also had suggested that the moderator’s approach, by providing focus and inspiration in discussion may play a vital role in increasing the higher order thinking phase of students.

In this case study, the physics teacher participated in the online discussions with several posts to encourage and inspire students to review newspaper articles (see Daisy’s comment and teacher’s post in section 5.2.1). The teacher’s involvement in the online class discussion influenced the student participation level as illustrated by the response differences between the two STSE-based discussions. That is, resolution messages were about 10% higher in the second online STSE-based discussions than the first online discussions without the class discussion or the teacher’s online guiding messages. Hou and Colleagues (2008) suggest that:

It is possible for this [teacher’s] guiding message to improve the quality of problem solving and knowledge construction in online discussion at the same time; thus we suggest that teachers refer to the results of this research, diagnose limitations of students’ discussion processes, and provide timely messages such as those mentioned above to promote the depth of students’ discussion. (p. 26)

Hence, teacher’s guide can provide added support and facilitate students in expanding their ideas and opinions with sustained online collaboration.
Students who engage in sustained communication via the online discussions find time to reflect and learn from each other (Bassett, 2011). In this case study, the physics teacher’s implementation gave an opportunity for students to present their views and analyse the overall situational crisis which was later debated and the problems discussed collaboratively online. Constructing new meaning and collaborating amongst peers online offer science students the time to think critically by considering various socio-eco-political factors. The benefit of time and space for extended online student collaboration may enable the construction of new meanings and boost higher order thinking in enhancing cognitive development.

Schrire (2006; 2004) argues that a relationship exists between written communication and cognitive development. The relationship is attributed to the effect of writing on thinking and its suitability for collaboration that facilitates deep and meaningful learning in a community of learners. Garrison et al.’s (2000; 2001) view of computer-mediated interactions through the online community of learners informs their practical Inquiry Model of Cognitive presence. With respect to the framework of Community of Inquiry (Garrison et al., 2000), Cognitive presence is just one of the three elements of the framework where social and teaching presence are the other two elements of the framework. Rourke and Kanuka (2009) maintain that both teaching and social presence support and promote cognitive presence. In the next section, the importance of both teaching and social presence will be discussed in relation to developing cognitive presence in students.

5.3.4 Teaching presence and social presence. In this case study, one of the possible reasons for the increase in students’ online response and in reflective thinking skills is due to the teacher’s instructional strategies in their physics course. The notable strategy was enabling students to present and discuss some of the Green Energy topics in class through student-
designed PowerPoint presentations in their physics class (see section 6.3.2). These in-class presentations of varied topics related to the Use of Green Energy and discussion opportunities enabled students to verbalize their concerns and debate these issues. Students developed their PowerPoint presentations prior to conducting the e-discussions which occurred about a week later. According to Garrison and colleagues (2000), the teacher performs a vital role in the educational environment not only by organizing and conducting the course but particularly in facilitating the learning activities – this is the key element of what Garrison and colleagues term teaching presence in the Community of Inquiry. It is known that teaching presence is an important contributing factor to enhance students’ critical reflective thinking processes (which they term cognitive presence) in addition to sustaining the social interactions of the students online. Although social presence is a contributing factor in the online conference, the importance of personal and community sharing of information influences the development of ideas is described next.

Developing a trusting community for learners is vital for information exchange and development of higher order reflective thinking in students facilitated by the instructor or teacher. Researchers suggest that instructional strategy in an e-learning community influences students in the online discussions (see, Hou et al., 2008; Kanuke, Rourke & Laflamme, 2007). For example, in webquests or through inviting experts into discussions, students have an opportunity to collaborate and debate and discuss matters of concern. Social presence is mentioned in Garrison and colleagues research (2000) as one of the three core elements of the P.I. Model. ‘Social presence is defined as the ability of the participants in the Community of Inquiry to project their personal characteristics into the community, thereby presenting themselves to the other participants as real people (p. 89). In this social presence, where peer
contributions reflect socio-cognitive processes through engagement in student-relevant STSE-based issues group discussions can create a sense of belonging that supports meaning creation, (Norman and Garrison, 2005).

In summary, the STSE-based threaded text-based discussions and face-to-face interactions in class settings are mutually facilitative in this blended approach to learning science. With the blended approach, physics students are able to frame their message postings online within a set timeframe (i.e., 5 school days), giving them time to reflect and develop meaning. The first STSE-based physics discussion involved Friction in Winter Tires that had little relevance to their lives, since most student were about 15 years of age and were not driving. As student confidence with online forum grew, teacher’s cyber presence and student classroom presentations contributed significantly to the second STSE-based topic, which itself was more engaging. The physics students gained not only knowledge on the Green Energy discussion issues but also had time to process some of the content and so reflect and be better prepared to argue and debate online.

As observed in Table 5.4, there were more learning attempts made to resolve issues categorized as Resolution Phase 4. This higher-order cognitive exercise can be seen by comparing the increase in message postings between the first and second STSE topic of 3% to 16% of peer postings, respectively. With the required assignment to create PowerPoint presentations for an in-class physics activity, physics students were given the additional opportunity to work with the material and then utilize the computer-mediated discussion forum to reflect, discuss and arrive at some resolution on the Use of Green Energy globally. In conclusion, the Practical Inquiry Model appears to characterize how the computer-mediated discourse facilitated student engagement in STSE-based higher order thinking discussions. The
next chapter will explore the third research question on the benefits and challenges of learning about STSE online.
CHAPTER VI
RESULTS AND DISCUSSION – PART 3

Students’ Perceived Benefits and Challenges of Learning about STSE Online

6.1 Overview

This chapter explores the third research question, which focuses on students’ perceived benefits and challenges of learning about STSE subject matter through an online environment. To address this question, I begin this chapter by discussing in general my data on the benefits and challenges of learning science through an online forum, and then focus my discussion specifically on the students’ perceived benefits and challenges of learning about STSE-based issues in secondary physics via the online forum. Finally, I include a brief discussion on blended learning as experienced by secondary school physics students in this study.

In answering this third research question, three artefacts are used, namely participants’ interview transcripts, computer-mediated interaction transcripts and my researcher notes from classroom observations. The major artefacts analyzed in this chapter are obtained from the pre- and post-STSE discussion interview transcripts with the nine focus participants. I examine their responses to the questions on the perceived benefits and challenges of learning about STSE-based issues in science through the online environment. In addition, my researcher notes of observations are examined to extract extraneous influences or significant events that occurred in class during STSE-based issues discussions. Notable classroom events are observed through the teaching strategies and student’s learning styles pertaining to STSE-based issues discussion. Finally, transcripts of the teacher - student and especially student - student computer-mediated interactions from the STSE-based issues are also examined. In particular, the data from the transcript is analyzed in relation to the impact of online discussions produced from the two
STSE-based physics related issues (i.e., Friction in Car Tires and Use of Green Energy). Hence, the aim of this chapter is to analyze and better understand students’ perceptions on the benefits and challenges of learning about STSE-based issues through an online environment.

The next section in this chapter will focus on presenting a general overview of students’ preconceived ideas about using technology in their courses prior to participating in STSE-based discussions in their senior physics course.

6.2 Ubiquitous Use of Technology in Learners’ Environment

This case study is designed to explore how a group of senior physics students perceived asynchronous online discussions as a learning experience with technology. It is worthwhile to view how students who use text-based cell phone communication perceive learning science through student-friendly technology. The data obtained from the pre-study online discussion interviews revealed 89 percent of the focus students (eight out of nine) favoured using computer-mediated discussions. When asked if they could predict problems with discussing social issues online, four focus students did not foresee problems with technology-supported discussions. These four students also expressed that they appreciate learning science through the online environment. Four of these focus students’ excerpts from the pre-online discussion interviews are identified here:

No, we haven’t really done much computer-related discussions, but I am pretty technologically savvy, so it’s not that hard for me to understand everything online. (Esther, Interview, February 2011)

No, I haven’t found any [problems with online discussions]. I have done discussion boards [forum] in history. Everything was fine. The teacher posted a question, we all replied. There were never any issues with it. (Holly, Interview, February 2011)

I don’t think I feel that I have problems per se. It’s normally pretty easy to communicate. It depends, in science; I don’t think things would get lost in translation. Because science is more or less structures as opposed to English. So communicating ideas, thoughts,
concepts in science online, I don’t think I would have any problems with that, honestly. (Veronica, Interview, February 2011)

I guess the only problem I would face is being distracted by everything else on the computer, because there is all that other stuff like social networking sites, like Facebook and twitter and all that stuff. Other than that, I don’t think there would be problems. (Flora, Interview, February 2011)

The pre-study interview findings suggest that students are comfortable using technology in their learning environment. From the excerpts, these four focus students perceived online science discussions as a valuable learning strategy in today’s technology-enhanced society. Today’s tech savvy students who are identified as digital natives (Adams, 2008; Prensky, 2001) embrace a technology-based lifestyle using cell phones to text in order to enhance their social lives. These digital age students also use other technology-supported devices (such as, ‘i-pads’, ‘i-phones’ and other communicative devices) to influence their social environment. Bennett (2012) adds that social networking through cell phone text-based messaging is enhancing students to become effective communicators with their peers.

Holly adds to the generation of students who are not just avid users of the phone texting system, but rely on ‘Facebook’ and computer email features to access assignments, talk about projects or seek explanations of a concept in other courses. An excerpt from Holly’s pre-study interview identifies her realities of 21st century education with the ubiquitous use of communicative technology:

Facebook, if you need to get touch with people. Texting, phone calls, even twitter. It’s easier to get in touch with them [Peers] and you can include, say if you guys are all in different locations, include more than two people in it [engage in discussions]. You could be on the phone and Facebook, explaining it [engaging in discussions] while you’re actually sending the different equations or whatever you are learning. (Holly, Interview, February 2011)

Holly’s comments reveal how students in the 21st century classrooms are technological savvy
and are capable of multi-tasking. These pre-study findings present a challenge to teachers to incorporate technology and online studies in their classrooms, and as such, connect with the 21st century student by meeting their learning needs. Simultaneously, other focus students from the pre-study interview present some of their perceived challenges with online discussions used in education.

Some of the focus students comment that learning science via the Internet suggest that the online deprives students of several communicative aspects. These students view the elements of online communication to lack social interactions and verbal and physical cues with their peers and teachers, while lack of visual demonstrations to go with physics theories and face to face interaction with the teacher. Violet emphasizes the importance of face-to-face interaction with her teacher as:

…sometimes people take a while to understand a concept, and if you are face to face [with a teacher] you get to ask that question. And the teacher could explain it to you more than one way, but if it’s through the online [forum] they could only explain it one way which is telling them examples. But, face-to-face you could give those demonstrations, analogies, and demonstrations which could help someone understand it. (Violet, Interview, February 2011)

Other focus students describe that the computer-mediated activity lacks synchronous and immediate delivery of information, while online distractions (including social network sites, emails, twitter, and advertisements on search sites) interfere with the understanding of science concepts. As such some of these focus students perceive that learning situations, as in learning science concepts, are less explicit with reduce physical cues in social interaction (identified by Daisy and emphasized later in section 6.2.1) and with reduce instructional interactions via a web-based environment (described by Violet in the previous excerpt).

In a recent study, Paechter and Maier (2010) suggest that students have evaluated different kinds of outcomes that can be achieved through the different learning styles, such as the
in-class face-to-face sessions and the web-based learning. These aforementioned researchers, in particular with self-regulated learning (as in monitoring ones’ learning progress) appreciate students’ preference for online learning environment where there are possibilities for applying one’s knowledge. This suggests that a significant amount of time and self-discipline is required to be a successful online learner as students are expected to reflect and monitor their own learning.

Barnard-Brak, Paton and Lan (2010) highlight that given the framework of students’ age and their learning styles, these first generation online users prefer to learn via the Internet and manage issues differently from their parents who were educated in traditional face-to-face school environments. In addressing today’s digital learners, students who are technology savvy may possess the intuitive experience and insight to technological use in their own lives and extend to education in school. These first generation online users, also identified as the Millennium students (Roehling et al., 2010), are growing in support for self-regulated skills in their learning strategies where students become autonomous learners in their digital environment (Barnard-Brak et al., 2010). It is evident from students’ pre-study interviews that learning can be fostered by technology-enhanced communication in science education. The next section presents how the millennium or technology savvy students interact in learning science using the STSE-based issues discourse through online digital media.

6.3 Physics Students’ Perceived Benefits and Challenges of Online Learning

This section addresses the grade 11 physics students’ macro-level discourse via their collaborative experiences of learning about science issues through the online forum. I examine the threaded discussions resulting from the two STSE-based physics related issues (i.e., Friction in Car Tires and Use of Green Energy) to arrive at a general discussion on the benefits and
challenges of learning via the online forum. In addition to this, I have analyzed the pre- and post-interview transcripts with my nine focus students to explore their initial perceptions (in the pre-study interviews) and their recent experiences (in the post-study interviews) on the benefits and challenges of learning about science using the online platform. In the next section, I begin by discussing the dominant perceptions that surface from the online science learning analyzed from the pre-study interviews. Following the pre-study interviews, I discuss the dominant themes that emerged from the online experiences from the post-study interviews.

6.3.1 Dominant perceptions online: An exploration of the pre-interview responses.

An analysis of the pre-study interview responses reveals that students had an overall favourable perception about learning via the online discussion forum. The pre-study interview questions that focused on their past experiences of learning online were as follows:

1. How do you feel about the use of online discussions in your science class? Do you see any benefits to online discussions? Can you share with me some of the benefits you perceive from the online learning?
2. Do you face problems when using computer-aided discussions in your courses? Explain.
3. Do you think learning science with computer-aided technology is helpful or not in understanding and solving problems in your courses? Explain.

From these pre-study interview questions, students revealed their thoughts and ideas on the perception of learning science through an online discussion forum.

The following Table 6.1 summarizes the focus students’ perceptions about learning via the online discussion forum. This table is based on the pre-study interviews with the nine focus students in the senior physics class. Three dominant perceptions that emerged from the pre-study interviews are that the online forum would be beneficial to shy students, provide more
opportunities and build the confidence to participate, as well as, provide a multitude of emerging viewpoints that could be discussed. In addition to these advantages, a number of perceived disadvantages were discussed by the focus students in the pre-study interview. Students’ major concerns stemmed from the lack of synchronous discussion and feedback with the online discussion forum as well as the absence of body language and gestures. These dominant perceptions, expressed from the three pre-study interview questions, will also be discussed in detail following the Table 6.1

Table 6.1

*Pre-Study Interview Responses: Focus Students’ Perceptions of Learning Science Online*

<table>
<thead>
<tr>
<th>Focus Students’ Perceptions of Learning Science Online (Note: Total Number of Focus Students = 9)</th>
<th>Number of Focus Students with Similar Perceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shy students prefer the shield of an online discussion forum</td>
<td>4</td>
</tr>
<tr>
<td>Students will have more opportunity and confidence to present their views online</td>
<td>3</td>
</tr>
<tr>
<td>The online forum will broaden students’ horizons with more materials online for research</td>
<td>3</td>
</tr>
<tr>
<td>The online forum will allow for a multitude of points of view to emerge on a topic</td>
<td>2</td>
</tr>
<tr>
<td>With the online discussion forum there will be a lack of synchronous discussion</td>
<td>2</td>
</tr>
<tr>
<td>Body language will be missing from the online discussion forum</td>
<td>1</td>
</tr>
</tbody>
</table>

Analysis of the data from Table 6.1 indicates that a greater number of students prefer to discuss their views and opinions through the online forum because it provides a screen of anonymity. The semi-structured interviews with the nine focus students reveal that four students prefer the
online discussions because there is the invisible guard against the views presented to the class.

Esther, for example, states:

Class discussions are good because you kind of get everyone’s input, but I think some people are kind of shy in class so they don’t really want to talk about it. But a lot of people might have something to say about environmental issues, and things like that, so when you put it online, people can say what they want and not have to worry about someone else right away being ‘oh, you know, that’s wrong.’ People feel more confident when they are online. (Esther, Interview, February 2011)

Esther’s comment indicates that she recognizes the value of everyone’s ideas in a class discussion. However, Esther also notes that more timid students are hesitant to participate and share ideas in a classroom discussion. In her opinion, students are more confident about sharing their ideas with the online discussion forum.

Holly’s comments in the pre-study interview also reveal a deeper comfort level with the online discussion forum. She states, “I think online…it’s kind of like there’s a shield or a wall, and you can put your actual opinion without worrying about others” (Holly, Interview, February 2011). Holly’s comments indicate that she feels safe and as such, confident in sharing her ideas via the online discussion forum. Like Esther and Holly, Veronica feels greater confidence in using an online discussion forum to share her ideas. Her comments also indicate that the online forum is advantageous in that it allows for a plethora of opinions to be shared on a topic that may be controversial. She sees the online forum as a vehicle for voicing one’s opinion and states that the “computer is your voice so you can just say whatever you want” (Veronica, Interview, February 2011). Veronica’s comments are worth citing:

I guess a few people might slip through the cracks because they might either be too shy, or they might feel that their answer is controversial or it might be the unpopular opinion, so it’s kind of difficult to speak up and say that in class with a bunch of people who have a complete different mindset. Online it gives you an opportunity, because you know, the computer is your voice so you can just say whatever you want. So I think for the computer thing [the online discussion forum], it doesn’t take as much initiative to actually speak up on your concerns and opinions. (Veronica, Interview, February 2011).
Veronica’s perception reveals a greater comfort with using the online discussion forum to share one’s ideas and viewpoints. Research by Kanuka, Heller and Jugdev (2008) shows students’ comfort level increases behind a screen especially when using a well-structured discussion. For example in this case study, questions and discussion formats constructed and guided by the physics teacher aids students in their peer discussions and arguments when learning about physics theories. These positive outcomes surface with the post-study interview responses. The commitment in using discussions enables students to develop a focus on the questions where students can state their opinions without fear but with confidence.

The comments from Veronica’s and Esther’s interviews depict students as being more confident, expressive and courageous when addressing issues online than being in class during the face-to-face interactions. Vonderwell (2003) and Bassett (2011) support the idea that shy students tend to participate more online than in a traditional classroom. Furthermore, Ware (2004) affirms that students who interact online tend to feel less intimidated and less disturbed by language and accent as some students would be sensitive to accent in class work. According to Ware (2004), learners with accent or language difficulty often do not participate during offline class discussions but seem to find time to reflect on their independent writing online. Other researchers who support online interaction state that the computer-mediated exercise enables self-determined learners to be independent and positive (Bonk et al., 2006, Garrison et al., 2004). Furthermore, students with this autonomous attribute are observed to participate freely in the online discussions.

