Teachers’ Perspectives and Practices of Socioscientific Issues

By

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Abstract

This qualitative study examined teachers’ experiences with incorporating socioscientific issues (SSIs) in senior biology classrooms. Two current Ontario high school teachers who were confident in their ability to incorporate socioscientific issues were interviewed regarding their perspectives and practices. This study was conducted because the plurality of the STSE (Science, Technology, Society, and Environment) framework make its implementation difficult in the biology classroom. The findings of this study reveal that the teacher’s STSE philosophy and pedagogy influence the way in which socioscientific issues are incorporated. Participants in this study had teaching philosophies centred around: social justice, inquiry, equity, and neutrality. From the insights of the participants, the following overarching best practices surrounding pedagogy were identified: prioritizing critical thinking over memorization, creating authentic problems, and utilizing perspective analysis for values clarification.

*Keywords: Socioscientific Issues, STSE, Teacher pedagogy, Teacher Philosophy*
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Chapter 1: INTRODUCTION

1.0 Introduction to the Research Study

Why are we learning science? This question is ubiquitous in any high school classroom around the world. This question has also been the subject of much debate among educators in Ontario, and has been influential in the development of curriculum and policy (Bellomo & Pedretti, 2014).

Bellomo and Pedretti (2014) cite three succinct reasons for having science education: intrinsic value, utilitarianism, and citizenship science. Intrinsic value postulates that all students should be aware of the major cultural achievement in science, regardless of whether they decide to pursue a science-based career (Bellomo & Pedretti, 2014). Utilitarianism suggests that students develop generic skills in science that are useful for everyone (examples include measuring, estimating, and evaluating) (Bellomo & Pedretti, 2014). Finally, citizenship science postulates that science is not found in isolation; instead there are issues within science that overlap with society (Bellomo & Pedretti, 2014). Under citizenship science, knowledge of contemporary issues is critical if one wishes to participate in the discussion or decision-making around such issues (Bellomo & Pedretti, 2014). Citizenship science argues that understanding science is necessary for all individuals to actively participate in a democracy.

This research study will focus on citizenship science as a justification for science education. The concept of citizenship science is also closely linked to the concept of scientific literacy since both perpetuate the idea of informed citizens. Bennett et al. (2007) defines scientific literacy as:
The knowledge, understanding, and skills young people need to develop in order to think and act appropriately on scientific matters that may affect their lives and the lives of other members of the local, national, and global communities of which they are a part. (p. 348)

Traditionally, science education has been dominated by secure and factual knowledge, with teachers being regarded as ‘vats’ of this factual knowledge (Bellomo & Pedretti, 2014). This belief is reflected and perpetuated by textbooks, which are overwhelmingly about factual information (Bellomo & Pedretti, 2014). Additionally, many science teachers see themselves as an authority figure on scientific matters, preaching science in a lecture-based format (Bellomo & Pedretti, 2014). According to Hodson (2003), such a depersonalized view of science can alienate students and make them view science as difficult and abstract.

The desire to humanize and personalize science was the catalyst for the development of Science, Technology, Society and Environment (STSE). STSE challenges the notion that science exists in isolation, and recognizes scientific issues to be complex, with moral and ethical implications, as well as political, philosophical, historical and economic considerations (Bellomo and Pedretti, 2014). These issues are not only found within the scientific community, but in the public community at large (Bellomo and Pedretti, 2014).

Bennett, Lubben, and Hogarth (2007) conducted a systematic review to evaluate, synthesize and disseminate international research findings on the effects of STSE. They looked at students’ affective responses to context-based science, and how students feel about science. STSE education made students feel more positive about science by helping them to see the importance of why they were studying science (Bennett, Lubben
& Hogarth, 2007). The researchers also concluded that STSE approaches reduced the gender differences in the attitudes toward science (Bennett, Lubben & Hogarth, 2007).

STSE is presently influential in the development of the science curriculum across many countries worldwide (Bennett et al., 2006). Recently, there has been a push for the incorporation of STSE into the Ontario curriculum (Pedretti & Bellomo, 2014). STSE is very broad by nature and each teacher may approach STSE in different ways. To narrow my research focus, I will deal exclusively with how educators incorporate socioscientific issues – issues in science that overlap with society – into their classroom.