From Table 6.1, another dominant perception that emerges is that students believe that the online forum will provide more opportunity to discuss and also increase participation in discussions, by allowing students to learn from each other via their online discussion comments.
Esther’s comments underline the major point that the online discussion forum increases participation. She states:

The benefits are obviously, again, people who wouldn’t normally speak up in class, might speak up online, and then when they raise a good point, everybody else can learn from that and contribute their opinion and then overall, everyone kind of learns more, and kind of applies it to ‘this is how it’s relevant to life’, so everyone can talk about it. (Esther, Interview, February 2011).

Esther’s point underlines her belief that the online discussion forum can increase participation and can help students learn from each other.

Holly perceives that the online forum will support students in learning from each other. She also believes that the online forum will help students broaden their views by communicating with students whom they normally do not socialize with beyond their online discussions. In response to the pre-study interview questions, Holly foresees another benefit of the online forum in discussion:

… if you need help, because you tend to stick with your set of friends to contact for help, so if there are other people in the class that are there that may have a better understanding that could assist you just through that discussion, it would be great. Otherwise, you don’t really go out of your way to talk to them and look for help from them. (Holly, Interview, February 2011)

Holly continues by elaborating on how the online discussion forum can help broaden her learning and perspectives on issues. She states, “Learning other people’s points of view and like changing your own and growing from it because sometimes you kind of stick to what you believe and what your perceive things to be and having an open mind to other things definitely helps” (Holly, Interview, February 2011).

Similar to Holly, Daisy expresses her perception that the online discussion forum will help students learn from each other. Daisy believes that the online discussion forum will help her to “grab more information” and “think more” (Daisy, Interview, February 2011). She states:
You can grab more information from other people, whereas usually in class you see it from the teacher’s perspective, whereas, discussion online, because people usually don’t put their hands up in class. Whereas online, people you can hear from a bunch of different people and what their opinions are, and it gets you think more. (Daisy, Interview, February 2011)

Holly expresses a positive attitude towards learning via the online discussion forum. She believes that the online forum will help her to learn more by providing a multitude of perspectives on a topic and will encourage her to reflect on issues which she normally would not anticipate. Flora elaborates on the benefits of the online forum, by expressing how a technology mediated forum helps students learn from each other:

I think it would be pretty great, because I guess now our society is kind of based around technology, so by integrating it with our education, I guess it would help most of us kind of learn from each other and from the teachers, even. I guess it’s like learning from each other and kind of seeing everybody else’s opinion and how they kind of got that point of view and being able to share your opinion in expressing yourself. (Flora, Interview, February 2011).

Despite students showing a favourable expectation of online interactions, these nine focus students felt differently about learning science concepts online as opposed to discussing issues related to science via the online discussion forum. In the pre-study interviews, one student (Daisy) identifies body gestures and visual cues as being important in conversations. She explains:

I guess, I would expect there to be just conclusions and it it’s online, I expect it to be easily understood. Whereas, if it were face to face, then it would be probably be easier with hand actions and just for hand actions to be used. So I am looking for body gestures to help in discussions and it’s not found online. (Daisy, Interview, February 2011).

Daisy expresses the value of visual cues in discussions particularly in face to face interactions. This physics student comments that she could not find body language as conversational cues on the computer-mediated discussions to emulate human expression. She seems to value visual cues as an important aspect of the online discussion which is absent. Face to face interactions provide
a means for facial expressions and body language to support and provide a feedback mechanism during conversations seems to be important for some students (Wang & Woo, 2007). Other online education researchers also support that body language can be used to predict attention levels during conversations whereas body cues are absent in the online education (Wuensch, Aziz, Ozan, Kishore & Tabrizi, 2008).

Adding to the challenges of online education, eight of the nine focus students believed that face-to-face method was preferred to computer-based route, especially with learning science concepts as opposed to discussing STSE-based issues in science. These grade 11 physics students preferred learning science terms and concepts via the face-to-face approach during their class period. This idea of face-to-face learning about science concepts is evident for the following reasons which are extracted from the interviews shown in Table 6.2.

Table 6.2

*Pre-Study Interview Responses: Focus Students’ Perceived challenges of Learning Science Online (Ayyavoo, Personal Interviews, February, 2011)*

<table>
<thead>
<tr>
<th>Focus Students’ Perceived challenges of Learning Science Online</th>
<th>Pseudonyms</th>
</tr>
</thead>
<tbody>
<tr>
<td>I prefer learning science with demonstrations and hands-on activities</td>
<td>Ester</td>
</tr>
<tr>
<td>It is easier to understand during class interactions than searching for answers over the internet.</td>
<td>Holly</td>
</tr>
<tr>
<td>Sometimes people take a while to understand concepts, and if you’re face to face, you get to ask that question. And the teacher could explain it to you in more than one way, but if it’s through the online they could only explain it one way which is telling them, or giving them examples.</td>
<td>Violet</td>
</tr>
<tr>
<td>I can’t be patient with the computer; I need someone there in front of me.</td>
<td>Dahlia</td>
</tr>
<tr>
<td>I guess the only problem I would face is being distracted by everything else on the computer, because there is all that other stuff like social networking sites, like Facebook and Twitter.</td>
<td>Flora</td>
</tr>
</tbody>
</table>
The comments (in Table 6.2) illustrate that students favour face-to-face interactions in the classroom. Their comments illustrate their preconceived thoughts about the basic value of education with technology-supported communication, particularly with distractions from social opportunities online, lack of mentorship, lack of hands-on activities, and an absence of synchronous exchange of thoughts and ideas. These findings are consistent with students who prefer face-to-face with lecture styles lessons as opposed to computer-mediated communication where there are social advantages of making friends and exchanging ideas (Gosper, Green, McNeill, Phillips, Preston & Woo., 2008).

In addition, online discourse, particularly through the asynchronous communication, may reduce the richness of a message especially with reduced social interaction. Researchers also highlight the lack of physical cues or body language to add to the accentuation of delivery of the message (Winograd, 2003; Vonderwell, 2003). Simultaneously, students who express verbally might avoid making online entries since these students are outgoing and verbal (Vonderwell, 2003). Veronica, who prefers being verbal, responded to the question on how students feel about online discussions:

I enjoy class discussions. It is fast paced. You say what you want. You interject. You rebut what other people say, which makes it lively’. …But, like I said before, I prefer discussing things during class as opposed to just writing something. (Veronica, Interview, February 2011)

Veronica’s interview excerpt certainly shows her preference for face-to-face discussions as she enjoys lively interactions. Vonderwell (2003) highlights that understanding the learning styles of students, especially their communicative preference, is essential for enhancing face-to-face, asynchronous technology-related communication or a blend of both learning strategies.

Learning that encompasses both face-to-face and online discussion optimizes on students’ individual learning styles. In this balanced approach, students are provided the opportunity to
refocus from science content through worldly student experiences. Some authors stress that technology is a vehicle for pedagogy and learning of science (Singh & Reed, 2001; Bonk et al., 2006). Finding the correct balance of online pedagogy is in itself an inherent process requiring thinking and redesigning the access to learning via mixing technologies (Garrison et al., 2004). Hence, it is important to consider students’ learning styles and their orientation towards a specific social context that invokes interconnectedness of science with socioscientific matters (Develaki, 2008).

6.3.2 Five dominant themes online: An exploration of the post-interview responses and the online threaded discussions. Following the online STSE-based discussion study, students were interviewed and asked once again to share their views on the benefits of using an online discussion forum (challenges of the online forum are discussed in the next sub-section 6.2.3) in their physics course. When students were asked about the benefits of learning science through STSE-based issues, five key themes emerged in the post-study interviews with the nine focus students. Evidence of these themes were also located from the focus students’ online threaded text-based peer responses which are employed to substantiate the key themes. The five key themes are mentioned below:

I. In the online discussion forum, class materials are well-organized and easy to understand;

II. There is a sense of collegiality when using the online discussion forum;

III. The interaction with others in the online discussion forum and the access to World Wide Web means that students attain a greater support;

IV. The online discussion forum is self-paced; and

V. The online discussion forum provides students with the opportunity to reflect and
think more deeply than the in class discussions before responding.

The first theme that surfaced from the interviews, demonstrates a benefit of the online forum in terms of learners’ organizational skills. Veronica’s comment for example, addresses the fact that the online forum is well organized and as such, allows her to easily understand the ideas and share her own thoughts in a similar organized fashion. She states:

The [discussion] topics are a lot more organized. It’s easy to articulate as there are more resources; it’s a lot easier to communicate in general. It would really enhance learning experience….. The ones that were better written, I obviously, I clicked on all of them. If I saw that their writing didn’t make sense, or it was confusing, I didn’t really bother commenting on it because all I would be doing is harping on them…. I don’t want to be mean but just say, “you don’t make any sense.’ … And the ones that I saw that were better written, that used more complex language, actually made sense, they were coherent paragraphs, I commented on those. (Veronica, Interview, June 2011)

Veronica’s learning experience online was enhanced by well written and organized responses.

Properly written responses with complex languages and coherent paragraphs encouraged Veronica to read and respond to issues online. Evidence of Veronica’s view of organized responses is identified in the written text-based threaded comments when Esther answers to a well written online threaded response. Esther writes:

Love what you said. It’s definitely a lot more in-depth than my answer! Of course, that makes sense seeing as how you researched it, [but] not me! I guess you really do have to take both the advantages and the disadvantages into account. I like your answer, it’s very passionate. (Esther, Online Discussion Comment, May, 2011)

Esther’s online threaded comment to her peer, reveals an appreciation for a well-organized answer.

Another focus student, Daisy, also addresses the organizational skill of another peer student in the same physics class. Daisy says:

I completely agree with your statements. I appreciate how in your answer you provide throughout [your comment] examples, [and] provide more proof to your reasoning. I also
like your answer regarding the continuation of using coal to generate electricity. (Daisy, Online Discussion Comment, May, 2011)

Both Daisy and Esther responded to their peers’ comments during an online session addressing their peer’s research and organizational skills in their text-based threaded replies. In Daisy's comment, she is supportive of the examples used to substantiate the reasoning behind her organized views and evidence-filled response. Similarly, Esther addresses her peer’s well-constructed responses and their online written text format in the post-study interview. Esther describes that organized peer responses influence her selection criteria when perusing through the variety of peer texts and selecting which ones to read. In the post-study interviews, Esther raises the subject on selecting peer texts that are well written messages:

> If I chose to read a post, probably a lot of the time, it was because of the way the post was laid out. If it seems like a full answer, as opposed to just one sentence answers, then I wanted to read it to see what that person had to say. If it seemed like it was organized into [answering] a question to [the next] question as opposed to just kind of rambling on and on, and then I really wanted to read what the person had to say. Again, if was that initially it does look like a fully written response then I’ll give it a read through and if it seemed that there was something controversial or something that I could really agree with , then I’d respond. (Esther, Interview, June 2011)

Esther’s criteria in choosing a peer’s text to respond to was based on her classmate’s organized response statements. She felt that if her peers’ answers addressed the teacher’s questions in an orderly fashion, then she would continue to read the responses. This highlights the fact that the online discussion forum supports students in working on their writing style and being reflective on what they write. Esther also expresses an interest in reading controversial ideas that either support or oppose her own thought. Both Veronica and Esther exemplify that asynchronous discussions facilitate active learning through self-reflection which a number of researchers have also identified (Arend, 2009; Garrison et al., 2003; Picolli, Ahmad & Ives,
Researchers including Garrison and colleagues (2003) underline that the use of computer-mediated tools motivate students to do research outside of class, as well as, help them move towards finding solutions to the problems in written text-based responses. The expression of thoughts and ideas in the online text-based writing about the STSE issues helps students organize ideas and improve clarity of communication (Luppicini, 2002; Arend, 2009; Miller, 1999).

In addition to noting that the students’ discussion forum was well organized and easy to understand, the focus student participants also discussed a growing sense of collegiality when online. To these students, the second theme on collegiality was equated with a sense of community and belonging, which they found when collectively gathered online to discuss a topic. Flora’s comments stress the collegial nature of online discussions when she states, “I guess now our society is kind of based around technology, so by integrating it with our education, I guess it could help most of us kind of learn from each other” (Flora, Interview, June 2011). In this example, Flora underlines how the online discussion forum supports students in learning from each other, as opposed to simply learning from the teacher. In this sense, the dynamic of the classroom interactions changes from teacher-centred to student-centred. A student-centred approach seems to invite collegial and collaborative responses. Examples of collegiality in the online discussions are found in two different threaded responses, one response is from Flora and the other from Dahlia. Dahlia writes:

I think that you and I share a lot of the same opinions. I also agree with you answer referring to wind energy, because no real harm for the environment, it would be much more practical for Canada to switch to a safer resource. For the STSE answers, I noticed that you are also favoured environment over the cost of energy! By the way, I enjoyed your PowerPoint presentation on geothermal energy. (Dahlia, Online Discussion Comment, May, 2011)

Dahlia shares the concepts and opinions that she agrees with her peer. She is supportive of her
peer’s PowerPoint presentation which can be speculated to have similar supportive contributions to Dahlia’s thought processes. Flora adds to this theme of collegiality in the online threaded responses:

Just like most people, our answers were pretty similar. After reading your answer about the presentation [that] you most agreed with, I started to rethink my answers. … You had some great answers, good job! (Flora, Online Discussion Comment, May, 2011)

In these examples, students are referencing a PowerPoint presentation that they completed in class. These examples therefore highlight how the online learning forum encourages students to be reflective learners and incorporate what they have done in the face-to-face learning environment into the online learning environment. In essence, their learning from the in-class experience carries forward into the online forum and continues to expand in this forum, along with a growing sense of collegiality amongst students. Indeed, the collegial support in the threaded response enabled Dahlia to rethink about her own answers to the questions provided by the teacher’s initial post.

Another focus student Azilia, highlights in her post-study interview how the online discussion forum further allowed for a sense of collegiality to emerge in the STSE-based physics course. She expresses a sense of pride in the fact that one of her peers complimented her PowerPoint and learned new information from her presentation. Azilia states in the post-study interview:

For the first [STSE] discussions, I did not know what I was expecting, so I guess I just went into the discussion when I responded to it with more like, ‘I agree to all of your answers’. But for the second one [STSE discussions] I actually talked about what they said and one of them actually learned from one of my PowerPoint, so I said, ‘I’m glad you learned from my PowerPoint’. I was more open with my responses I guess for the second [STSE] I got used to it. (Azilia, Interview, June 2011).

Holly also comments on a greater sense of collegiality from the online discussion forum when she states in the post-study interview:
You learn more when...some things might resonate with you and especially you get to see the different side of things. You get to learn how other people feel. And also while you’re doing it online, like I said, you do research other things, and you do get to see ‘maybe I wasn’t looking at this right away, or maybe I was missing a key factor that should influence my decision’ (Holly, Interview, June 2011)

Holly’s comment supports the idea of students learning from each other and developing a multitude of perspectives from using the online forum to discuss ideas and to arrive at a decision.

It appears that the online forum provides the space for students to “listen” to one another by allowing all of their ideas to be visible in the form of threaded discussions. Such open and collaborative communication can support the important process of meaning construction. These student collaborations in meaning construction become an essential aspect of cognitive development. In other words, the social context of collaborating online provides the space and time to discuss and thus, develop their skills in reflective thinking (Garrison et al, 2000) in a community of learners.

The cornerstone of the Community of Inquiry (CoI) framework lies in the experience of the learner. The experience of the learner is embedded in three vital elements of CoI framework, namely the cognitive presence, teacher presence and the social presence (Garrison et al., 2000).

In the current discussion of students’ collegiality and collaborative behaviour online, the ability of students to interact socially online exhibits social presence (Garrison et al., 2010). With increased interaction online, it lowers barriers and leads to greater willingness to collaborate online by sharing experiences and contributes to discourse (Duncan & Barnett, 2010).

In order to contribute to the class discourse, students use the World Wide Web as a forum to interact and share ideas. This is in keeping with the CoI model where there is discussion on how social presence (namely the ability to identify with a community and communicate freely) supports discourse on a topic (in this case study, physics related STSE topics) and supports the
development of cognitive presence. Group cohesion is the essence of community, which when established allows for a multitude of ideas and perspectives to flourish. In this case study, the interaction with others in the online discussion forum and the access to World Wide Web meant that students attained a greater support in sustaining the CoI.

In addition to a greater sense of collegiality in the online social context, the focus students also discussed that the online forum provided them with a sense of support and help. In the post-study interview Flora addresses this when she states, “It’s just like the whole thing about everyone being able to say what they want to say. We all, kind of feed off each other and we get all this information off each other” (Flora, Interview, June 2011). In the post-study interviews, the focus students spoke about helping each other arrive at answers and problems together. Rosa adds the perception of support and help to the benefits of the online discussions when she states:

[If] you don’t understand anything, and you ask your friends face-to-face to explain it, sometimes, they don’t explain it well to me. And then you ask people online and it’s like a written lesson. (Rosa, Interview, June 2011)

According to Garrison and colleagues (2000), the challenge for many educators is to create a virtual Community of Inquiry (CoI). Teachers face challenges in setting up group discussions, which could foster a sense of community, through the online forum. However, the virtual environment such as this online STSE-based computer conferencing seems to naturally create the community of inquiry in this asynchronous text-based environment. Rosa adds that support and help comes in different forms in the online media. She describes that in text-based peer replies, a written text sometimes provides a better understanding and response to an issue when asked from “people online” stated in Rosa’s interview conducted in June 2011 as describe earlier. Using the Practical Inquiry Model (Garrison et al., 2000) as facilitation of discussion in a classroom community, De Leng and colleagues (2009) address the value of an online community
in sustaining help and dialogue. De Leng and colleagues (2009) propose the following:

An e-learning model integrating this ‘Practical Inquiry’ model in concerted facilitation by a human moderator and a program for asynchronous communication appeared to be successful in establishing a dialogue among an expert and a group of students. The structure of the e-learning model was useful in facilitating a sustained on-topic discourse involving critical thinking in a group of peers. (p. 12)

Hence students in the STSE-based online discussions establish a virtual community of inquiry to improve their understanding of science-based issues and transfer of knowledge.