Ethical and moral values are best taught by analyzing socioscientific issues (SSI), which are open-ended problems that have multiple solutions and necessitate complex scientific considerations (Sadler 2006). Socioscientific issues are sometimes controversial by nature, and bridge the gap between science and society (Sadler 2006). Some examples of socioscientific issues in the senior (grades eleven and twelve) biology curricula include: genetic screening, gene therapy, in vitro fertilization, bioengineering, and cloning, among many others (Ontario Ministry of Education, 2008). Sadler (2006) claims that discussing value-laden topics in biology will make learning more contextualized, differentiated, and relevant to student lives. Furthermore, Hodson (2003) believes socioscientific issues promote scientific literacy and social responsibility.

Scientific advancements are creating ever-growing bioethical dilemmas that people deal with on a day-to-day basis (Lazarowitz and Bloch 2005). There is a pressing need for citizens who can navigate and participate in socioscientific issues. As science teachers, it is our imperative to educate students to function in a society that is filled with issues having moral, ethical, political, economic and legal dimensions. However, as Lazarowitz and Bloch (2005) claim:
In order to avoid political and economic repercussions, public school teachers do not relate to these issues while teaching science and tend to stay away from controversial subject matter. Even on the college level, the preaching of ethics and values is primarily relegated to sociology, anthropology and philosophy courses. (p. 438)

Many teachers lack the pedagogical knowledge to implement value-laden issues effectively into the biology curriculum (Lazarowitz & Bloch, 2005). Educators primarily discuss established and secure knowledge, while contested knowledge and values often get discounted (Bellomo & Pedretti, 2014). I will interview experienced biology teachers who implement discussions of socioscientific issues within their classrooms. I will gather insights from these participants on the challenges of incorporating value-laden topics, and the techniques that can be used to overcome these challenges.

1.1 Purpose of the Study

The purpose of this study is to investigate experienced high school teachers’ perceptions of incorporating socioscientific issues into senior biology. The research will address the challenges that experienced teachers faced in incorporating controversial issues into their classrooms, which may or may not be pedagogical in nature. Also it will deal with how these experienced teachers overcame such challenges. Currently there is a lack of research in the areas of techniques for incorporating ethical discussions into senior biology classrooms. The goal is to provide biology teachers with insights that will assist them in approaching socioscientific issues confidently within the classroom setting.

1.2 Research Questions

The following overall question will frame my research:
How do experienced senior high school biology teachers incorporate socioscientific issues into their classrooms?

Key issues will be addressed by the following sub-questions:

1. How does the teacher’s philosophy influence their ability to incorporate socioscientific issues within the classroom?

2. How does the teacher’s pedagogy influence their ability to incorporate socioscientific issues within the classroom?

1.3 Background of the Researcher

I am currently a teacher candidate student in the Master of Teacher program, Intermediate-Senior division, at the Ontario Institute for Studies in Education at the University of Toronto. My teaching subjects are Mathematics and Science-Biology. I aim to teach biology at the secondary school level. I have tutored high school students in biology for many years. Complaints of memorization and regurgitation from students are ubiquitous. My personal experience as a senior biology student also consists of large amounts of memorization without any higher order thinking or analysis. Learning was abstract and hardly ever contextualized to the world around us. The desire to contextualize learning motivates my interest in the topic of how to incorporate socioscientific issues into the classroom.

Two events have led me to pursue my research topic in socioscientific issues. In grade 12 Biology class, we were assigned a range of controversial topics to explore. I was asked to write an assignment on the ethical implications of in vitro fertilization and take a stance. The assignment was memorable because I had never done an open-ended analysis of a controversial topic in Biology. We had to gather information, take a stance, and justify that stance. I worked hard at justifying my stance and was slightly
disappointed when the discussion was not brought up in class. I remember being curious about what stance my biology teacher and my peers would have taken on the issue. Having a class debate, in which students are assigned different roles to defend, could have made for a stimulating class discussion and a very stimulating atmosphere for learning.