A third theme which emerged from the post-study interviews was the sense of a greater support to learning because of the access to the World Wide Web. Students felt they benefited from having the time to research an answer before responding to it online. In addition, some students also commented that having the internet close at hand for research, meant they sometimes did background and/or additional research and reading on a topic, thus constructing meaning from their reflections or in other words, developing their cognitive presence (Garrison et al., 2000). Holly describes this experience of researching online when she states in the post-study interview:

Like I said, it [STSE-based issues] made you more aware [of socially-related science issues]. And, it also, with learning through the online you went into research, like on Google to help with you answer and stuff. So you went to other resources. But here it’s just one person or few people who could help you. (Holly, Interview, June 2011)

Holly speaks of internet browsers like Google to attain resources for her research.

Other physics students in this study have also accessed WWW beyond retrieving science content related information addressing STSE issues. Violet expresses the value of Internet as a learning tool:

I think if its’ STSE, like relating to that, I think it’s really good. It’s really good because you get to research more on the topic. It’s not that you are forced to, but just because its’ open there, okay, I am going to take advantage of this and I can use the internet, but if it’s for science like chemistry, not related to STSE, just regular curriculum, I think it would
be a drag for me, because I would rather write it. But if it’s discussion wise, I think it’s really good tool, and just because you have the internet and also you have people responding to other people and what they have to say. And you won’t forget it. Because you could always go back to look at it. So it’s really a good learning tool. (Violet, Interview, June 2011)

In the post-study interview, Violet speaks about the Internet as a learning tool for research and helping each other arrive at results and answers. Dahlia adds the perception of support and help to the benefits of the online discussions when she states: “The online, it helped us because it made us not just read the article, but I think I actually did more research around it. So it helped us learn more” (Dahlia, Interview, June 2011).

All three students (Holly, Violet and Dahlia) express how the Internet provides support to access more information for their online discussions and to thus enhance learning in science. Researchers also state the best approach to internet-based learning is to provide responsibility for students to be interested in probing and prodding issues that seek explanations, clarification and refinement from the learner (Arend, 2009; Gaimeter, 2008; Larson & Murray, 2008; Maruino, 2006).

The online discussions were also described as enabling students to learn at their own pace. Given the advantage of time convenience, learning at your own pace is identified as the fourth theme from the post-study interviews. Esther reflects upon the flexibility of learning at her own pace as she states:

I think it was the fact that we were put on a time constraint and it was something that we almost not forced to do it, obviously you have the option of not doing it….The fact that you were on that kind of time constraints and it was easily accessible because it was at home on a computer made me want to do this [STSE] topic, and then that urge to answer that question and do that topic, made me want to research it further and research it fully, because it had that opportunity to do it. So that kind of factor influenced me to want to learn more about the science so I could further understand it. (Esther, Interview, June 2011)
While the teacher created time constraints, for example, a one week period was provided for students to respond to questions. Their physics teacher did not regulate students to respond within a restricted time period. In the face to face classroom, discussions occur synchronously, and as such, students have little time to reflect at their own pace. Esther’s reflection reveals that the online discussion forum provided her with the flexibility of time and place to work on her response. In addition, the online discussion forum gave Esther time to research her answers and better organize her thoughts before posting them online.

In this example, it is therefore evident, that the online discussion forum supported students by providing them with flexibility in the pace at which they learned, as well as, by allowing them the time to think more critically about their responses and write a more reflective post. De George-Walker and colleagues (2010) suggests that computer-mediated learning offers students the autonomy to learn at their own pace and in the manner that suites their learning modality. Computer-mediated technology provides pedagogical value to the online teaching and learning approach, and this has been highlighted by the comments of the focus group students as indicated previously (see, Holly, Violet and Dahlia).

Indeed, there is a clear link between the self-paced nature of the online discussion forum and the reflective thinking that students discussed in their interview responses. Violet highlights the fact that the online discussion forum allowed her to be more reflective in her writing when she states:

Face to face, the discussions I think go more fast, and so I don’t get to say everything I want to say. But online, if I post something, I usually don’t post it right away. I usually keep it for a day and then read others, and if something comes up I add to it, so I think the discussion online is more in depth. It’s kind of broad and then people bring it to the middle to have a common agreement on things, but there is disagreement the discussion keeps going on, and I think it’s better than face to face. (Violet, Interview, June 2011)

Violet discusses how she writes drafts of her ideas with the online discussion forum. This
pedagogical tool actually allows for her to be more reflective in her writing and thinking because she has the time to articulate her thoughts and to do outside research to support her ideas.

Garrison and Colleagues (2000) describe cognitive presence in P.I. Model where learners construct ideas, confirm meaning for their ideas, and identify solutions through sustained group reflection and critical discourse. Garrison and colleagues (2000) state:

Critical thinking or inquiry is seen here as a holistic multi-phased process associated with a triggering event. This triggering event is followed by perception, deliberation, conception, and warranted action. …That is, there is a synergy between reflection and communicative action. Critical thinking is the integration of deliberation and action. This reflects the dynamic relationship between personal meaning and shared understanding (i.e., knowledge). Purposeful thinking and acting are essential to the educational process.... Moreover, we assume an approach where learning how to think is embedded in what to think; that is, it is domain-specific and context-dependent. (p. 98)

Writing through the online forum provides a powerful mediating technology in developing in subject-specific knowledge. The specific knowledge acts as a trigger for constructing meaning through discussion. The following is another excerpt that demonstrates the dominant responses by focus students with respect to the opportunity to reflect and think deeply during the online discussions. Esther underlines how the online forum allows her to formulate and construct ideas based on careful reflection. She states in the post-study interviews:

Online, I’m definitely more articulate in what I’m trying to say. My vocabulary is better because I’m trying to formulate my sentences, and what I’m trying to say kind of makes more sense, because when I’m offline and speaking out loud, a lot of the time I’m just kind of rambling off the top of my head and it doesn’t make sense, but when I’m, online I can kind of formulate my ideas and put them into something that can make sense. (Esther, Interview, June 2011)

Esther expresses that the online text messages are formulated to make sense since there is ample time to reflect and express the ideas. Asynchronous online text messaging usually requires time to frame responses (Wang & Woo, 2007) and as such allows students more time to read and reflect at their own convenience to construct a good written response. Daisy also underlines this same point of increased time for reflection with the online discussion forum. She believes the
online discussion forum focuses her concentration on the topic at hand, “When I talk, I don’t pay attention to what I’m saying, whereas if I type it, I have time to think back and I can feel the keys” (Daisy, Interview, June 2011).

The fifth theme which is reflecting and thinking deeply surfaced from the post-study interviews. The online discussion forum accomplished through the asynchronous text-based environment provides students with the opportunity to reflect and think more deeply than during the in-class discussions. The theme highlights the logical reasoning current of the STSE education (Pedretti & Nazir, 2011). In this logical reasoning current, “the focus is to enhance student understanding and/or decision making about SSIs by encouraging them [students] to think ‘the way scientists do’” (Pedretti & Nazir, 2011, p. 12). With the logical reasoning current, students are encouraged to focus their attention and think systematically about issues, and to work towards a solution. The focus is on thinking purely in terms of science and to explore the science behind the STSE issue at hand.

In this bounded case study, this systematic thinking coincides with the Practical Inquiry Model of Cognitive Presence (Garrison et al., 2000). The PI Model of Cognitive Presence is also comprised of systematic stages (triggering, exploring, integrating, and resolving) and as such is analogous to the logical reasoning current where there is a systematic approach to addressing an STSE-based issue. Violet highlights how the online forum supports her in thinking through, in a systematic and reflective way, on the issues at hand. She states: “I usually don’t post right away. I usually keep it for a day and then read others, and if something comes up I add to it, so I think the discussion online is more in depth” (Violet, Interview, June 2011).
Azilia’s comments also reinforce the logical reasoning current as she adds:

…you always get the information, you get time to think. And you can always research, you don’t have to answer right on the spot, you have time to research or look up stuff. (Azilia, Interview, June 2011)

In this example, Azilia is recognizing the problem, gathering information, and reflecting on how to arrive at a solution. She is “thinking the way scientists do” by using logical reasoning when online.

In summary, the post-study interview transcripts and the online threaded discussion transcripts allowed for a multitude of themes to emerge that highlight the perceived benefits of using an online forum to learn about STSE-based issues. The most dominant and recurring themes have been discussed in this section. The first theme explores the organization of the online forum and how the physical layout of material makes it accessible to a wide audience. The second dominant theme that emerges is the sense collegiality in the online discussion forum that highlights Garrison’s social presence in his Community of Inquiry Model (Garrison et al., 2000). As a result of increased interaction online, a third theme emerges which is focused around a greater access to information both from peers and from online resources. Students also discussed the self-paced aspect of the online forum and focused their discussion on how they enjoyed having the time and space to carefully craft their ideas “like a scientist.” This connects to the fifth theme discussed in this chapter which is focused on cognitive presence and specifically on how the online forum provides students with the opportunity to reflect and think more deeply before responding.

6.3.3 **Perceived challenges of online learning.** Despite all the benefits of the online forum that the focus students elaborated on in the post-study interviews, a few challenges also emerged. The most dominant challenge that students perceived with the online forum was the lack of synchronous, face-to-face, discussion and a lack of immediacy in responses to questions
and comments. A second challenge that students identified was the inability to focus when online due to being distracted by social media and other websites. Finally, a few students also reported challenges with logging onto the online forum and accessing information.

The most dominant challenge that students in the focus group identified was a lack of synchronous, face to face, discussion. Four out of the nine focus students stated that they prefer to use a face-to-face approach to learn and conduct science dialogue or discussions. Face-to-face and online learning have their fundamental differences in terms of learning autonomously. Since for some of these senior physics students the blended learning approach is their first exposure to online activity or they may have had minimal access to online activity in other courses, the marginal exposure to computer-mediated learning could create a preconceived notion and sense of discomfort about online discussions. Flora comments on how she prefers learning science concepts face to face:

[I prefer learning sciences via] Face-to-face, because I think it would be easier with a teacher than through technology. If I had a question, I don’t think it would be clear than if I were to type if through technology. If the teacher was writing on the board or showing you a PowerPoint presentation then you get all the visuals. For Chemistry, there are all those demos and stuff that you see physically happening as opposed to being described through the computer.

The comment expressed by Flora shows reliance on the teacher to provide and explain concepts.

Recent research findings demonstrated that several students had withdrawn from engaging their learning processes online and had come to a realization that returning to the easier, dependent lectures was a better choice that suites their learning modality (De George-Walker et al., 2010). Four focus students (44%) expressed preference for face-to-face learning. These students expressed discomfort in learning science concepts and problems-solution online. Excerpts from their post-study interviews are provided here (in uncorrected student extracts):
…The teacher can explain it to you more than one way, but if it’s through the online they could only explain it one way or giving examples. (Veronica, Interview, June 2011)

…Face-to-Face, you could give demonstrations, analogies to help some understand it. (Flora, Interview, June 2011)

….Or technology is not cooperating. (Daisy, Interview, June 2011)

…Being distracted by everything else that is on the computer like social networking sites, Facebook, twitter and all that stuff. (Holly, Interview, June 2011)

In addition to a lack of synchronous, face-to-face, discussion, students also commented on the lack of immediacy in responses to the online postings. Students wanted to receive immediate feedback from their posts and were at times frustrated with having to wait for their peers and teacher to respond to their ideas and/or questions. Holly expresses her frustration in the lack of immediacy when she states:

...And also again, you can get the help you need immediately [face-to-face] instead of waiting for someone to see your message [online] and reply. And in the case of STSE [face-to-face discussions], then your opinion is heard right away and your teacher will respond to you” (Holly, Interview, June 2011).

Veronica’s comments also express frustration with the lack of immediacy in the online forum. She states, “You can’t really ask your teacher for clarification. Yeah, you can email your teacher, but it’s not really instant” (Holly, Interview, June 2011).

In a 2003 study, Vonderwell (2003) found similar results with students being frustrated by the lack of immediate feedback and response from the teacher. One participant in his study stated that when he emailed a question to the instructor, “it might take hours, maybe a day or so before you get an answer back for the question” (Vonderwell, 2003, p. 84).

In addition to the delay in instructors’ online response time there is the distraction of social media and other websites online that students in the focus group identified as a challenge
to the online learning forum. Flora states, for example, “The internet has a lot of things, so it’s really distracting all the social networking stuff, and being a teenager I’m easily distracted” (Flora, Interview, June 2011). Flora elaborates when she states:

So, I guess, because the browser that I have is Google chrome, so it has tabs, so it’s easier to have the discussion open, and then you could have something like Facebook open and you could have something like Twitter open. So it’s like you are bouncing back and forth from tabs and then, I guess, the two social network tabs kind of are a little more distracting. (Flora, Interview, June 2011)

These comments reveal that students need discipline when using the online forum, and that perhaps the online forum can help challenge students in developing their time management skills. The online forum is self-paced, but this format means that time constraints need to be in place for students to develop a focused approach to learning and discussing.

Finally, a further challenge which emerged concerned the technical aspects of the online discussion forum. While all students had experience texting with their cell phones, emailing, and surfing the Internet, the online discussion forum through the school board was unfamiliar to students in its format and layout. Initial posts reveal confusion in how to actually post a threaded response to a peer’s comment. Indeed, this forum had a “submit” button for posting a reply in a threaded discussion and a “save” button for saving a draft of their reply and not submitting it. Rosa expresses this confusion, “When I first tried to do the posting, I couldn’t…I didn’t know how to do the threading, so I accidentally replied to someone else with my answer. And then I remembered that you always have to submit, not save” (Rosa, Interview, June 2011). Violet, on the other hand, was frustrated about attempting to post her response multiple times and it not appearing on the online discussion board. She states:

When I responded, I actually responded to three people, and that was the night before, it was due on Thursday at 11:59pm. When I checked my answer in the morning, because I was scared, for the first one, I replied two days in advance before it was due. I was scared that might not go in but when I checked, it didn’t go [was not posted online], so my
response wasn’t there. It didn’t show up and so I was kind of bummed out. (Violet, Interview, June 2011)

While the technical aspect of this bounded case study was a challenge, this was quickly overcome once students familiarized themselves with the layout and workings of the board’s website. These students are digital natives and as such are familiar with problem-solving and troubleshooting with technological barriers and challenges. As mentioned, all of the participants had their own cell phones, email addresses, and social networking pages, and as such, had experience and the knowledge base for communicating via technology.

6.4 Blended Online/Offline Teaching and Learning through STSE-based Discussions

This case study deals with a senior physics class where the teacher had incorporated a blended approach to teaching science. In this approach, the physics teacher integrated the teaching of STSE-based issues in her physics course by introducing the online discussion component where students were to read and complete the task of threaded postings. A key finding which emerges from this case study is that students preferred to work in a blended approach during the STSE-based discussion component of their physics course. This means they appreciated learning in the offline environment, particularly when learning new concepts in physics, but that they discovered a sense of collegiately and an opportunity to reflect on their learning in the online environment.

Indeed, the findings from the post-study interviews of this case study suggest that there are several benefits from structuring science courses in a blended manner that incorporates both the offline and online learning environment. Positive outcomes that emerged from this blended learning approach include both a deeper reflection on learning, as well as, positive interactions amongst peers during the online component of the course. This section of the chapter will explore both the metacognitive learning that emerged from the blended approach, as well as the
social peer compliments that were evident in the online threaded discussions.

6.4.1 **Online discussions and adapting students’ preferred way of learning to discuss.** This section examines individual’s preferred way of learning through the online discussions. According to Santo (2008), there are numerous ways to define individual’s preferred way of learning but the focus seem to be with learning styles that are used to predict student success. To predict success in students’ learning, the focus in this section is to observe online discussion and students preferred way of learning science by discussing issues related to science. In this online discussion emphasizing STSE-based topics in physics, three key learning preferences emerged from the interviews with the focus group. These learning preferences are the online discussion, offline discussion, and blended discussions are identified as peripheral findings in this STSE-based science discussion.

Two STSE-based topics were chosen by the teacher as part of this case study and to reiterate; they are Friction in Car Tires and Use of Green Energy. These topics correspond with the physics curriculum guidelines of Ontario Curriculum (Ontario Ministry of Education, 2008). In order to explore the positive and negative features of the computer-mediated (online) and face-to-face (offline) learning approaches, the student interviewees were asked to compare between online and offline learning about science concepts through STSE issues.

According to the post-study interview question based on benefits and challenges of online approach, students preferred to employ a combination of techniques to understand and discuss science issues. These combination of teaching and learning approaches ranged from traditional face-to-face, online asynchronous learning, and blended (including both in-class and online) strategies as shown in Figure 6.1. The findings from the study show 8 out of 9 focus students from the high school preferred having some technology-involved discussions.
The figure illustrates 9 focus students’ and their preference method for discussions.

The results in Figure 6.1 display that four focus students (44%) prefer discussing online and equally four students (44%) of the focus group prefer the blended approach of using both online and offline strategies in discussing STSE-based topics in physics. With technologically savvy students of the 21st century, a combined 89% (eight out of nine focus students) of the focus students prefer online and/or a blended approach to conduct their STSE-based discussions. Conventionally, web-based discussions with, flexible computer-mediated activities, particularly with time-delay and time for reflection have had positive impact on students. With more time to reflect on issues, asynchronous online postings have provided students opportunities to consider different dimensions of responses and being careful about posting their ideas (Park & Bonk, 2007). As suggested by several researchers the gift of time for reflection seems to be consistently
identified as in this study (Park & Bonk, 2007).

It is interesting to note that the students were eager to view everyone’s input online which suggests that these students are motivated to read and investigate on peer’s views. Azilia mentions:

I was Okay with people responding to what they thought…. I actually was a little excited when people responded to mine, or to see how they perceived and responded. I just liked going back [to the online threaded response pages] to see if anyone had any new responses, and just checking if anyone wanted to say anything else about what I said. (Azilia, Interview, June 2011)

With reference to Azilia’s excitement, researchers claim that reflective writings or responses are individual events but require collaboration from other students (Bassett, 2011; Gerbic, 2010). Azilia found that peer responses are important to her as she revisits the online discussion forum for new responses. Gerbic (2010) supports the idea that participation in an online discussion needs to be motivated as identified in this student. Azilia seem to be motivated with excitement in viewing any new text-based threaded responses. The consequent attention to the online asynchronous discussion provides students with feedback and support as it closely connects the threaded responses and discussion closely to the physics course encouraging students to be engaged.