The second event deals with my experience as a Master of Teaching student at the University of Toronto. Here I took the ‘Educational Professionalism, Ethics and the Law’ course with Dr. Elizabeth Campbell. The most memorable and exciting parts of the course were group study cases. In these group study cases we would be presented with teachers who were participating in questionable activities in their capacity as a teacher. One case study, *Communities Near and Far*, dealt with a teacher who was heavily involved in volunteer work for an international relief agency. The teacher believed that students would benefit from his charitable involvement and be transformed into moral agents. However, parents and colleagues complained the teacher was prioritizing the relief agency over his own students. As a group we analyzed this case using different ethical frameworks and came to a conclusion. The clashing of multiple viewpoints from different people within the group made for a very thought-provoking discussion and some of the most unforgettable moments of the course.

In hindsight, my biology teacher, like many biology teachers, probably felt uncomfortable addressing an issue that was so controversial in nature. It takes time and experience for a teacher to develop the pedagogical-content knowledge to confidently navigate controversial topics in science. My research study aims to serve as a guide to imbue science teachers with the pedagogical insight needed for the navigation of multi-faceted socioscientific issues in biology classes.
1.4 Overview of Research Study

Chapter 1 covered the introduction and purpose of the study, the research questions, as well as the background of the researcher. Chapter 2 will cover a review of the literature. Chapter 3 will provide the methodology and procedure used in this study, including information the sampling procedures and data collection instruments. Chapter 3 will also include the limitations of the study. Chapter 4 will identify the participants in the study and describes how the data addresses the research question. Chapter 5 will include the implications for the educational community, recommendations for practice, questions for future research, and the conclusion. References and a list of appendixes follow at the end.
Chapter 2: LITERATURE REVIEW

2.0 Introduction to STSE

What can we do about climate change? Is animal research still a necessity for scientific progress? Should we eat genetically modified organisms? These questions draw on controversies that face not only the scientific community, but also society at large. The term STSE provides an opportunity to explore each of these issues in social, cultural, and political contexts, preparing students to think about such issues which permeate society (Bellomo & Pedretti, 2014). Jim Gallagher first coined the term STSE 43 years ago. In his seminal paper, Gallagher wrote:

For the coming generation of learners, who will live in a world deeply affected by science, knowledge of the processes and concepts of science, and their interrelations with technology and society will be prerequisites to knowing and functioning in the culture in which they will be living. (p. 337)

STSE allows students to learn, view, and analyze science in a broader context. STSE with its numerous currents (or forms) brings along with it relevancy, interest and real-world connections to the traditional science classroom (Pedretti, 2011). STSE requires that teachers still teach fundamental concepts in science, albeit through a contextual lens (Bellomo & Pedretti, 2014). Therefore, incorporating STSE requires the teacher to be aware of the messiness of science, and its dependence on ethics, politics, economics, and society (Bellomo & Pedretti, 2014).
2.1 Importance of STSE

STSE has grown in popularity within the field of science education for multiple reasons. Its first purpose is to serve the *science for all* philosophy (Bellomo & Pedretti, 2014). This philosophy is rooted in making science accessible and relevant for everyone—not only future scientists. Secondly, it began the idea of citizenship science. Citizenship science revolves around understanding and participating in contemporary issues (Bellomo & Pedretti, 2014). Citizenship science is about empowering students so that they are equipped with the necessary knowledge to participate and make informed decisions within a democratic society (Bellomo & Pedretti, 2014). As stated by Bellomo and Pedretti (2014): “[Citizenship science] promotes critical thinking, informed decision making and action on science and technology issues that affect the quality of one’s life and community” (Bellomo & Pedretti, 2014, p. 7). Thirdly, STSE humanizes the otherwise cold, rigid, and calculated nature of science, changing students’ perceptions and attitudes towards science. Aikenhead’s (2006) study found that students who learn science in non-traditional (STSE-based) classrooms improved their understanding of social issues and improved their attitudes towards science classes and learning. Students also improve their critical-thinking skills and decision-making skills (Bellomo & Pedretti, 2014).

2.2 Teachers’ Perspectives on STSE

STSE has many proponents worldwide (especially researchers) who believe in bringing relevancy and interconnectedness into the science classroom. In Ontario, the Ministry of Education has amended the curriculum to give STSE education a central position (Ontario Ministry of Education, 2008). Although STSE has made substantial
progress in the past few years – especially in research and policy – it has made mediocre progress in practice (Bellomo & Pedretti, 2014). Ultimately, the responsibility falls onto the science teacher who must incorporate STSE-based perspectives into his or her classroom. However, for many science teachers, there is still much confusion surrounding the STSE slogan (Pedretti et al., 2006). The purpose of this paper is to dispel some of the confusion surrounding the STSE slogan. The following subsections review several reasons why teachers find the implementation of STSE difficult within their classrooms.

2.2.1 Lack of Facilitation Experience

Pedretti et al. (2006) discusses many reasons why teachers – specifically preservice teachers – do not feel comfortable in incorporating STSE into their classrooms. Firstly, traditional science teachers often consider themselves to be a ‘sage on the stage’, an authority figure of factual knowledge (“sage on stage”), which must be transmitted onto their students (Pedretti et al., 2006). Since STSE demands open-ended and student-directed inquiry, the teacher must take on the role of a facilitator, which feels alien and uncomfortable for the traditional science teacher (Pedretti & Bellomo, 2014). Additionally, an STSE approach is also difficult for many teachers because it requires them as facilitators to navigate classroom discussions that may not have neat and predictable answers (Pedretti & Bellomo, 2014).

2.2.2 Lack of Teacher Support

Teachers also reported feeling alone in their quest to incorporate STSE into the curriculum. They felt that colleagues, parents, and administrators did not deliver the support or collaboration they needed (Pedretti et al., 2006). Teachers were also worried
2.2.3 Lack of Time

Teacher candidates realize that the science curriculum is content-heavy. Teachers feel that time spent covering STSE would be better spent covering the curriculum requirements (Pedretti et al., 2006). Due to the multiple demands placed on teachers, such as covering content, assessing students, creating lesson resources, teachers simply do not have the time for issues-based STSE practices (Pedretti et al., 2006). Therefore, although STSE is at the forefront of all science curricula, it is often neglected or marginalized by teachers (Pedretti et al., 2006).

Much of the research done on teachers’ perspectives of STSE has been on novice teachers or teacher candidates. Additionally, numerous studies deal with the challenges teachers face in incorporating STSE into the curriculum. To distinguish from this body of research, this study will focus solely on experienced biology teachers, and how they overcome such challenges to incorporate STSE practices into their classrooms.

2.3 Theoretical Frameworks: STSE Currents

STSE by its very nature defies having a clear-cut definition (Bellomo & Pedretti, 2014). STSE is broad and each science teacher will approach STSE incorporation in different ways (Bellomo & Pedretti, 2014). Different groups of STSE practices are possible, each with their own unique set of pedagogical approaches and methods. To help guide individuals through this bewilderment, Pedretti & Nazir (2011) created six ‘currents’ or categories for STSE education: application/design, historical, logical reasoning, value-centred, sociocultural, and socio-ecojustice. This research topic will focus primarily on the value-centred current, logical reasoning current, and the socio-
ecojustice current of STSE. This is because these currents will appear within the findings. Discussing the remaining currents is beyond the scope of this literature review.

2.3.1 The value-centered current

Throughout the paper, we will use the value-centred current as a theoretical framework to understand the findings from the research study. According to Pedretti and Nazir (2011), the value-centered current recognizes that science is value laden. Therefore, presenting science without such considerations would be inaccurate. The value-centered current of STSE recognizes that the other currents in STSE do not adequately address the ethical aspects of science and therefore seeks to close this gap (Pedretti & Nazir, 2011). It does this through multiple approaches: character education, values clarification, and cognitive moral development (Pedretti & Nazir, 2011). The overall aim of the value-centered current is to promote character formation within students. Students are often required to critically analyze the issue using ethical frameworks and ultimately develop a personal value position that they are capable of defending.

2.3.2 Logical Reasoning Current

The logical reasoning requires students to be able understand multiple perspectives, think critically, and and make informed decisions (Pedretti & Nazir, 2011). The logical reasoning current is based on the fundamental principle that the consideration of a socioscientific issue can be handled through the careful consideration of the science behind the issue and applying logical reasoning to the situation (Pedretti & Nazir, 2011). Within the classroom the logical reasoning current can be used by doing a risk/benefit analysis, stakeholder analysis, or through the use of argumentation (Pedretti & Nazir,
2011). In effect the logical reasoning current teaches students to think like scientists, where logical thinking is used as a basis for gathering knowledge and making a decision.