The nature of the online discussion also provides the democratic space to interact with any peers to discuss or debate. Students are free to create an interactive response with whom they prefer in the online media. Examples of selected terms and phrases that identify benefits through text based writing not shown in Table 6.1 and Figure 6.1 include: Chance to view different sides or viewpoints; ability to formulate ideas before writing; better motivation to respond online and ability to return to re-read view. With these responses, one focus student (Veronica) summarizes the benefits and challenges of the online discussion:
Yeah, I see benefits. As opposed to teachers saying, ‘do these questions in the text book’, now that’s pretty dry. And you put it off [and say] “Oh, I don’t want to open my textbook, I don’t want to lug it home.” So as far as convenience, STSE online is a lot easier. Just open up your laptop, do the questions and you’re done. So I think it is better motivation for you. That’s probably the best thing that I like about that. The fact that I can just do that and it’s quick and it’s easy. But, like I said before, I prefer discussing things during class, as opposed to just writing something and not having most people read it, because I doubt that anyone read as many of the comments that I did. (Veronica, Interview, June 2011)

Veronica’s comment is consistent with the findings identified in Table 6.1 and Figures 6.1 and 6.2 with students’ perceptions of the online learning approach especially with a majority of the focus students engaging and participating in the STSE-based physics discussions. Adding Veronica’s comments to the study results, students have different science learning experiences through STSE-based physics discussions conducted both online and offline. It seems that the blended approach brings convenience to the 21st century learners while offering a deeper understanding of how discussions are linked to students’ learning outcomes as it provides more meaningful understanding of the real world.

As Ellis and Calvo (2004) argue that, in the blended situations, face to face may emphasize learning through physical experience of others while the online platform emphasizes the cognitive process of reflection on issues debated and discussed through a variety of perspectives. In this blended teaching environment (using both online and offline classroom situations), the engaging function of the online atmosphere may keep students focused on the task and create a positive environment and a spirit for community interaction where all decisions can be presented. This peripheral finding identifying learning preferences through STSE-based science discussion and collaboration needs further investigation which is not part of this dissertation.
6.4.2 Adapting teaching styles to blended learning. In building the community of learners, true collaboration can become apparent when all components and events are accounted for in a learning environment such as the online discussions for STSE topics and influential factors extraneous to the online event. The teacher’s role was seen as a facilitator who could manage teaching between the online and offline situations. The teacher’s role is crucial in facilitating true group cohesion (Duncan & Barnett, 2010) and the task is modified online from being delivered by a traditional instructor or a knowledge-transmitter in class (Kim, Anderson, Nguyen-Jahiel & Archodidou, 2007).

From my research notes of class visits and interaction with teachers and students, it was apparent that the teacher was making modifications to her second STSE online discussions to attain certain goals, particularly with reflection time dealing with ethical issues. The physics teacher modified her teaching approach to the second STSE online discussions by assigning a PowerPoint presentation component prior to introducing the web-based STSE-based physics Green Energy topic discussion. The Green Energy topics were divided into two categories, specifically the 6 non-renewable energies and 13 renewable energies. Some of the topics included oil, natural gas and coal versus solar energy, hydroelectric, wind, tidal, geothermal energy. When asked through email for her rationale in the teaching strategy used in the introduction of Green Energy student presentations prior to the online interactions, the teacher responded extensively as illustrated:

This is the first time that I introduced student presentation assignment before the online discussions. I had done 2 online discussions already [past two semesters in another physics course], and felt that the energy topic was ideal for in-class discussions before going online. Great for feedback and students would have to pay attention to their classmates’ presentations and a chance to reflect more in class. The students felt that this topic [Green Energy] was more interesting, as well. …More so than tires [first online STSE-based discussion]. Also, with the focus on ethics, this topic was ideal. Besides, the assignments included a written report and a presentation with opportunities for class
discussions after each presentation. Here, students were given the time [in class] to ask the presenters questions. I steered questions based on clarification, information required for students and on current issues. Daisy and Violet (pseudonyms) [2 of the focus students who preferred face-to-face discussions] and one other student [a non-focus peer] participated in discussions. Veronica and Esther (pseudonyms) [who prefer both in class and online discussions i.e. blended in the focus group] also spoke extensively. (Ayyavoo, Email Communication with the Teacher, June 2011)

The teacher’s strategy in introducing presentations was to increase the opportunity to reflect and discuss the Green Energy topic. This idea of class presentations was mentioned briefly to me verbally prior to commencing the unit on Green Energy in order to identify a change in the teaching strategy. The power of this newly introduced opportunity (PowerPoint presentation prior to online discussion) was to encourage the learners to attend to views and issues, interact by discussing social and ethical matters face-to-face, and provide time to reflect during the class on the student relevant issues. The teacher’s innovative lesson strategy through the PowerPoint presentation was to increase interactions amongst student discussions of the different Green Energy topics, enable students to become knowledgeable about STSE issues and trigger students to contemplate on third world issues as it was mentioned in the online discussion questions.

Researchers like Predretti and Nazir (2011) have identified that such socioscientific matters become value added science and represent the true nature of science in the real world. Other researchers confirm that considering the ethics in science subjects is a natural process of negotiating issues in socioscientific content aimed at promoting socially responsible decision makers (Develaki, 2008; Zeidler & Sadler, 2004; 2008).

6.4.3 Encouraging negotiation. Students who experience negotiating of scientific context within the scope of STSE-based issues tend to show evidence of epistemological development (Zeidler et al., 2009). Accordingly, students who have a broader scope with STSE driven curriculum, tend to visualize growth in reflective judgement. Researchers, who promote the aims of science education to consider scientific evidences in the context of real world
situations and crisis, cultivate in students the concern for social matters (Zeidler & Keefer, 2003; Zeidler et al., 2009). The importance of selecting contemporary topics, for example use of marijuana in certain diseases or its effect on the cerebral cortex of the brain provides opportunity for students to seek knowledge and prepare for class debates and discussions where there are opportunities to negotiate their conclusions. Such an approach to teaching science stimulates the development of reflective judgment which is critically important with STSE framework. In this case study, dealing with the blended approach of the teaching of STSE-based discussions, the physics teacher consciously made an extra effort to capitalize on the natural process of discussions and provide opportunities to argue and negotiate on matters in the socioscientific content of Green Energy Use particularly in third world countries.

The teacher’s decision, to record and name a few students in her email to me regarding class discussion, provided an opportunity in this case study to understand especially the focus students’ perceptions of STSE context use in physics. The reason for the fortuitous association was due to my ability to match the focus student names with those whom I have been observing via their interviews and online transcripts. I was able to identify students arguing and negotiating on third world use of renewable energy sources in the Use of Green Energy STSE-based topic in physics. As mentioned in the above teacher’s excerpt, the physics teacher demonstrated the nature of the blended (online and offline) approach in science where value of the hybrid teaching strategy enhanced learning styles of students, especially with extroverted (in-class) and introverted (online) learners.

The richer picture of students’ learning factors that contributed to the positive outcome of the blended approach is pointed out by the teacher in the following example. Daisy and Violet were two of the focus students who preferred having face-to-face discussions. Veronica and
Esther were identified as having spoken extensively in class who prefer both in class and online discussions (i.e., blended approach). These interview responses exemplified the declaration of students various approaches and according to Hodson (1998), leading to learning science, learning about science and learning to do science.

6.4.4 Findings from blended approach: Expressing social peer compliments.

Apart from the class interactions where some students express their views, there were few chances for students to express their emotions especially on complimenting their peers in their discussion responses. Duncan and Barnett (2010) address that there were little evidence of affective domain in the inter-student communication. However, by the end of the second STSE-based discussions, there were a number of comments that were identified during the peer threaded response as distinct compliments to their fellow peers. They began expressing emotions to each other when threaded responses were presented online. Many students would complement their peers for their responses which is an activity not often encountered during in class discussions. Such peer compliments identify the emotional well-being which is dramatically and positively predictive not only academic achievement but also about productive experiences (Goleman, 1995).

Some of the positive phrases included:

- ‘enjoyed reading your response’,
- ‘like the connection you made to society’,
- ‘love your post and it was effective’.
- Others examples of peer statements include,
- ‘You researched a lot with good examples to explain your view’;
- ‘I love your answer and you explored more and it made sense’;
- ‘I understood your explanation’;
• ‘Interesting reasoning and you made me think about scientific laws’;
• ‘Your way of persuasion is more effective’.

(Focus students, Interviews, June 2011)

Comments from students indicated positive social interaction and encouragement in relationship building that both the attributes seem to occur beyond the expected asynchronous task as in this case study. This value added interaction in the online learning experience is unique and favours students’ collaborative learning skills. The positive influences on students’ perception of learning and the online environment (Oztok & Brett, 2011) with encouraging comments identified in the online interaction suggest the value of online student community. Oztok and Brett (2011) suggest that in such an online community, social presence becomes a significant predictor of students’ overall satisfaction. Here, the online environment enables one to contribute to the messages or threads, especially if learners provide positive attributes to the peer responses. The importance of the social interaction outside the social media task is vital to online teachers and learners as the participants understand this safe virtual ‘gatherings’ that nurtures the online community.

In a nurturing community, McInnerney and Roberts (2004) suggest that learning needs to be pleasurable even if the content is controversial, academic or serious in nature, as identified in the physics related STSE-based discussions of the winter tire requirements in the province of Quebec. Kolsto (2001) support the idea of contextual factors being important in discussions. He calls it the ‘Content transcending knowledge’ to draw learners to citizenship and enhancing controversial issues. The topic of relevance of the content places importance to the science curricula that students recognize in their lives.

In summary, the teachers’ role is a catalyst for student learning through online discussions and most certainly in the classroom. The quality of student discussions is powered by
teacher’s construction of the online discussions and the constructive feedback that the teacher can prompt through an ongoing basis (Ertmer et al., 2007). In this case study, the richness of the data has illustrated student involvement through strong teacher facilitation and moderation of the blended online discourse. De George-Walker and colleague (2010) argue that the role of the teacher is not to prescribe the nature of the blend but to build the course, scaffold, support and engage students to develop their self-directed and regulated skills to become cognitively independent learners. The next chapter provides the overall discussion and conclusion to the case study.
CHAPTER VII

Summary Discussion and Conclusion

7.1 Online Pedagogy: Using Asynchronous STSE-based Discussions

The advent of blended (online and offline) teaching approach in high schools is the result of the increasing educational use of information and communication technologies, as well as, growing technology trends in society. Computer-mediated communication is more prevalent in tertiary education (De Wever, 2006a) and is currently being incorporated in high schools in Canada (Abrami, Bernard, Wade, Schmid, Borokhovski, Tamim, et. al., 2006; Bennett, 2012). Indeed, Canadian students are ‘cyber-savvy’ and seek out opportunities to use their own handheld technological devices (i.e., iPhones, iPads, etc.) in classrooms (Bennett, 2012). This digital preference seems to be a key feature for learning among the Millennium Generation. Roehling and colleagues (2010) coined the term Millennium Generation to help educators understand digital-age learners especially to describe digital natives and immigrants in 21st century education. Inspired by the growing demand for the use of technology in teaching and learning, De Wever (2006a) underlines the need for teachers to support the growing thirst students have for technological literacy, particularly with students’ use of text-based communication. Therefore, technology-mediated communication has the potential to support science learning in the 21st century and thereby uphold an inclusive differentiated learning environment by using online discussion tools in STSE-based science.

My case study was designed to observe the online STSE-based discourse as it fits with the growing trend of science education and especially, to adopt an online learning vehicle to improve individual and group discussions in a blended learning environment (Bennett, 2012; Horn & Staker, 2011; Project Tomorrow, 2010). Particularly in this doctoral research, online
asynchronous conferences were implemented in a senior physics course in an all-girl school to provide opportunities for STSE-based discussions related to concepts and applications studied in class. These online discussion groups do not replace the offline (traditional face-to-face) teaching methods but are used in collaboration with the in-class science cognitively enhanced discursive activities.

The main purpose of this case study was to examine secondary science students’ experiences as they engage in STSE-based issues in an online forum in a blended teaching approach. This chapter highlights the summary discussions focusing on the impact of students’ experiences in STSE-based discussions, the nature of science students’ online discourse and, students’ perceived benefits and challenges of learning about STSE-based topics through the online environment. Further, I conclude this chapter with a general discussion of the findings, limitations of the study, significance of the results, implications, recommendations including an introduction to an STSE-issues Based Analysis Model, future research and the conclusion of the study.

7.2  General Discussion of Findings

In this section, the most important findings are highlighted from each of the three chapters that discuss the findings of the study (namely Chapters 4, 5, and 6) corresponding to the three research questions posed in this dissertation. The doctoral research presented here is situated in STSE-based issues that allow for professional growth for teachers and, especially academic and lifelong skills development for students in the real world. The decision-making skills are warranted in sustaining oneself in a contemporary society with constantly changing technologies that impact on social-cultural-economic perspectives of cyber-savvy citizens.
Chapter 4 discusses the first research question that focuses on students’ experiences of STSE-based science education. The findings show that all nine focus students enjoy STSE-based issues discussions and also like using online discussions in their physics course. Eight of these physics learners also stated that STSE-based physics-linked discussions supported them in establishing connections between physics and real world events. For example, Esther (a focus physics student in the study) spoke about the different forms of green energy and its application in different parts of the world. She also expressed the value and necessity to address ethical and environmental impacts of coal use especially in Canada. The data highlights students desire to make connections with science concepts, its value in their personal lives, physical environment and in socio-political-ethical issues.

Pedretti and Little (2008) suggest that students’ desire to connect real world scenarios to science underlines the main tenets of STSE-based education. Essentially, the main tenets of STSE-based education are described by Pedretti and Little to address; stewardship to care for the environment, decision-making skills to help citizens to make informed decisions, ethical issues in science, social value in science, actions to empower citizens, critical social reconstruction to develop both intellectual and ethical skills, and the emphasis of nature of science to recognize scientific knowledge in society. STSE-based issues can motivate students to apply their knowledge in solving a problem that has socio-cultural implications (Hodson, 2011; Pedretti et al., 2011; Zeidler et al., 2009; 2005) and which may be relevant to their lives.

More specifically in this case study, various themes emerged when looking at the relevancy of STSE-based issues in students’ lives. Addressing the first research question in Chapter 4, secondary science students’ experiences were examined as they engaged in STSE-based education. In particular, the research showed themes that focused on the connections
students made between STSE-based issues and their lives. These key themes are the use of
STSE-based discussions to learn concepts in physics, the connections between STSE-based
issues and their personal lives, the connections between STSE-based issues and their social-
moral worldview, and the connections between STSE-based issues and the socio-political-ethical
world. The data in this bounded case study reveals that physics students learn about physics
concepts as they make connections to their lives and, according to Zeidler and Sadler (2008),
personal experiences facilitate meaning construction with science concepts. For example, some
focus students were able to provide a rationale to convince their peers and parents to use deep
threaded tires because this would increase friction on roads during the winter months in Ontario,
and would therefore, be safer. Researchers suggest that the inclusion of STSE-based issues in
class can motivate students to act based on a sense of moral commitment (Kolstø, 2001; Zeidler,
2009; Sadler & Zeidler, 2003). In the above example, Dahlia demonstrated this sense of moral
duty, as she tried to convince her family to purchase snow tires based on their proven safety in
winter driving. Indeed, Dahlia applied her learning of physics concepts on friction, to her social-
physical environment at home. As such, this dissertation study underlines the importance that
researchers (Sadler & Zeidler, 2003) have ascribed to making connections between personal
experiences and learning. When students are able to apply their knowledge in a real world
context, the learning is more meaningful and relevant.

Interestingly, this case study data also reveals that some physics students are able to
understand the interdependence of science with society that describes social dilemmas. Making
connections, negotiating science-related social issues and adopting a position with physics and
socio-political-ethical issues (as in this case study) are important skills needed for the
development of scientific literacy skills in students (Sadler, et al., 2004). For example, Veronica
commented about her conceptual understanding of physics concepts related to the topic of the Use of Green Energy, and how she consequently adopted a position with ethical values. Veronica expressed her ideas in relation to the topic of the Use of Green Energy, when she stated her position on Third World countries giving priority to food over green energy. Veronica’s position is expressed with the following quote: “The cries of mother nature are quiet when the grumbling of your empty stomach is all you can hear” (Veronica, Online Discussion Comment, May, 2011). In her quote she explains that the priority of the underdeveloped countries would be to deal with the social and financial issues surrounding poverty, not wasting money on 'green initiatives'.

Several researchers support integration of social and ethical issues in learning science as a transformative and motivating experience (Sadler, Klosterman & Mustafa, 2011; Sadler, et al., 2007, Zeidler & Sadler 2008). Hodson (2011) finds that motivating experiences arise from students’ accessing their prior science learning through comments, critical analysis and reflection. Indeed, students’ written reflections in the online threaded discussions and their views in the interview transcripts reveal application of STSE-based currents, specifically the value-centered and socio-ecojustice current (Pedretti & Nazir, 2011). In this case study, the overview of STSE-based issues-driven curriculum reveals interrelationships between classroom physics content knowledge and the complex STSE-based social-ethical frameworks (Pedretti & Nazir, 2011) identified through the technology-supported learning environment.

According to Roehling and colleagues (2010), digital-aged students require a high-level of cognitive stimulation, and socioscientific discussions in their courses satisfy this need. Through technology-mediated learning, physics students in this case study expressed their ideas and opinions of STSE-based education with greater comfort than in the face-to-face classroom scenarios. Rosa, for example, described her comfort with conducting online text-based
discussions as being free and unrestricted to express her views in STSE-based issues. Similar findings are reported in Wang and Woo’s study (2007) where students discussing socially-related issues online were more comfortable and willing to voice their opinion rather than in a face to face environment. Wang and Woo’s, (2007) findings are confirmed in this case study. In addition, researchers (Bostock & Lizhi, 2005) found female students in their study prefer online discussion to face-to-face interactions. Bostock and colleagues’ (2005) results showed female students wrote a greater number of messages and preferred online discussions because they felt empowered and were “able, conscientious and engaged” (p. 81) in a class of male students.

Bostock and colleagues’ (2005) findings are confirmed in this case study of a single gender class, in that the female science students felt confident and preferred the online forum over the face to face discussions. Furthermore, students were not limited by academic ability and writing skills when they were discussing online.

With the addition of online technology in the physics course, student participation in STSE-based discussions is enhanced, and students are encouraged to be active learners. The digitized technological exposure of 21st century learners fosters the development of new skills such as computational skills, technological literacy skills, communicative skills and new learning styles connected to social networks which enhance curriculum-based activities. Exposure to online discussions of STSE-based issues challenges learners to seek out problems, and to identify and suggest possible solutions to real world events. Being acclimatized to digital communication with text-based messaging, students seem not to be apprehensive about presenting their ideas or solutions online, as well as critiquing their peers’ responses in the online forum.

Asynchronous online discussion differs from the face-to-face discussions in class, where participation is often limited to a small group of students (Sherry, 2000; Wang & Woo, 2007;
Wishart et al., 2011). Online learning opportunities may be particularly appropriate when presented to digitally acclimatized science students. When students are given time to think and reflect, they seem to better prepare STSE-based issues arguments related to science subject content. Hence computer-mediated technology is effective in allowing students time to re-examine and reflect on science related issues.

All nine focus students are motivated to reflect on STSE-based issues through the online discussions. Asynchronous online discussions provide time for students to organize their findings, facts and argumentative thoughts to arrive at a decision. As mentioned in the logical reasoning current (Pedretti & Nazir, 2011), reflection through scientific reasoning facilitates better management of science facts and processes that garner better decision-making opportunities. The development of decision-making process through the reflective mechanism of scientific analysis is one of main approaches to the logical scientific thinking illustrated by the P.I. Model of cognitive presence (Garrison et al., 2000) as emphasized in this case study. Hence, when online learning opportunities are presented to digitally acclimatized science students, these students have the opportunity to become better prepared with STSE-based issues arguments as well as benefit from studying science from a humanistic perspective.

While, chapter 5 provides a deep overview of my findings connected to the nature of science students’ online discourse in the context of STSE-based education, this next section will highlight the key findings and its interpretation to the online discourse. To reiterate the terms used in these findings, the Macro-level interactions show participant-to-participant STSE-based dialogue through the text-based threaded postings. Students’ perceptions and attitudes towards online learning are revealed through STSE text-based discussions. The Micro-level interactions revealed the quality of participants’ STSE-based threaded postings discussions.
The underpinning for the quality of discourse is dependent on the four phases of the P.I. Model (Garrison et al., 2000) where the cognitive presence focus is consolidated. The cognitive interactions through the online asynchronous STSE-based discourses are examined according to the four phases of the P.I. Model, which include the following phases, Triggering (Phase 1) and Exploration (Phase 2), as well as, Integration (Phase 3) and Resolution (Phase 4).

The Macro-level interactions involve the quantity of STSE-based discourse (including in-class responses and the online threaded responses), as well as, the demographic of student responses (in relation students’ thinking process in the P.I. Model) of the issue-based discourse in physics. Eighty three percent (83%) of the class of 23 physics students in this case study participated in both the two STSE-based online discussions as opposed to 30% participation during in-class STSE-based discussions. This data may in part be attributed to the fact that this case study dealt with a female group. According to Bostock and colleague (2005), similar patterns of increased online participation were identified in single gender groups with higher percentages of messages (participation) in the online forum, as well as, higher cognitive interactions. Bostock and colleague’s study (2005) was a comparative one looking at online asynchronous, text-based discussions in all-female group, an all-male group, and a co-ed group. Their findings reveal that the all-female group wrote lengthier and more detailed messages, and as such a greater participation, than the all-male groups. In this case study, one of the reasons for the increased STSE-focused online dialogue can be attributed to the structured virtual discussions with questions to guide students. For example, some of the online questions enhanced students’ desires to further explore issues that are relevant to their lives and which are ethical and socially based.
In addition, increased time for interaction may have also contributed to the increased participation in the online forum. In the online forum, students had the availability of time to reflect on assigned topics for discussions, time to compose a better response on text than face-to-face, as well as, the opportunity and accessibility to conduct an extended research on the STSE-based topic. Furthermore, the teacher’s innovative supplement to the online component through the class assignment influenced the student discussions. The Use of Green Energy PowerPoint presentation by the physics students appeared to increase class dialogue (in the second STSE-based conference) which was noticed on the online platform.

This increased higher cognitive level interaction is a testament to the hybrid teaching and learning approach utilizing both the face-to-face and technology-mediated communication. The blended implementation of the online and offline learning strategies seem to support the computer-mediated asynchronous communication by benefiting learning and engagement which are often suggested for social and academic development in learners (De George-Walker & Keeffe, 2010; Wishart, Green, Joubert & Triggs, 2011; Garrison & Kanuka, 2004).

Gaudry-Hudson’s and Yalda’s (2010) suggest that the use of online interactive activities can be related to increased student motivation in their courses, particularly in participation levels, interest and success. If students’ motivation, comfort and interest in the subject matter is not maintained than this may result in poor performance in the course (Gaudry-Hudson et al., 2010). However, in this case study, the senior physics students displayed improved confidence, which emphasizes the importance and relevancy of the topics to learners’ secular perceptions, and opportunities to respond with different socioscientific views or dimensions. It is the controversial nature of some scientific topics, e.g. cloning or prenatal genetic testing, that provide the entry point to ethical discussions (Waddington & Imbriglio, 2011) which engage students. According
to several researchers integrating ethical questions in social issues encourages students to become aware, motivated, engaged, reflective and encourages learners to further explore ways to solve issues in their personal lives (Sadler, 2004; Zeidler & Keefer, 2003; Zeidler & Sadler, 2008; Waddington & Imbriglio, 2011).

Within the Micro–level online discussions, the quality of threaded discussions was examined using the four phases of the P.I. Model (Garrison et. al., 2003). In this analysis, cognitive presence was considered to play an important role in exploring the text-based knowledge construction. In this dissertation, the level of critical thinking (or cognitive presence) was again related to the different phases of the P.I. Model of cognitive presence (Garrison et al., 2000, 2001; Schrire, 2006; De Leng, et al., 2009). In my bounded case study, a particularly interesting finding was that 16% of students’ responses were at the Phase 4 (Resolution) level in the second STSE-based discussion (Use of Green Energy), as compared to the 3% in the Phase 4 (Resolution) responses in the first STSE-based discussion (Friction in Tires). The increase in Phase 4 responses in the second STSE-based discussion (Use of Green Energy) can also be attributed to the teacher’s novel intervention of using PowerPoint presentations to support the discussion. The incorporation of students’ PowerPoint presentation seems to enhance the deliberation of ideas and theories during the online text-based discussions making it meaningful. Furthermore, an increase in participation with meaningful discussions can also be attributed to the topic selection. Discussions centered on environmental issues are much more relevant and meaningful to youth today, than discussions centered on a physics concept such as Friction in Tires. Most high school students do not drive or are just learning to drive and hence, the topic of friction in tires is disconnected from their everyday experiences. Meanwhile, many Ontario urban high schools participate and/or organize Earth Day celebrations, recycling programs, and
discuss the environment in courses across the disciplines. Hence, topics related to environmental awareness and student involvement may naturally generate more interest. As such, students are involved in exploring a topic outside of the classroom, and then their interest in the same topic inside of the classroom is enhanced. This dissertation confirms this argument, in that students in this study were more interested in the topic of Use of Green Energy than they were in the Friction in Tires topic, because of their experiences at their high school with the Eco Club, Gardening Group, and environmental awareness activities organized for the entire school. An increase in participation in the second conference, the Use of Green Energy, may as such be attributed to the choice of topic.

Developing meaningful discussions employed through CoI framework is a concern raised by Rourke and Kanuka (2009). The aforementioned researchers’ reviewed numerous articles with reference to CoI framework where they indicate a lack of measures of learning. Additionally, Rourke and Kanuka (2009) reviewed a number of studies where a close-form survey had been used, for example, where students use three response points (such as, agree, don’t know and disagree) about the online discussions used in their courses. Other researchers used itemized surveys to indicate teachers’ presences and perceived learning. The close ended questions and other similar survey modes fail to really focus on the issue of meaningful learning. Rourke and colleagues’ (2009) reviewed articles related to CoI framework in order to show the limits of the CoI Model in specifying the necessary elements of successful online learning in that they failed to come to grips with the complexity of measuring learning outcomes in a meaningful way.

Interestingly, Test Blueprinting is a method used by Schrire (2006) and Meyer (2003) to identify meaningful learning in the online platform. Schrire (2006) measured meaningful
learning by using a matrix with different levels of learning within Bloom’s taxonomy and SOLO (Structure of Observed Learning Outcomes) and related these with the phases of cognitive presence in the P.I. Model. Schrire found parallels between how these models coded higher levels of learning when analyzing student data. However, Rourke and Kanuka’s (2009) claim is that higher cognitive levels found in student responses are not clearly identified with particular online activities related to the CoI model. Hence, the aim of my case study is to observe physics students’ development of meaning construction and learning through online discussion, as operationalized through the use of the P.I. Model (Garrison et al., 2000), rather than being a test of the CoI model as a whole.

In response to the ‘Learning in Communities of Inquiry’ literature review written by Rourke and Kanuka (2009), the following excerpt addresses the value of CoI as a process and dynamic model to learning:

Specific to the focus on cognitive presence, we emphasize that cognitive presence, as operationalized through the Practical Inquiry (PI) model, is a process that is consistent with the transactional nature of the CoI framework…. It describes potential learning activities as well as prescriptions for deep and meaningful learning. It includes understanding an issue or problem; searching for relevant information; connecting and integrating information; and actively confirming the understanding in a collaborative and reflective learning process. (Akyol, Arbaugh, Cleveland-Innes, Garrison, Ice, Richardson & Swan, 2009, p. 125)

The potential learning activity is seen as a process identified in the P.I. Model of cognitive presence. The analogical relationship found by Akyol and colleagues (2009) of the potential learning activity to the process component of the P.I. Model underlines learning as an ongoing cognitive reflective process. Akyol et al.’s (2009) excerpts claim the ‘potential learning activities’ as providing deep meaningful learning which parallels in this study, the components of nature of science – which itself is based on a systematic approach to gathering, analyzing, interpreting and providing solutions (NSTA, 2000; Pedretti et al., 2008; 2011; Sadler, 2004).
The dynamic nature of the CoI framework is emphasized by the interactions of the cognitive presence, social presence and the teacher presence.

In this case study, the teacher’s role is to facilitate learning while maintaining a social presence through collaborative online and offline learning activities. The teacher’s facilitation of both online and offline activities help physics students to learn physics in a meaningful way through student relevant physics-related issues. The teacher’s innovative plan to extend the curriculum time for reflective and collaborative discussions began in class during the second STSE-based topic (the Use of Green Energy) where she assigned PowerPoint presentations and continued the learning through the online discussions (second STSE-based discussion). The teacher facilitated text-based threaded online discussions which became cognitively interactive opportunities for students to construct meaning through STSE-based issues. These digital discussions provided more time for students to become aware, search for detailed information, think and reflect on discussion issues before contributing to online discussions and these results are confirmed in other studies (for example, Arend, 2009; Derier, 1999; Dringus & Ellis, 2004; Hewitt, 2001; Kear, 2001; Meyer, 2003).

In Chapter 6, the third research question addresses students’ perceived benefits and challenges of learning about STSE-based issues in science through the online learning environment. Three artefacts are used, namely the participant interview transcripts, computer-mediated interaction transcripts and my researcher notes of classroom observations. These artefacts are analyzed to better understand students’ perceptions on the benefits and challenges of learning about the two physics-based STSE issues (i.e., Friction in Car Tires and Use of Green Energy) through an online environment. The most dominant and recurring themes that surfaced about the perception of learning STSE-based issues in science include: the organization of the
online forum and the role this played in scaffolding learning, the sense of collegiality, access to information, self-paced aspect of online forum and the opportunity to reflect and think before responding to issues online.

The time to think and reflect with the online asynchronous forum was a key theme which emerged with respect to text-based STSE discussions. Two interesting percentages are worth addressing with regards to online asynchronous discussions. Although 89% (8 out of 9 focus students) prefer using the online forum for STSE-based discussions with their peers, 44% of the students (4 out of 9 focus students) disagree with learning of science concepts online. The difference in terms of percentages depicts the digital-age students’ preference for discussion of issues online rather than learning about a science concept online. One of the major obstacles for not wanting to learn science concepts online is due to the perceived lack of synchronous feedback from teachers and peers, as opposed to immediate delivery of information through face-to-face contact. According to several focus students, some other shortcomings of online learning include interruptions and distractions that students confront during their online activity, such as social network sites, email, and online chatting.

Roehling and colleagues (2010) claim that millennium students are capable of self-regulating their online activity by choosing relevant and appropriate learning strategies in the digital environment. Indeed, student subjects in Roehling and colleagues’ study reported that digital discussions “helped them ‘focus better,’ ‘make it easier to pay attention,’ and stop them from ‘zoning out’” (p. 2). Digital discussions, as discussed by Roehling and colleagues, are useful to millennium students because it is a means of active learning, where students contest ideas and come to their own conclusions, hence, facilitating their own learning. Other researchers suggest that online discussions provide time to reflect and assess information with a critical mind.
(Barnett et al., 2005). According to the dissertation data, learners have the opportunity to assess the different viewpoints of their peers, formulate ideas and reflect on the matter in query before responding to the issue or question. Other benefits observed include broadening students’ horizons with more information from their computer-mediated research, as well as, increased participation with more opinions to discuss. There were concurrent challenges identified by the focus students, namely, facing technological problems involved with logging in and accessing the online forum through the secured websites, but these problems were minimal and solved with the help of the teacher during the first online STSE-based discussion. Furthermore, social network distraction (e.g. Facebook) and the availability of too many Internet sites to select an area to focus their thoughts on have also been a deterrent factor for students learning concepts online.

Despite identifying some challenges of the asynchronous online discussions, students in this case study indicate benefits of the online text-based environment for reflective discussions. Students perceive the online forum creates a task-oriented emphasis that is productive in terms of opportunities to develop higher-order thinking skills. The online STSE-based discourse leads students to explore the uncharted territory of questioning beyond the science concepts that are grounded in socially-related science issues. Finally, the quality of STSE-based discussions is driven by the teacher’s construction of the online STSE-based student forum. In essence, the richness of the STSE-based discussion data occurred through an effective and dedicated facilitation of the physics teacher.

7.3 **Limitations of the Case Study**

While this case study presents a solid argument for the use of the blended-learning approach, there are also limitations of the study that need to be accounted. My presence in the
classroom, for example, may have influenced the behavior of students. Furthermore, while my small sample size of 23 students and 9 focus students provides a rich description, it also makes it difficult to generalize the findings. In addition to this, the study was conducted in a relatively short time frame of one school semester (5 months) and as such the students were online for a very limited amount of time. Finally, even though this research approach attempts to analyze and triangulate data through multiple and complementary perspectives of the P.I. Model (Garrison et al., 2000), I acknowledge that I am the one framing and interpreting the study with my biases and beliefs. However, I have attempted to remain open-minded and flexible in my observations, analyses and recognize that data may emerge contrary to my beliefs.

My presence in the classroom could possibly have heightened the awareness of teaching and learning strategies amongst the participants which may have influenced the findings. However, Tsai’s (2008) study illustrates that this influence may be positive. During this investigation, the teacher’s active collaboration and dialogue with the observing researcher (myself) benefited the teacher, the researcher and the class without changing or interrupting patterns of instruction. I maintained a superficial dialogue in class without interfering with instructions, especially on observational days, which helped to enable and create an environment of relaxed atmosphere for all participants. Particularly on the observational research days, I endeavoured to be aware of my own biases, reduce any intrusions, be reflective, and to use the multiple data collection techniques to the full potential to accurately describe the phenomena under study.

This case study is confined to a small class of 23 female physics students in a single gendered Canadian high school located in a large urban Ontario city and this small sample size may be a limitation. The research settings are described sufficiently, but the generalizability of
the findings may be limited due to the small sample size and due to the fact that this study included only female students. This small data size does not produce any inferential statements. Instead the data produced indicates descriptive numbers involved in the bounded case study. The results of this single-class case study are also limited by the relatively short duration (i.e., one school semester of 5 months) of the blended offline and online environment.

Another limitation is in the confined and restricted scale of the study. This case study involved only two STSE-based online discussions, and within each online discussion students were only required to post twice as requested by their teacher. Students, therefore, followed this minimum requirement in their postings. As such, the data gathered from this study was rich in description, but limited to the sample size of two postings. The Micro-level interactions focus particularly on the quality of student threaded postings with limited postings (i.e., teacher required two postings per student). While analyzing the text-based threaded responses, there were some limitations in identifying the cognitive dimensions (Phases 1 to 4) of the student threaded discussions. It was challenging but sometimes particularly limiting to categorize a student’s threaded response when it fell between Phases 3 (Integration) and Phase 4 (Resolution) of the P.I. Model. Similar limitations with deciphering participants’ views and reading their written discussions and particularly in attempting to match students’ text-based responses to the different P.I. Model Phases were addressed by Schrire (2006). Accordingly, the synergistic interaction between computer-mediated conferencing and the link to show deeper learning is difficult but this process seems to be a pedagogically worthwhile experience. Perhaps one possible solution to this limitation is to request for the classroom teacher or other researchers to analyze and rate the coding of the cognitive domain.
7.4 **Significance of Results**

Particularly in terms of pedagogical significance, this case study sheds light on the cognitive reflective phases of students’ discussions on STSE-based issues in physics in a blended learning environment. My case study data discloses that students are interested in a blended-learning environment. There seems to be greater participation in a blended learning environment. Furthermore, the quality of discussion in the blended-learning environment hints of a higher cognitive caliber, in that students tend to move beyond asking and answering questions related to content knowledge, but rather begin to make global connections with STSE-based issues in their learning. This bounded case study suggests four significant outcomes of learning about STSE-based issues through a blended learning approach in a secondary school:

- Blended structured lessons tend to provide time and space for higher cognitive interactions;
- Logical reasoning skills seem to be developed with STSE-based issues through the P.I. Model;
- STSE-based topics can be applied in other subject areas for an interdisciplinary approach to learning, and
- The blended learning environment could foster the development of an online community of learning.