2.3.3 Socio-ecojustice Current

The socio-ecojustice focuses on understanding the impact of scientific issues on society and environment, but also on how these issues can be resolved with human agency and action. Activities done within the classroom typically appeal to students’ sense of justice. One example of how socio-ecojustice may be incorporated into the classrooms is through place-based education, where learning is derived from immediate vicinity of the learner, such as a local park or stream.

2.4 Socioscientific Issues

The value-centered current is similar in nature to socioscientific issues (SSIs). SSIs is a movement that arose with the growing popularity of STSE. According to some educators it shares its principles and vision with STSE (Pedretti & Nazir, 2011). For example, both STSE and SSIs recognize the need to transform traditional science education and promote scientific literacy. Saunders and Rennie (2011) define scientific literacy as sufficient awareness of science and its processes to confidently address contemporary science issues. Scientific literacy requires science teachers to tailor science education for future citizens and not necessarily science professionals (Saunders & Rennie, 2011). Scientific literacy extends beyond the understanding of basic concepts in science; it requires students to analyze and evaluate information and use this information in the decision-making process (Pedretti & Nazir, 2011). Achieving scientific literacy requires the development of certain ways of thinking: acquiring skepticism, being open-minded, using critical thinking, consolidating multiple viewpoints, and accepting ambiguity (Zeidler et al., 2005). This explicit focus on the decision-making process
promotes the epistemological growth of children (Zeidler et al., 2005). By promoting scientific literacy, the goal is to empower students to make their own decisions regarding current socioscientific issues.

2.5 Differences between SSI and STSE

Some educators, however, believe SSIs to be a separate entity from STSE because of its explicit focus on the moral development of children (Zeidler et al., 2005). Zeidler et al. (2009) state that STSE currents do not adequately express the ethical nature of science. Zeider et al. (2009) defines SSIs issues as a movement that empowers students to make decisions regarding current social issues that are ethically or morally laden. The expectation is that by presenting students with moral problems within the domain of science, and allowing them to deliberate, students’ views on socioscientific issues will develop and solidify, and can be shared vocally with others (Pedretti & Nazir, 2011).

Zeidler et al. (2005) summarizes SSIs by stating:

[SSIs] focus on empowering students to consider how science-based issues reflect, in part, moral principles and elements of virtue that encompass their own lives, as well as the physical and social world around them. (p. 357)

Unlike STSE, SSI focuses explicitly on the character/moral development of students, which is often given little to no attention in traditional STSE. For example, Zeidler (2009) states:

STS[E] tended to emphasize student understanding of the interactions among science, technology, and society, but paid scant attention, if any, to the quality of social interactions and reflective discourse most closely aligned with the formation of conscious and principles of justice. (p. 360)
In summary, the conscious effort of promoting epistemological and psychological growth in children is what distinguishes SSI from STSE.

2.6 Teachers’ perspectives on SSI

In Ontario there has been a shift in science curricula to incorporate SSI, which falls in the realm of STSE (Bellomo & Pedretti, 2014). Many science teachers still feel they lack the support and confidence to address the topic of SSIs. Literature from all around the world suggests that teaching students about socioscientific issues is especially difficult for teachers.

2.7 Conceptual Frameworks: The First and Second Record

La Velle et al (2004) provides a conceptual framework, which guides my understanding of the content-based and pedagogy-based challenges that teachers may encounter when trying to incorporate socioscientific issues into the classroom. The conceptual framework of La Velle et al., consists of the first record and second record.

2.7.1 First Record

The first record refers to the beliefs teachers hold about the content they teach. It considers how teachers view themselves as specialists in their designated field, and how much content they know in their designated field (La Velle et al., 2004). The first record can be alternatively thought of as the depth and organization of content knowledge (La Velle et al., 2004). It can be broken down into substantive knowledge (organization of basic concepts in the field) and syntactic knowledge (ways in which basic concepts in the field arose). According to La Velle et al. (2004), having an abundance of both substantive and syntactic knowledge is fundamental before approaching issues that are encumbered with ethics.
2.7.2 Second Record

The second record – arguably more important than the first – is concerned with pedagogy instead of content knowledge. The second record is defined by La Velle (2004) as the system of ideas that help organize learning within the classroom. This includes personal theories teachers will have of teaching, learning, education, curriculum and their pedagogical style. The second record is all the knowledge and experience of ‘teaching’ teachers bring to their ‘first record’.