Firstly, the application of online and offline structured lessons could promote critical, reflective thinking and strategic cognitive processes for learners. In particular, students in this study appear to have engaged comfortably in computer-mediated STSE-based discussions without fear or embarrassment. They discuss in an online environment with comfort and confidence when responding to the online text-based postings of the STSE-based issues. Indeed,
my findings show that students compliment one another in their online posts and express comfort in sharing their views on the online forum. Because the online forum provides students with time and space for thought processes, they seem to indulge in higher level cognitive interaction where there is time to research and reflect. This can also be attributed to the teacher’s structured lessons both in class and online. The teacher’s scaffolding of the STSE-based issues facilitated the students’ learning and discussions.

In this study, well-structured lessons provided time and opportunity for students to compare ideas, reflect on and develop higher order reasoning for discussion. The physics teacher’s organizational skill in the lesson plans elicited students’ ideas before extending those ideas through discussions and argumentation. My case study reinforces a study conducted by Simon and Richardson (2009) which highlights that lesson structure offers opportunities to compare and reflect to improve their own reasoning and argumentations. Hence, physics students had an opportunity to reflect on their text-based threaded responses and use a variety of argumentation strategies (for example, Toulmin’s argumentation patterns presented by Osborne, Eduran & Simon, 2004) to express their points of view on STSE-based issues. Time to reflect and assess STSE-based issues seem to enhance students’ learning experience. Zeidler and colleagues (2009) emphasize that when students reflect on issues, they have the opportunity to evaluate the claims, analyze evidences presented and assess a variety of viewpoints through social interactions and discourse. Learners who participate in a reflective process may engage in critical and reflective thinking exercises. Such an activity of reflective thinking is considered to be synonymous with the skills of inquiry (Garrison et al., 2000; 2001; 2003) and it is the fostering of the skill of inquiry that leads students to challenge the status quo and work towards problem solving for positive social change. Garrison and colleagues’ (2000) Practical Inquiry
(P.I.) Model introduces the idea of higher-order thinking coupled with the four different phases of the inquiry skills. Accordingly, the higher-order thinking mentioned in the P.I. Model includes reflection and discourse which displays the creative, critical and intuitive components of inquiry skills.

The second major significance of this study is that STSE-based discussions provided opportunities to promote the development of logical reasoning skills. Azilia, a physics student in the case study, explained her systematic approach to solving STSE-based problems by crafting a response, assessing her answer, making changes to improve her reasoning and later sharing her solution. Essentially, this case study reinforces work done on the development of logical reasoning (Pedretti & Nazir, 2011; Simon & Richardson, 2009) skills through STSE-based issues. According to Pedretti and Nazir (2011), logical reasoning is one way in which STSE-issues can be utilized for discussion in the science classroom to “enhance student understanding and/or decision making about SSIs by encouraging [students] to think ‘the way scientists do’ ” (p. 12). Discussion on an online forum allows for the development of logical reasoning skills of STSE-based issues.

Furthermore, this study underlines that more students achieve Phase 4 of Garrison and colleagues’ (2011) P.I. Model when STSE-based discussions are incorporated in physics courses and extended over a period of reflection in a blended learning approach. Sixteen percent (16%) of the peer text response were categorized to be in the higher-order thinking process where students apply, defend and suggest solutions in the second STSE-based Green Energy discussions. Computer-mediated STSE-based discussions may give science teachers both insights into online teaching methods and strategies to develop critical thinking skills in learners. Findings also reveal some of the factors that may influence the reflective thinking process
through the online forum by exploring the perceptions of the students and their thought processes as evidenced in the understanding of STSE-based issues. Another influential factor of the logical reasoning skill lies in class group dynamics where developing ideas from collaborative online work could possibly attempt to solve crisis or problems. The objective is for students to move from identifying and being aware of STSE-based issues to critically analysing and making decisions towards implementing the action. Given that today’s students are digital learners, the online forum becomes a space for social interaction, and consequently a venue for learning through discussion. Furthermore, my results may inform those developing science curricula of the importance of integrating online STSE-based issues within a science program.

A third significance of this study highlights key features and effective strategies for implementing STSE-based discussions in subject areas other than science using video-based blogging. The findings from this case study have informed a new cross-curriculum venture looking at the application of STSE-based issues in secondary core French courses (Paniccia & Ayyavoo, 2012). In the current Ontario French as a Second Language curriculum (2000), the emphasis is on skill development for language acquisition, as opposed to content knowledge. Indeed, this curriculum emphasizes the development of skills in oral communication, reading, and writing (Ontario Curriculum, French as a Second Language, 2000). With the current case study results, The PI Model of Cognitive Presence comprised of systematic stages (triggering, exploring, integrating, and resolving) and the analogous logical reasoning STSE current serve to inform the development of the systematic approach to addressing an STSE-based issue in the French course. With this emphasis on skills development in the French curriculum, STSE-based issues can become the content knowledge that teachers can use to motivate discussions which may help students develop skills in expressing opinions, supporting their ideas, contesting the
ideas of their peers, and arriving at a conclusion. In a project devised by Paniccia and Ayyavoo (2012) for a large urban Ontario school board, a sample online forum as an exemplar was created to discuss society’s current environmental issues in the grade 12 University French course, FSF 4U1. Topics developed for French teachers to use in blended learning environments ranged from ‘Organic Clothing’ to ‘Plastic Debris in the Oceans’ which are planned for board implementation in 2013. Particularly innovative in this project, is the development of a video based approach to blogging where students are not typing responses to questions, but being asked to record their opinions using a program called Jing (www.jingproject.com), where they will record their speech and support their opinions with visuals. This project will be piloted in a large urban Ontario school in the spring 2013. This project will include the exploration of environmental issues through a blended learning approach that uses digital electronic oral discussions.

Finally, this case study particularly contributes to the literature on the effective approaches and challenges to the teaching of science using a computer-mediated learning community. Blended learning in an educational setting (such as a secondary science course) has the potential to create a sense of community similar to a face-to-face environment (Bonk et al., 2006; Garrison et al., 2000, 2003) which mitigates antisocial conduct such as destructive criticism and personal attacks (Brew, 2008). In addition, online discussions are teacher mediated; hence the occurrence of antisocial behavior, such as cyber-bullying, could be reduced. Zeidler (1985) suggests that the ability for participants to engage in discourse involving social issues with moral matters encourages reflection towards developing optimal solutions. Zeidler and fellow researchers (2009) provide a guide for incorporating STSE-based issues into a course. These strategies include:
• Showing respect for students’ assumptions regardless of the developmental stages of their discussions;
• Discussing any ill-structured, controversial issues with the students by providing resources that indicate facts and different lines of reasoning for different perspectives;
• Creating opportunities for students to analyze each other’s views with respect;
• Teaching students strategies to systematically gather data and assess the relevance of the data in order to make judgments or decisions, and;
• Helping students address uncertainty and examine their assumptions about the knowledge in question.

This study, therefore, provides a concrete example of Zeidler’s ideals reflective thinking and problem solving, which are theoretical conceptions. A blended approach to learning how to discuss STSE issues, which includes both online and offline learning models, supports students and demonstrates Zeidler’s theory. In line with the critical reflective thinking format, the model proposed here involves STSE-issues based analysis using an adaptation of the P.I. Model (Garrison et al., 2000).

7.5 Implications of the study

This case study reveals a range of views of student experiences of STSE-based education in a blended (offline and online) science learning environment. These findings also present a challenge to current science teachers who do not have the expertise to apply a blended approach in their classroom and/or may not know how to incorporate STSE-based issues in their courses. Although the findings point to a greater need to incorporate STSE-based issues through a
blended learning approach in a science classroom, teacher training on science-related social issues through online discussions needs to be addressed.

It is difficult to watch a newscast or read an online article without encountering science and technology being embedded in social issues. For example, reading about genetically modified tomatoes with flounder fish genes to help the produce stay fresh on the grocery store shelves is an issue that encompasses both science and society. Today’s technologically-savvy students, as in this case study, reported that the most convincing and relevant STSE-based issues in physics (e.g., new technological innovations in the Use of Green Energy in their lives) were those closely aligned to their own prior beliefs and experiences. Hence, the educator’s goal should be to challenge and encourage a higher level cognitive interaction where students have time to research and reflect on alternative views to examine their own opinions. If science students are to reach a higher level of cognitive interaction, then it is worth considering the instructional strategy of teachers in an online STSE-based issues discourse.

Researchers have articulated that teachers need training to effectively integrate STSE issues into science classrooms (Mrazek, 2004; Pedretti, 1999; Sadler et al., 2004; Pedretti et al., 2011). The aforementioned researchers have underlined that while teachers are trying to implement STSE-based issues in their science classes, the pedagogical approach with which they do so, has not been a priority. Pre-service teacher programs and professional development activities need to reconsider and transform issues dealing with STSE science matter and incorporate student relevant issues into instructional and learning opportunities. Teachers may, for example, require training on the application of computer-mediated discussions while learning to become technologically savvy and amalgamating student virtual interactions within the science course. Teachers may find this case study to be encouraging namely with the high
percentage of students who arrived at a Resolution Phase (Phase 4). At this phase of cognitive presence, teachers can shed light on the higher order reflective thinking process which can be achieved through a blended learning approach discussing STSE-based issues. The advantages of a blended approach that have been highlighted in this study seem to outweigh the apprehension that some teachers may harbor about technology-supported discussions.

This case study may encourage teachers to become digital immigrants while interacting with 21st century learners. Today’s learners are digital natives who are swift with their thumbs through text messaging on their phones and through communicating with their tablets. This ‘Thumb Tribe’ generation of learners is familiar and comfortable with technological gadgets and generally displays eagerness about learning with computer-mediated technology. This motivation for students to interact with technology is reason to include a blended-approach to teaching. A possible counter-argument to the implementation of a blended learning approach that might be raised is that the use of computer-mediated technology will increase the workload of teachers, in that more time will be required to read and respond to all the threaded student discussions and messages of an issue. However, this time consuming assessment is where the teacher can use pedagogical strategies from the online learning literature to manage their workload (Baran, Correia & Thompson, 2011; Baran & Correia, 2009; Garrison et al., 2000; Rovai, 2007; Wade & Fauske, 2004).

A number of pedagogical strategies are available to teachers to reduce their workload. For example, Rovai (2007) provides sample discussion rubrics where a scoring system is employed to judge performance online that includes messages accessed in terms of quantitative, content, type of questions asked, collaborative evidences, message tones and mechanics of writing. Rovai’s online discussion rubric is shown in Figure 7.1
Figure 7.1 Online Discussion Rubric, adopted from Rovai (2007).

Figure 7.1 shows a typical rubric format that focuses on a stated objective (e.g., psychomotor or cognitive) and a performance criteria with a rating scale. In addition, Rovai’s (2007) online discussion rubric informs students of the written expectations of the online discussion of issues. For example, the rubric emphasizes that students need to ask questions, collaborate, and maintain a certain tone online (Rovai, 2007). A particularly noteworthy feature in Rovai’s rubric is the criteria of collaboration where he writes, “Collaborative learning is evidenced by comments directed primarily student-to-student, rather than student-to-instructor. Evidence of support and encouragement is exchanged between students, as well as willingness to critically evaluate the work of others with constructive comments” (p. 80). In Rovai’s rubric students are encouraged to discuss ideas amongst themselves and as such, his rubric upholds the creation of a learning
community. Rovai’s (2007) rubric is an assessment strategy that teachers can use to assess or evaluate student participation and to encourage building a learning community online.

In addition to the learning and teaching strategies suggested in literature, implementing student peer feedback may be a strategy to consider (Ertmer at al., 2007) as it adds to the sense of community. Providing feedback to students, in the learning community, has the potential to increase the quality of student discussion responses and to encourage students to learn from each other. In order to decrease teachers’ workload without jeopardizing students’ learning experiences, high school students may feel empowered to provide feedback and share in the learning responsibility with their fellow classmates. Indeed, teachers can build this as part of their evaluation criteria. While teacher-student discussions are valuable, student-student discussions can also shed light on new insights. Researchers have shown that there is an inherent value in participating with the feedback process, for example, reflection through feedback process aids in improving their own message postings (Ertmer at al., 2007).

As in this case study, the results from the blended online teaching and learning approach with STSE-based issues highlight the need for instructional attention. This study also shows that learners and instructors can build and promote a strong sense of community through the blended (online and offline) environment that can occur at anytime and anyplace.

7.6 Recommendations

Having designed and conducted a pilot study in my science class (2009) and having observed student-student and student- teacher interactions in the current case study (2011), the following issues are important recommendations for both teachers and students to consider about computer-mediated communications in secondary science programs. This section is presented with two subsections (section 7.6.1, recommendations for effective online communications and
the next subsection (section 7.6.2, recommendation for Blended online STSE model for high school science).

7.6.1 For effective online communications. Training and guidelines for science teachers and students are required for effective interactions in asynchronous online STSE-based discussions. The following are some basic online communication rules that science students could apply during the online discourse. Teachers can work with their students to develop such a list personalized to their own class in order to give students understanding of the rationale, and ownership in, such netiquette rules. For example, teachers should:

- Encourage students to start with subject lines that correspond to students’ topic discussions in order to provide specificity, clarity and validate the body of the message.
- Encourage students start their response using some simple salutation, (e.g., Dear Jacintha) and sign off with their names (e.g., cheers, Rosemary) to establish a sense of a respectful community online and to help develop social presence online,
- Encourage students to be respectful and use tact in all written comments to uphold a safe learning environment,
- Encourage the use of complete sentences when warranted (such as during threaded discussions, so that others reading the threads can understand the context of the discussion),
- Encourage students to avoid using abbreviations and words or phrases that might be misinterpreted or unknown to students and teachers during serious class discussions,
- Encourage students to use a common appropriate font size (e.g., 10 - 12), style or color to read during text responses on computer-mediated class discussions.
Other text-based skills that students need to be aware of within online discussions are to avoid plagiarism when posting responses or failing to cite sources. Citing peers’ response is different from copying parts of an entry to which a person is replying. In the online forum, students may copy parts of their peers’ responses to address an issue that has been raised, and this is to be encouraged because it shows they are carefully reading and specifically addressing their peers’ points. This is different from the copying of an idea from an outside resource without giving it proper reference. The copying and posting of a peers’ response is warranted when a student is trying to provide the context for their answer. It is the teacher’s role to instruct students on proper citation when working online. In addition, it is important that teachers also support students in developing their writing skills online. Students who proofread their discussion responses often identify spelling errors, grammatical mistakes, and other issues dealing with the mechanics of writing. These kinds of errors can reduce the communicative effectiveness of student entries and the teacher can approach this element of online writing from that perspective. In addition to monitoring student online writing structures and suggesting strategies, science teachers may also consider the recommendations in the next section for how to implement STSE-based discussions in a blended learning environment.

7.6.2 Blended online STSE model for high school science: In-depth processing.

Promoted by educational researchers (Zeidler et al., 2009; 2008; 2007), the objective of STSE education is for students to develop and employ reflective thinking and judging skills as a tenable part of science education. Secondary science educators can employ the online discussion features used in this study, in their own classrooms where they are developing a blended setting for students to develop critical reflective thinking skills. Teachers can facilitate learning by developing questions (placing constraints on questions) from the socioscientific context in order
to scaffold learning in science. If teachers design questions using the P.I. Model (as described in the paragraphs that follow) to address the different aspects of STSE-based issue, then it could allow students to focus and reflect on issues and develop solutions while using the online text-based threaded responses. Furthermore, in an online forum, students not only respond to teacher posts, but to the posts of their peers. This online threaded reply involves students posing questions and offering suggestions/answers to their peers. Therefore, the online approach provides an opportunity for students to scaffold their own learning through discussing STSE-based issues and creates a student-centered approach to learning in the 21st century rather than a traditional transmission approach.

The model proposed in Figure 7.2 is an adaptation of the general P.I. Model (Garrison et al., 2000) to focus specifically on analyzing controversial STSE-issues in science. Science teachers often face the challenge of managing controversial topics (such as STSE-based issues) in science. When an educational rationale and guide is provided (Levinson, 2006; Zeidler et al., 2009) there is an increased sense of comfort for including STSE-based issues in science courses. To that end, Figure 7.2 is a model proposed for science teachers to use in order to refine the content and the teaching strategies employed through the online media to increase students’ cognitive reflective skills.
As observed in this case study, the results in Chapter 4 describe students’ desire for engaging with controversial issues in physics and the strategies employed by the physics teacher both online and offline to incorporate issue-based physics topics. To enhance higher order thinking skills during the STSE-based science discourse, science teachers may need to develop new socially-related science activities to help initiate critical reflective thinking skills in students.

As in the STSE-issues Based Analysis Model (Figure 7.2) and the P.I. Model, critical thinking is an effortful and difficult process for students to actualize (De Leng et al., 2008). However, this critical thinking and reflective process can assist students to remain focused on the structure and investigative process which is often observed in the scientific inquiry model. As in the P.I. Model, the process of reflective critical thinking is a cognitive activity with four consecutive phases: triggering events, exploration, integration and resolution. During the first
Phase (Triggering event) students become aware of STSE-based issues and become curious about the problem or issue. This first phase is where students begin to form a question around an STSE issue, for which they want to work towards identifying a solution. When learners progress to the second Phase (Exploration), students make connections between the problem they want to solve and the science concept linked to this line of inquiry. Reflecting on the evidences individually or in a group setting entices students to build on consensus for hypothesis as identified in Phase three (Integration). New ideas are conceived through reflection and discussions as learners apply these new accepted concepts in Phase four (Resolution). This newly acquired knowledge is applied to situations or issues to arrive at a new solution. The data in this thesis generally shows that there is less discourse at the Phase 4. However, my data also suggests that the STSE-based topics, as selected by the teacher, are an important mediating factor that determines student participation and consequently the quality of discussion. About 3% of the text-based responses were identified with Phase 4 in the first STSE topic on the Friction in Winter Tires. In the second STSE-based topic on the Use of Green Energy, 16% of peer text responses were classified within the Resolution Phase (4). Topics related to environmental awareness and student involvement (e.g., Earth Hour activities) may naturally generate more interest because they are relevant to students’ lives, and at the same time these topics will encourage critical reflective thinking of issues in science.

Garrison colleagues’ (2000) Practical Inquiry (P.I.) Model incorporates higher-order thinking, which the online learning context appears to support in this study. Higher-order thinking is evidenced by a greater percentage of students achieving Phases 3 and 4, when compared to an offline class environment (see Table 5.4 for actual figures). The reflective inquiry elements of the P.I. Model seem to provide a viable way to understand the effects and
value of the STSE-based online discussions. According to De Leng and colleagues (2008),
online asynchronous communication and discussion can be successful when integrated with the
Practical Inquiry Model. The higher order thinking achieved when students arrive at Phase 4
(Resolution) can be achieved if more time is specifically allocated to the last two phases of the
P.I. Model (De Leng et al., 2008) which in this case study was achieved through the use of
various in-class activities to enhance integration and resolution.

7.7 Future research

Future research in online and offline blended pedagogy may consider students in both
single gendered and co-educational (mixed gendered) school settings. This case study explored
science students’ experiences in an all-girls high school. Science students in this bounded case
study expressed that a mix of computer-mediated as well as face to face communication added
meaningful context to their physics course. Other potential research could investigate gender
related discussion patterns particularly extrapolated in a single gendered boys’ school. It could be
worthwhile comparing both single gendered science secondary classrooms with co-educational
classes with different proportions of male and female students in the classes. Guiller and
Durndell (2007) find that in tertiary institutions, female message postings have the tendency to
display features in their writing that include apologizing, revealing thoughts and feelings and
supporting others. While male message postings show more adversarial and lengthy discussions.
It would also be worth considering gendered styles of communication online and its impact on
science learning and discussion of science related issues in a technology-mediated environment.

Further research in asynchronous communication modes can focus on the impact of
group dynamics in the online discussion environment. For example it would be worthwhile
studying the impact of assigning roles to secondary students during their online STSE-based
discussions. De Wever (2006a) and De Wever and fellow researchers (2006b) have discussed the importance of student roles and their impact in e-discussions conducted in tertiary institutions. A future study could involve a comparison with secondary institutions. Assigning roles to students has been found to have positive effects in helping develop efficient and rich discussions. Similar introduction of role assignment and designated tasks for secondary science e-discussions (such as, starter, group reporter, group coordinator, source researcher) may be worth investigating in high school science asynchronous online communications.

7.8 Conclusion

This bounded case study examined the online environment of a grade 11 physics class located in a large urban Ontario city and the outcomes from those online discursive opportunities with STSE-based materials. From my own teaching experiences and others in this field, in-class discussions are often perceived as low-quality discussions in traditional classrooms because they originate from an inadequate introduction and facilitation of socially relevant issues in science programs and because they often only include a small number of students. This research identifies the need for science curriculum to include STSE-based issue discussions through a blended approach consisting of both an in-class and asynchronous computer-mediated discussions.

The objective of this case study is not limited to the success or failure of the online forum. It is rather meant to focus on exploring the potential value of computer-mediated discussions in STSE-based issues and for supporting greater cognitive reflective thinking processes. The STSE-based online discussions are intended to go beyond goals of knowledge acquisition in the science curriculum and support the development of different perspectives on issues. For example, students may learn content knowledge about different chemical reactions in class, but in an
STSE-based approach they also incorporate social, cultural, political and economic perspectives. Students go beyond learning about the chemical concepts by delving deeper into the application of that chemical knowledge and evaluating the impact of those chemical reactions on society and the environment. Thus, students may discuss and debate before arriving at some consensus about the effect of chemical additives in food and propose alternatives to chemical additives. In this way, science concepts are applied to solving a problem or answering a question in a socioscientific environment, which corresponds to higher order cognitive activities in the Resolution Phase (4) of the P.I. Model (Garrison et al., 2000) and the logical reasoning current (Pedretti et al., 2011). This study reveals that a blended approach to teaching allows for the development of logical reasoning skills.

The development of logical reasoning skills is important for this heightens cognitive skills. The logical reasoning current is “one of strongest currents in the STSE continuum” (p. 13) that is used as a basis for gathering knowledge and employing decision making cognitive skills in controversial issues (Pedretti et al., 2011). Henri (1992) emphasizes that these cognitive skills and the potential to develop these skills are important in learning processes connected with understanding, reasoning, critical thinking, and especially arriving at a resolution. Supporting such in-depth cognitive processing, through online threaded asynchronous discussions during STSE-based science classes, might be a modification worth considering in the secondary science. Indeed, this study reveals that students are given the opportunity to think, reflect, collaborate, and come to a decision (resolution) when given the time and space to do so in a blended-learning approach, and as such highlights the value Henri places on the development of cognitive skills.

An important feature which emerges from this study on a blended learning approach, is that the asynchronous computer-mediated discussions provide the time and space for students to
revisit their reflective online dialogue over a period of time (e.g., 5 days as in this case study). Furthermore, keeping the cycles of dialogue and collaboration short (e.g., 5 days) ensures high school science students remain focused on the issue. As such, students read, reflect and collaborate to develop ideas and solutions with their peers online in a supportive community of learners. In this community, students not only respond to the teacher prompts in this forum, but also support each other’s learning by commenting on the ideas of their peers. This online cognitive reflective exercise therefore, may stimulate the learning of ideas through interaction amongst science peers as explored in this thesis.

The main contributions of this thesis to teacher education in science are:

a) The development of a teaching and learning rationale for implementing STSE-based discussion in an online environment at the secondary level. This rationale, based on the Practical Inquiry model of Garrison and colleagues (2000) and the Logical reasoning approach of the STSE continuum (Pedretti et al., 2011) in controversial issues offers strategies and a process that other teachers can use in secondary classrooms.

b) The introduction of a new model (STSE-issues BAM) to be employed by teachers in the development of lessons plans connected to STSE-based issues in a blended learning environment. As noted earlier, the STSE-issues BAM model, is an adaptation of the P.I. Model for an environment that is not fully online.

c) This blended approach may help a greater number of teachers and students engage with STSE-based topics by motivating science-based computer-mediated discussions around student relevant issues across interdisciplinary programs. It may impact teacher education (i.e., teaching teacher candidates about STSE approaches; development of teachers as
digital professionals and introducing new methodologies that help students engage in science related issues in their personal and global matters.

Garrison, Anderson and Archer’s (2000) CoI framework can provide a structure for interpreting student and teacher interactions as well as understanding how to structure cognitive processing of STSE-based physics issues in an online approach. The dynamic nature of the CoI framework is observed online through the interactions among the three presences (namely, social, teacher, and cognitive presence). Asynchronous computer-mediated communication provides an extension of the social interaction (social presence) over space and time and is not limited by geography. Having an extended time to respond online enables cycles of reflection and communication to occur about the science concepts. The gift of time also allows students to explore the STSE-based issues in physics and provides time for critical reflective thinking (cognitive presence) about these issues. To start and maintain the STSE-based physics discussions, the teacher facilitates (teacher presence) the interactions by posing questions which encourage students to respond (Duncan & Barnett, 2010; De Leng et al., 2009) with more in depth reflection (Garrison & Anderson, 2003).

The intention in the online STSE-based discourse is to promote higher-order thinking identified in this study as the Integration Phase (Phase 3) and Resolution Phase (Phase 4) of the P.I. Model. To that end, cognitive reflective thinking is a dynamic learning process that involves higher order thinking. Hence cognitive presence emphasized by Akyol and colleagues (2009) “is a process that is consistent with the transactional nature of the CoI framework” (p. 125). To build a community of thinkers and collaborators, the teacher encourages his/her students to respond to each other’s threaded discussion posts especially online. Identifying this collaborative learning function in the senior physics course, the teacher upholds a positive community experience
centered on real world events explored through STSE-based issues as manifested in the Ontario science curriculum (2008).

The goal of relating science to technology, society, and the environment (STSE) is an important feature of the Ontario science curriculum, which advocates that:

In order to attain this goal, connections between science and technology and between science and the world beyond the school must be integrated into students’ learning of scientific concepts and skills. Where possible, concepts should be introduced in the context of real-world problems and issues. (Ontario Science Curriculum, 2008, p. 9)

Particularly in the curriculum goals for students in grade 11 and 12 Sciences (Ontario Ministry of Education, 2008), discursive capability embodies how future citizens view the world. A worldview of socially-related sciences entices a new science academic façade requiring STSE-based science knowledge construction in current events or crises. This blended STSE-based approach helps students recognize the social value of science concepts and motivates science-based discussions around student relevant issues. Such newly collaboratively constructed knowledge could occur through argumentation and debates, but especially through modern technology-mediated communication where digital age students of the 21st century education are comfortable.

Technological literacy is already on the rise as many students registered in Canadian secondary schools are digital natives (Bennett, 2012; Prensky, 2001) whose lives are continually exposed to and infiltrated with current technologies (Adams, 2008; Bennett, 2012, CCL, 2008; Prensky, 2001). Due to their familiarity with the electronic medium of instruction, STSE-based education through e-learning may facilitate students’ involvement in and understanding of the economic, political, cultural and technological dimensions of science education. The rich data from this case study illustrates patterns of student decision-making skills, learning and potential for self-regulated for a blended learning approach in science. The data also indicates that
successful learners in science can develop critical thinking skills that are reflective, self-directed and self-regulated in computer-mediated settings.

The online discursive interactions amongst students provide a cognitive framework for students to develop skills that can be transferable to other courses and to their lives. In turn, assessing the nature of discourse amongst students can provide insights into the nature of teaching and the way students learn about science with an STSE emphasis via technology. It is possible that secondary science education in Ontario could recognize this new revolutionary nature of learning technologies where e-learning will be in the forefront especially for online discursive science pedagogy.

The potential influence of online discursive e-learning in new learning communities of Ontario brings about challenges in education. The frequent challenge for many educators is to understand such new emerging technologies and create learning environments using these new technologies in education. As today’s learners enter their learning environment as digital natives and ‘Thumb Tribe’ communicators, educators need to become digital immigrants to enhance the transformation of information through reflective and collaborative manner, to negotiate and support students in arriving at new ideas and solutions in a meaningful way that encompasses beyond Science, Technology, Society and Environment (STSE).
References


Appendix A

Semi-Structured Interview Questions for Teacher Participant

Pre – Study Interview Questions

Research Question 1 on:
Teacher’s Perceptions of online and offline environments in STSE-based discussions

1. How long have you been a science teacher?

2. Do you enjoy teaching science? Can you share with me what aspect of science teaching that you get most pleasure from?

3. State some of your own expectations that you believe are important for your science students to acquire. What do you think science education should be about?

4. Recently, STSE has become an important part of the new science curriculum. What is your understanding of STSE or science, technology, society and environment? Can you provide me with some examples of STSE in your teaching? Is STSE important to you, why or why not?

5. Having done the blended teaching approach (both online and offline) in your class, how do you feel about teaching STSE-based issues online compared to teaching face-to-face? Do you feel more confident in one that the other? Can you tell me more about the differences?

Research Question 2 on:
Science students’ and their teacher’s nature of online discourse in the STSE context

6. What problems do you face when you use online discussions in your courses? What problems exit when you use online discussion formats for STSE-based topics? Can you describe any incidents (memorable, good or frustrating events) of online in your science courses?

7. State some examples of questioning strategies used in the online science discussion forums used in your class? How do you encourage your students to respond to the STSE related topics in science?

8. With your experience with teaching online, what differences might there be in discussing social issues in science between online (computer-assisted) and offline (in-class) discussions?
Research Question 3 on:  
Teacher’s perceived benefits and challenges of online learning about STSE subject matter

9. What do you believe are the benefits of using online discussions in science class? Can you share with me some of the benefits you perceive from the online learning?

10. What do you see as limitations to online discussions? If so, can you tell me more about some of limitations that you perceive from your online experiences?

11. Is there anything else that you like to comment about computer use, STSE-issues use in your class or any other science matters?
Appendix A

Semi-Structured Interview Questions for Teacher Participant

Post – Study Interview Questions

Research Question 1 on: Teacher’s Perceptions of online and offline environments in STSE-based discussions

1. Did you enjoy teaching the STSE portion of your science course as part of your usual in-class activities? Please elaborate. What about teaching STSE online? Please elaborate.

2. Have your feelings and views of STSE use in-class and online changed in any way? Do you feel at ease in using online or offline STSE-based discussions? Can please tell me more about the differences between the online and offline teaching strategy?

3. Did you find using the online and offline techniques affected any aspect of your students’ participation in STSE-based discussions? Please share with me in what ways your teaching techniques changed the way your students discuss STSE-based issues in science?

4. How do you feel about teaching online compared to teaching face to face? Can you tell me more about the differences?

5. Are there any differences that you have noticed in the way you as their teacher affected STSE issues are discussed online compared with face to face? Can you please describe the differences in discussions with the online vs. face-to-face?

6. Are there any differences that you have noticed in the way your students were affected by STSE issues discussed online compared with face to face? Can you please describe the differences in your students’ discussions with the online vs. face-to-face?

Research Question 2 on: Science students’ and their teacher’s nature of online discourse in the STSE context

7. Has your comfort level changed since using computer-mediated technology in emphasizing STSE issues in your science course? Please elaborate your answer.
8. Do you find using online (computer programs) in your courses more or less frustrating? Can you describe any incidents of computer usage in your classroom that showed the above mention frustration level?

9. What did you notice about your students’ nature of discussions (i.e., were the discussions of academic nature, developing new questions, providing or seeking clarifications, suggestions of solutions to STSE-based issues)?

10. Is facilitating online discussions different than facilitating offline discussions? Please explain the differences to me.

**Research Question 3 on:**
Teacher’s perceived benefits and challenges of online learning about STSE subject matter

11. How do you feel about the use of online discussions in science? Do you see any benefits to using online discussions? Can you share with me some of the benefits you perceive from the online learning?

12. Do you see any limitations to using online discussions? If so, can you tell me more about some of limitations that you perceived based on your online experiences?

13. What do you think of the hybrid (online and offline) approach do to boost students’ thinking skills in your science course? Please suggest examples of thinking skills that students use from this technology-aided process of learning science.

14. Are there any comments that you would like to add here on your whole experience with online, offline discussions or any other experiences with STSE topics?
Appendix B

Semi-Structured Interview Questions for Student Participants

Pre-Study Interview Questions

Research Question 1 on:
Students’ Perceptions of online and offline environments in STSE-based discussions

1. How do you feel about learning science in high school? Can you tell me more about your favourite part of learning science?

2. From your own science experiences, state your expectations that you believe are important in learning science? In learning science, what are your expectations of socially-related issues in science discussions (such as environmental issues) both online and offline circumstances?

3. If you were given a choice between learning sciences online (computer-supported) or face-to-face (in-class), what would you prefer? Why? Please describe the difference between online and offline (in-class) learning.

4. When dealing with your science projects or homework, what methods do you use to discuss science topics with your classmates? Can you tell me the difference between using technology versus face to face discussions?

Research Question 2 on:
Science students’ and their teacher’s nature of online discourse in the STSE context

5. Have you heard of Science, Technology, Society, Environment (STSE) based-issues in your science classes? Prompt if say no: What about issues such as dealing with the use of diet pills, surrogate mothers or environmental degradation, in your Science classes? If yes, can you provide some other examples that you are familiar with?

6. Do you have access to the technology (i.e., cell phones, computer or other forms of technology) that would allow you to engage in STSE issues (or issues of social/scientific nature- which is what we call STSE) type of discussions? What technology do you use to talk about science topics? Please explain how you use technology in your talk or discussions with your classmates.

7. Do you use online features (e.g. email, MSN, phone ‘texting’) to discuss science related topics and issues with friends or even teachers? Explain what kind of influence this method of discussion has on learning science?
8. Have you used online discussions in your other senior science courses? Do you think that such computer-supported discussions are a helpful way to learn science? Why or why not?

Research Question 3 on:
Students’ perceived benefits and challenges of online learning about STSE subject matter

9. How do you feel about the use of online discussions in your science course? Do you see any benefits to online discussions? Can you share with me some of the benefits you perceive from the online learning?

10. Do you face problems when using computer-aided discussions in their courses? Explain your answer.

11. Do you think learning science with computer technology is helpful or not in understanding and solving problems in your courses? Please explain your answer.

12. Are there any comments that you would like to add here about computer-supported, in-class discussions or other science matters?
Appendix B

Semi-Structured Interview Questions for Student Participants

Post – Study Interview Questions

Research Question 1 on:
Students’ Perceptions of online and offline environments in STSE-based discussions

1. How did you feel about having STSE issues (or discussions of social/scientific issues) incorporated into the science curriculum? Please provide me with some examples of what you have done in science classes? What did you like/not like about having STSE discussions in your science class?

2. Do you feel at ease or uncomfortable in using both the online and offline discussion format for STSE issues? Please explain the STSE-based discussions. Can please tell me more about the differences between the online and offline teaching strategy?

3. Did you find using the online and offline techniques affected your participation in STSE-based discussions? Please share in what ways your technique of STSE-based issues discussions changed the way you discuss in science?

4. Are there any differences that you have noticed in the way you respond to STSE issues discussed online compared with face to face? Can you please describe the differences in your discussions with the online vs. face-to-face?

Research Question 2 on:
Science students’ and their teacher’s nature of online discourse in the STSE context

5. Were there adequate opportunities and time during the online part of this science course to understand the STSE issues? Please explain your answer.

6. How did STSE issues-based science influence your understanding of science concepts in biology, chemistry, etc? Can you give any examples of concepts that you learned online through the STSE topics?

7. If you can recall about your online activity, approximately how many online postings did you read by your peers for each STSE issue? What factors influenced the reading of your peers’ postings? What criteria did you use to respond to the issues posted?

8. Did you do anything differently in terms of responding to the two online conferences? Explain what factors influenced you in responding to your classmates’ discussion threads.
9. What role do you think your teacher played in the online discussions? Can you remember the type of questions you asked your teacher (i.e., about the online method of discussions or any issues about the STSE topics)? Please explain answers.