The second record can be broken down into four main categories: general pedagogical knowledge, curriculum knowledge, pedagogical-content knowledge and educational context (La Velle et al., 2004). General pedagogical knowledge refers to the broad principles and strategies that teachers use for classroom management and organization, which are distinct from the subject matter (La Velle et al., 2004). Curriculum knowledge in this case will be a teacher’s understanding of socioscientific issues and how they fit within the Ontario guidelines for senior biology (La Velle et al., 2004). Pedagogical content knowledge is the way in which a teacher makes socioscientific issues accessible to pupils (La Velle et al., 2004). Lastly, educational context includes understanding individual and group relationships and how they will impact the learning environment when discussing socioscientific issues (La Velle 2004). Additionally, educational context also refers to the awareness of local, regional and national contexts when teaching SSIs (La Velle et al., 2004).

2.8 Conclusion

Rapid scientific and technological change has presented society with many socioscientific issues. Within the senior biology curriculum there are issues of genetic
screening, cloning, and reproductive technologies among others. Therefore, there is an increasing need for students to be scientifically literate in socioscientific issues so that they may participate and make informed decisions in society. Much of the research on addressing SSIs focuses on students and how they navigate SSIs (Saunders & Rennie, 2013). In contrast, far less research has been done on addressing teacher pedagogy, even though teachers have a vital role to play (Saunders & Rennie, 2013). Evidently, as teachers become more informed in their pedagogical practices, they are more likely to incorporate SSIs into their teachings, and provide innovative learning opportunities for their students.
Chapter 3: METHODOLOGY

3.0 Overview

In this chapter I describe the research methodology, which I used to conduct my research study. I will then review the research approach, procedures, and strengths of qualitative research. Subsequently, the instruments used for data collection will be outlined. Next, I detail the criteria for sampling prospective participants as well as recruiting these participants. Thereafter, I discuss how I approached the analysis of data and I review the ethical considerations pertinent to my study. Subsequently, I discuss the limitations of this qualitative research study. Finally, I conclude the chapter with a summary of key methodological decisions and their rationale.

3.1 Research Approach & Procedure & Strengths

This research looks at the implementation of socioscientific issues within the senior biology curriculum. The study was conducted by reviewing the literature, and then carrying out semi-structured interviews with experienced high school biology teachers. The participants in this research study were senior biology teachers residing in the Greater Toronto Area. The research study involved sampling and choosing participants, collecting data in the form of interviews, transcribing data, and storing data.

Qualitative studies seek to understand a problem from a holistic perspective and provide data that is a culmination of participants’ lives, cultures, and attitudes. This can provide researchers with a meaningful understanding of a real-life phenomenon that is complex in nature and not easily deconstructed. Although the results of qualitative research are not generalizable, they provide the reader with the opportunity to live the experience. Qualitative research factors in all the nuances and complexities that exist in
real life (Creswell, 2013). My research study was designed as an instrumental case study approach involving a specific issue, problem, or concern (Creswell, 2013). The instrumental case study approach fits well with the research question because it provides an in-depth understanding of how socioscientific issues are incorporated within the real-life setting of a high school classroom (Creswell, 2013).

3.2 Instruments of Data Collection:

The primary instrument used for data collection were semi-structured interviews (see Appendix B). Semi-structured interviews provide a systematic and structured method for addressing the researcher’s questions, whilst allowing participants the flexibility to elaborate on their ideas and venture into new and unforeseen territories which that may be related to the research question.

My semi-structured interviews were carried out individually and face-to-face in the participant’s school. Each interview lasted approximately 45 – 70 minutes. During the interview, a microphone was used to record audio, and written notes on the participants’ reactions were also taken.

Participants were asked questions created well in advance. Interview questions focused on participants’ beliefs and experiences regarding the incorporation of socioscientific issues into the biology classroom. The research questions were prepared and memorized prior to the interview and were designed to be open-ended to allow the participant to answer the question in their own terms. Additionally, appropriate follow-up questions were used to ensure participants stay on topic. Before the actual interview, one pilot test interview with a colleague from the Master of Teaching Program was carried out. Creswell (2013) notes the importance of pilot testing for refining and adapting the research questions and process. Additionally, pilot testing questions on
student teachers provides a vantage point for addressing concerns in incorporating socioscientific issues from an inexperienced teacher’s standpoint. Therefore, pilot testing provided an interesting juxtaposition when compared to veteran teachers.

3.3 Participants

3.3.0 Overview

This chapter discusses the methodology concerning participant recruitment. I review, in detail, the sampling criteria I used to narrow my selection of suitable participants and the procedures I used to locate these participants.

3.3.1 Sampling Criteria

The aim of this research study is to examine exceptional teaching practices to guide educators (and preservice teachers). Since the inclusion of socioscientific issue in the classroom can be challenging for novice teachers, it was important for the participants to be experienced and well versed in the realms of STSE and socioscientific issues.

The sample criteria I used to locate participants was two-fold. First, it was important the teacher had ample experience in teaching biology at the intermediate/senior level. This was important because Pedretti et al. (2006) found that even pre-service teachers who express confidence in teaching STSE still express a decreased likelihood to teach STSE-based lessons in their early years of teaching. Additionally, novice teachers are more concerned with relinquishing control because conventional science teachers are taught to be an authority figure (Pedretti et al., 2006). Incorporating socioscientific issues into the classroom defies a neat approach and lends itself to a more open-ended and student-directed approach, which some novice teachers perceive as a loss of control (Pedretti et al., 2006). Secondly, the participant should be making continued efforts to
better their understanding of STSE/socioscientific issues and willing to share their experiences thus far.

3.3.2 Sampling Procedures

Participants were selected based on a combination of purposeful and convenience sampling. Purposeful sampling is the narrowing of the sample participants to those who will best inform the researcher and the research question (Creswell, 2013). I used purposeful sampling to narrow participants on the aforementioned criteria of being an experienced teacher and willing to share their teaching experiences. Additionally, convenience sampling was used because of the time constraints placed on finding participants (Creswell, 2013). Since I am immersed in a community of colleagues and mentors in the teaching profession, I made full use of these connections to recruit suitable participants.

I spoke with prospective participants either by telephone or through email. I introduced the purpose of the study, the design, and the extent of their involvement for the research study. This information was described in the consent form (see Appendix A), which the participants signed. Also, I provided the option of remaining in contact with the participants via email should they have any questions or concerns after the completion of the interview process.

3.4 Data Collection and Analysis

After the transcription of the interviews, the data was coded into different categories and themes. The data was analyzed with a focus on the literature review. In particular, there was an emphasis on finding common themes, and locating any divergences in the data from the literature.
3.5 Ethical Review Procedures

Detailed efforts were made to ensure that participants were treated according to the ethical guidelines. A consent letter was provided to research participants once they agreed to be a part of the study. The consent letter explicitly states the purpose of the study, the research question, the interview process, and the extent of participant involvement to ensure complete transparency.

Prior to the interview I will communicated with participants to address any questions or concerns they may have about the research study. I will also informed them of the minimal risks associated with participating in the research study. Participants were given the freedom to withdraw from the study at their discretion at any point along the study. The location and the timing of the interviews will be negotiated for the convenience of the participant. When I began the interview protocol I gave participants the opportunity to: refrain from answering questions, ask for a revision of the question, and/or recant earlier statements.

I safeguarded participants’ anonymity and confidentiality with utmost precedence. Participant confidentiality and anonymity will be preserved through the use of pseudonyms and by eliminating any identifying details about the participant’s personal life. Any recordings and transcripts were stored using password-protected file encryption. All research materials was destroyed immediately after the completion of the research study. All procedures were conducted as itemized on the consent letter that the participants signed.
3.6 Limitations

The largest limitation will be the time and resources I can devote to this study. Limitations on time will narrow data collection to primarily teacher interviews. A more holistic analysis using classroom observations and audiovisual material will not be possible. Firsthand field notes on how teachers actually implement ethical discussions into the curriculum, however invaluable, were not feasible for my study. Additionally, only a small subset of the literature will be used as a framework to guide research, pose questions, and analyze primary data.