Research Question 3 on:
Students’ perceived benefits and challenges of online learning about STSE subject matter

10. When comparing the online to in-class discussions, what factors influenced you in learning science concepts through STSE issues? Can you tell me more about how it did or did not help in understanding STSE issues in your course?

11. How do you feel about the use of online discussions in your science course? Do you see any benefits in the online discussions? Can you share with me some of the benefits you perceived from the online learning?

12. What kinds of problems did you face when using computer-aided discussions in your courses? Explain your answer.

13. Are there any comments that you would like to add here on your whole experience with online, offline discussions or any other experiences with STSE topics?
Appendix C

Information Letter for Participating Teacher

Dear Physics Teacher;

I am a doctoral candidate in Curriculum Teaching and Learning at the Ontario Institute for studies in Education of the University of Toronto. Having discussed with your principal regarding my observational research with you, I am writing to formally request permission to conduct a case study research with your senior science class. I am approaching you because your science course includes a suitable context for my research based on the nature of the senior science courses (Ontario Ministry of Education, 2008) which encompasses Science-Technology-Society-Environment (STSE) based science curriculum. My interest is in your method of teaching STSE via the online discursive platform and my research could contribute to your professional development in both technological and scientific literacy. Out of respect for your students’ and your most valuable time, I will provide a detailed feedback of the online teaching and offer ideas for computer-supported activities.

Research Thesis
As part of my thesis research, I am interested in exploring more about STSE embedded science discussions. In particular, I want to explore more about using computer-mediated interaction in science. Therefore, my research entitled, Using Online Pedagogy to Explore Student Socioscientific Issues in a Secondary Science Classroom, may help to shed some light on teacher’s and especially the students’ cognitive process through the online discussions.

Researcher’s and the Teacher’s Role
My research role is to be an observer and an occasional technical-moderator with respect to STSE related online discussions. I am interested in observing your class on two occasions of the STSE discussions for both offline and online teaching situations: Offline scenarios involve in-class observations and online scenarios involve your class’s computer-mediated transcripts accessed through TCDSB’s online environment. You would advise me in advance which two class periods you would want me to visit that corresponds to the two online observations. These two online and offline observations could be observed through a two month period. I will also conduct two interviews with you; one, prior to class observation and the second, at the end of the research period. The interview is to discuss your understandings of STSE-based Science teaching strategies, STSE issues and about the offline and online discussions of student interactions. All interviews will be voice recorded and transcribed later.

When will the study begin?
The research will commence in April, 2011. All the online and offline activities, together with the interviews will be completed before the end of the semester, May 2011.

Student Participants & Parental Permission
I intend to invite your students from only this senior class to consider participating in this study by providing the general parental consent forms. The approved parental permission will allow
me to observe students’ online and offline interactions on the STSE issues. I will distribute the consent forms during my visit and collect these consent forms at a later scheduled time. With your support, a small focus group of 5 to 7 students will be selected for an in-depth study. The selection criterion for the focus students will be identified with your help to encompass a diverse academic ability within the class. Only the focus group will be committed to complete the pre- and post-study interview questions in person with me. Each of the interview sessions will be audiotape and transcribed later for data analysis. These interviews will be conducted after class hours but within school time and premise.

Availability of Thesis Research
If you kindly agree to participate, your privacy will be protected at all times. All collected raw data will be kept confidential, known only to me and my thesis committee. The research findings will be published in my Ph.D. thesis. The research summary will be available to you, your principal and your students, upon request. If needed, the entire thesis will be available to you.

Confidentiality and Withdrawal
Everyone’s identity including your own, your students’ and the school’s will be kept confidential in the thesis and subsequent presentations and publications. Pseudonyms will replace your name and your students’ names in the articles. I will assure that neither your identity nor the students’ will be revealed at anytime during or after the research is completed. The audiotapes from the interviews, including both interview transcripts and the online transcripts will be securely kept in my house in a locked filing cabinet. All printed materials will be destroyed by shredding. All research data will be destroyed after seven years. During the research duration, you may refuse permission, or withdraw from this case study research at any time without providing reason. Withdrawal from this research will not result in any penalty or effect on teaching evaluation.

I hope you will agree to participate in this innovative study of STSE issues-based online science education. This research may prove to be beneficial to students, teachers and possibly online science curriculum developers who are interested in discursive learning.

Consent Form and Contact Information
There are two copies of the consent forms attached with this letter. Please complete them both and return one copy to me on my prearranged visit and keep the second copy for your records. If you would like to receive more information about my research, please contact me in person, by telephone or via e-mail mentioned below. You may also contact my thesis supervisor, Dr. Erminia Pedretti at (416) – 978-0080 or erminia.pedretti@utoronto.ca

If you have any questions at all about your rights as a participant in this study, please contact the Ethics Review office at the University of Toronto at 416- 946-3273.

Sincerely,

Gabriel Roman Ayyavoo
Ph.D. Candidate, Curriculum, teaching and Learning
Ontario Institute for studies in Education/University of Toronto
Email: Gabriel.ayyavoo@utoronto.ca
Appendix D

Consent form for the Teacher

(To be signed by teacher participants)

Title of the Research: Using Online Pedagogy to Explore Student Socioscientific Issues in a Secondary Science Classroom

Name of the Researcher: Gabriel Roman Ayyavoo

Institution Affiliation: Ontario Institute for studies in Education of the University of Toronto

Please complete both copies of this consent form, sign and date them in the designated areas. Keep one copy for your records and return one copy to the researcher through the teacher.

I, ________________________________, agree to participate in the proposed research case study that was described in the attached letter. I understand that I may withdraw from the study at any time without giving a reason.

Signature of the participating teacher: ________________________________

Name of the Teacher (Please Print): ________________________________

Date of signature: ________________________________
Appendix E

Information Letter for Potential Student Participants

(To be read by student participants – 18 years and above
Or by parents whose child may be under 18 years of age in high school)

I am a Ph.D. candidate in Curriculum Teaching and Learning at the Ontario Institute for studies in Education of the University of Toronto.

Research Aim
As part of my thesis research, I am interested in exploring online environments in science. My research is entitled, Using Online Pedagogy to Explore Student Socioscientific Issues in a Secondary Science Classroom.
The main objective of my study is to shed some light on students’ thinking process and the integration of socioscientific issues (for example, Genetically Modified food scares and Mobile phone safety) identified in the revised science curriculum (2008) through the online discussions.

Rational – Why do the study?
In today’s education system, there is an increasing trend for using computer-supported activities inside and outside of classrooms. Yet, many of the computer searches and exercises are geared towards retrieving concepts and process of science, and not discussing about science-based issues. It is my hope that by using computer-supported communications to help students develop higher-order thinking skills, I may not only help current students in the study but also make a contribution that may benefit teaching and learning.

Brief Overview of the study
Student participants who commit to this research will spend approximately one to two hours over the period of two months in completing the online discussions as such activities are part of your or child’s senior science course. The completion of both the online and offline discussions is important data to be collected from the student participants.

Researcher’s Non-Evaluative Observations
My research role is to be an observer and occasional technical-moderator with respect to science related issues discussions. I intent to observe the teacher and students during the two in-class observations as it is part of the science course. My observations are not evaluative of the student’s performance and will not make any impact on the students’ grades. All data from the observations are strictly confidential and will not affect the student’s evaluation or shared with other teachers. I intent also to observe the online interactions of the class which the teacher will set up through the school board’s secure site.
What are the benefits for science education?
By participating in this study, you will make contributions to teachers’ understanding of critical thinking process involved in discussing social issues in science curriculum. Any suggestions provided to the study and findings from study may benefit classroom teachers, Information Technology (I.T.) teachers and other educators who work to improve quality of science education and cognitive learning skills.

Are there risks for the students participating in this study?
This study does not involve the collection of sensitive data nor pose any external risks. Only the students and the researcher will know about the particulars of the collected data that encompasses discussions of Socioscientific Issues.

What about Confidentiality?
All raw data will be kept in confidence and will not be identified by name but by pseudonyms. As consented participants, you (or consenting adult) will have access to the data collected about you (your child’s) at any time after the study is completed. All data will be destroyed after seven years. Every effort will be made to conceal your (your child’s) identities, and pseudonyms will be used to reference participants in the thesis and other publications.

Can you withdraw from the project?
You may, most certainly, refuse permission, or withdraw from this case study research at any time without providing reason by informing the researcher or the thesis supervisor, Dr. Erminia Pedretti. Withdrawal from this research will not result in any penalty or affect the evaluation on your course.

When will your (or child’s) participation with the study begin?
The research will commence in the beginning of the semester, April, 2011. All the online and offline activities, together with the interviews will end by May 2011.

I hope you will agree to participate in this innovative study of online science education.

If you would like to receive more information about my research, please contact me in person, by telephone or via e-mail mentioned below. You may also contact my thesis supervisor, Dr. Erminia Pedretti at (416) – 978-0080 or erminia.pedretti@utoronto.ca. If you are consenting and have any questions at all about your rights as a participant in this study, please contact the Ethics Review office at the University of Toronto at 416- 946-3273.

Sincerely,

Gabriel Roman Ayyavoo
Ph.D. Candidate,
Curriculum, teaching and Learning
Ontario Institute for studies in Education/University of Toronto
Email: Gabriel.ayyavoo@utoronto.ca
Appendix F

Consent form for student participants

(Print in duplicate and to be signed by student participants – 18 years and above)

Title of the Research: Using Online Pedagogy to Explore Student Socioscientific Issues in a Secondary Science Classroom

Name of the Researcher: Gabriel Roman Ayyavoo

Institution Affiliation: Ontario Institute for Studies in Education of the University of Toronto

Please complete both copies of this consent form, sign and date them in the designated areas. Keep one copy for your records and return one copy to the researcher through the teacher.

I, __________________________, agree to participate in the proposed research case study that was described in the attached letter. I understand that I may withdraw from the study at any time without giving a reason.

Signature of participating student: __________________________
(For 18 years and older)

Name of the student: __________________________ Date of signature: __________
(Please Print)
Appendix G

Information Letter for Focus Student Participants

Thank you for indicating an interest in participating in this research project.

I will be carrying out all research as part of the project entitled; Using Online Pedagogy to Explore Student Socioscientific Issues in a Secondary Science Classroom. You will be involved in the study as one of the 5 to 7 focus case study participants.

There is no difference in the rationale for the study nor the risk involved in all subjects as you have read and signed in the potential student consent form.

Brief Overview: Task for Focus Students
As a member of the 5-7 focus student participants, you are to complete all activities of your normal online and offline discussions together with the class, with the addition of the pre- and post-interviews. The interviews will each take about 20-25 minutes to complete. All consented members of your class will participate along with you in the online discussions. No other commitment is required of being in the focus student group. By being a focus student, your offline and online discussions could predict your ability in managing socially-based science topics. By participating as focus students in this in-depth study, you will make contributions to teachers’ and students’ understanding of critical thinking process involved in discussing social issues in science curriculum.

What risks are there for you in participating as a focus student in this study?
This study does not involve the collection of sensitive data nor pose any external risks. Only you and the researcher will know about the particulars of the collected data. All raw data will be kept in confidence and will not be identified by name but by pseudonyms. You will have access to the data collected about you. All data will be destroyed after seven years. Every effort will be made to conceal your identities, and all publications including the thesis will be given a pseudonym.

What about Confidentiality?
All raw data will be kept in confidence and will not be identified by name but by pseudonyms. As consented participants, you (or consenting adult) will have access to the data collected about you (your child’s) at any time after the study is completed. All data will be destroyed after seven years. Every effort will be made to conceal your (your child’s) identities, and pseudonyms will be used to reference participants in the thesis and other publications.
Can you withdraw from the project?
You may, most certainly, refuse permission, or withdraw from this case study research at any time without providing reason by informing the researcher or the thesis supervisor, Dr. Erminia Pedretti. Withdrawal from this research will not result in any penalty or affect the evaluation on your course.

When will your participation as a focus student in the study begin?
The research will commence in April 2011. All the online and offline activities, together with the interviews will be completed before the end of the semester, May 2011.

I hope you will agree to participate as one of the focus student in this innovative study of online science education.

If you would like to receive more information about my research, please contact me in person, by telephone or via e-mail mentioned below. You may also contact my thesis supervisor, Dr. Erminia Pedretti at (416) – 978-0080 or erminia.pedretti@utoronto.ca. If you have any questions at all about your rights as a participant in this study, please contact the Ethics Review office at the University of Toronto at 416- 946-3273.

Sincerely,

Gabriel Roman Ayyavoo
Ph.D. Candidate,
Curriculum, teaching and Learning
Ontario Institute for studies in Education
University of Toronto
Email: Gabriel.ayyavoo@utoronto.ca
Appendix H

Consent form for Focus student participants

(Print in duplicate and to be signed by focus student participants – 18 years and above)

Title of the Research: Using Online Pedagogy to Explore Student Socioscientific Issues in a Secondary Science Classroom.

Name of the Researcher: Gabriel Roman Ayyavoo

Institution Affiliation: Ontario Institute for Studies in Education of the University of Toronto

Please complete both copies of this consent form, sign and date them in the designated areas. Keep one copy for your records and return one copy to the researcher through the teacher.

I, ________________________________, agree to participate in the proposed research case study that was described in the attached letter. I understand that I may withdraw from the study at any time without giving a reason.

Signature of participating focus student: ________________________________
(For 18 years and older)

Name of the student (Please Print): ________________________________

Date of signature: ________________________________
Appendix I

Sample Instructions (Message Constraints) for 2009 Conference

Instructions here were used in my own class work on the STSE discussions.
(Based on the P.I. Model of Cognitive Presence)

Instructions for the Computer Conference – With message constraint or restriction
TASK: Your tasks are of two folds:
1) Read the instructions to prepare your response to the article, in accordance to the 4 stages mentioned below. Post your response under the each of four stages for the topic presented.

2) With restriction:
Next, you need to respond to at least two other peer responses of your choice by threading your response to their postings. But certainly you can post more than two threaded responses if you prefer. In your threaded response, you are to respond to yours messages by focusing your reply on (3) integration and (4) resolution components of discussions.

Discussions in 4 stages:
1) Objective: Identify a problem or issue with the (topic).
2) Explore: What do you understand is the problem with (topic)?
3) Integrate: What are your views? Reflect on the issues or possible problems affecting STSE.
4) Resolution: How can you solve the issue?
Appendix J
STSE Topic used for 2009 Online Conference

Is Fluoridation Needed?

In Canada, fluoride is added to drinking water. But fluoridation of drinking water has been argued to be unsafe by some people.

Perhaps North Americans need fluorides because of poor diets. Some argue that fluoridation may cause serious health issues or even be an environmental pollutant.
Appendix K

The Friction on Tires (Page 1 of 2)

Screen Shot with Instructions used for STSE-based Topic

NOTE: Questions are also presented in Chapter 3, Section 3.5.2
Appendix K

The Friction on Tires (Page 2 of 2)

Screen Shot with Instructions used for STSE-based Topic

NOTE: Questions are also presented in Chapter 3, Section 3.5.2
Appendix L

The Use of Green Energy (Page 1 of 3)

Screen Shot with Instructions used for STSE-based Topic

NOTE: Questions are also presented in Chapter 3, Section 3.5.2
Appendix L:
The Use of Green Energy (Page 2 of 3)

Screen Shot with Instructions used for STSE-based Topic

NOTE: Questions are also presented in Chapter 3, Section 3.5.2

Production:

During this last week, we heard your classmates present on non-renewable and renewable sources of energy.

Canada is one of the leading producers of energy in the world, and is also one of its biggest users. Most of the energy produced in Canada is from non-renewable sources such as coal, crude oil (including gasoline and diesel), natural gas, radioactive elements such as uranium.

As was presented, coal, natural gas, and uranium are extracted from deposits deep within Earth’s crust. Crude oil is either mined or purified from oil-soaked tar sands, such as those in northern Alberta. Most of the coal and uranium mined in Canada is used to generate electricity, the most versatile form of energy. However, when coal is used to generate electricity, gases are released into the atmosphere, contributing to climate change.

We are constantly searching for cleaner and ‘greener’ ways of producing electricity. One promising solution is to use wind to produce electricity. Large groups of turbines, called wind farms, may provide electricity for an entire community. Wind farms may be located on land or in large bodies of water.

Ontario has the largest wind farm in Canada: the Melancthon EcoPower Centre. This wind farm is located in Melancthon Township near Shelburne, Ontario, and provides electricity for over 52,000 homes. Ontario plans to construct six new wind farms by 2012 that will provide enough electricity for another 150,000 homes. Even more wind farms are planned for the future. Now wind turbine technologies are also addressing some of the problems associated with wind turbines, including excessive noise and danger to flying animals such as birds, bats and butterflies.

Wind turbines are only one of many exciting technologies being designed to reduce our reliance on coal, oil, natural gas, and uranium. Other alternative energy technologies include solar cells, geothermal systems, tidal turbines, and biofuels. During this week, you learned about energy and the technologies being developed to produce and use energy in the most responsible ways possible.
Appendix L:
The Use of Green Energy (Page 3 of 3)

Screen Shot with Instructions used for STSE-based Topic

NOTE: Questions are also presented in Chapter 3, Section 3.5.2

Wind turbines are only one of many exciting technologies being designed to reduce our reliance on coal, oil, natural gas, and uranium. Other alternative energy technologies include solar cells, geothermal systems, tidal turbines, and biofuels. During this week, you learned about energy and the technologies being developed to produce and use energy in the most responsible ways possible.

1. **Physics Questions:**
   a. What does it mean: “electricity is the most versatile form of energy”?
   b. Provide the name of your energy source you researched and state the cost analysis you found for your energy source.

2. **Application Questions:**
   a. We use energy for many purposes. Let’s see if the class can come up with 10 different purposes. Give one (1) way in which we use energy.
   b. Should Canada continue to use coal to generate electricity? Is it ethical for Canada to do so?
   c. Your classmates have presented alternative energy technologies. Which alternative energy technology did you agree with the most? Why?

3. **STSE Issue questions:**
   a. We as a society tend to look at cost analysis to determine which energy sources to use without looking at the overall effect to the environment. What is more valuable? Explain your reasoning.
   b. Is it fair for rich developed countries to force poor developing countries into using expensive renewable sources of energy? Should the developed countries assist the developing countries in developing renewable sources of energy?