Data collected will be bounded by parameters such as time and place. Interviews will be relatively short, lasting from 40 to 60 minutes, and only two to four teacher participants will be interviewed. I was unable to conduct a longitudinal study to examine if teachers’ practices and beliefs of ethical issues change over time. Since I used referrals to gather teacher participants, they will most likely be restricted geographically to the Greater Toronto Area.

My biases as the researcher cannot be discounted. I support the infusion of value-laden topics into the biology curriculum, which is a polarizing stance. My position and past experiences impacted the research design, selection of participants, data collection and data analysis. Additionally, I was cognizant and reflective of my own biases as I conducted my research.

Additionally, I focused my research on senior biology teachers. However, a similar follow-up research question is applicable to elementary school teachers teaching science.
3.7 Overview

This chapter discussed the research approach and procedure for the execution of this qualitative study. This study used qualitative analysis to allow teachers the opportunity to share their own unique experiences and insights associated with incorporating socioscientific issues within the classroom. Semi-structured interviews were used to gather data from participants. The open-ended nature of the questions will encourage participants to share their beliefs and experiences. Great care was taken to choose participants that were deemed experienced and passionate about socioscientific issues. The ethical considerations of the study – namely confidentiality and transparency – were discussed explicitly. Finally, the limitations of the research study were provided such as the: sample size, research bias, and time constraints. The following chapter will outline the research findings.
Chapter 4: FINDINGS

4.0 Participants

I interviewed two participants for this study – Matt and Grace. Both participants are Ontario Certified Teachers teaching senior biology in Toronto. Both participants are an ideal fit for this study because they have at least five years of experience teaching senior biology, and are strong advocates of implementing STSE in their classrooms. Additionally, Grace contributes to the development of the STSE curriculum, providing her with a unique perspective regarding w

4.0.1 Participant # 1: Matt

Matt teaches academic science and senior biology at School X, a private school for academically inclined students. Students at School X are from middle and upper-middle class families. Most students in School X are South-Asian, East-Asian, Eastern European or Jewish. Few students are from Portuguese, Italian, Jamaican, and Caribbean backgrounds. Matt’s perspective on STSE has been shaped by the numerous female scientists he has encountered in his academic career. He is a progressive educator trying to learn more about relevant scientific issues that he can incorporate into his classrooms.

4.0.2 Participant # 2: Grace

Grace teaches grade 9 academic science and grade 11 university biology at School Y, a private school for academically inclined students. Students and their families at School Y value education. Students at School Y aim to enter prestigious universities for their post-secondary education. Diverse ethnic groups are represented: Asians, East-Asians, South-Asians, Eastern-Europeans, and Jews. Parents of these students usually have white-collar jobs. Some parents may have blue-collar jobs and are willing to work
extra hours to enroll their kids into this prestigious school. A large portion of the student population is also identified as being gifted.

Grace brings her 12 years of knowledge as a professional scientist into the classroom when incorporating STSE. She also brings with her a passion and love for the sciences, and an awareness of urgent socioscientific issues which need to be discussed in the high school biology classroom (see examples below).

4.1 Overview

This chapter presents the findings collected from semi-structured interviews with both participants. The statements made by each participant were analyzed based on the themes identified within the literature. Two overarching themes emerged when teachers discussed incorporating socioscientific issues in their classrooms: their teaching philosophy and teaching pedagogy.

4.2 Teachers’ STSE Philosophies

A teacher’s STSE philosophy is determined by an amalgamation of all of their past experiences. A teacher’s philosophy will have a significant influence on their pedagogical approach to STSE. It is important to note that these teaching philosophies are not exemplars to be followed indubitably. Instead, they can be used to explicitly consider and then arrive at one’s own teaching philosophy, which will undoubtedly differ. The philosophies given below illustrate how teachers who are well-versed in STSE and socioscientific issues, decide to navigate the multifaceted topic of STSE within their classrooms.
4.2.1 Definition of STSE

The STSE slogan is infamous for the confusion it brings to educators. There is no single, widely accepted definition of STSE within the literature (Pedretti & Nazir, 2011). Educators are often baffled by the incorporation of STSE because its scholarly definition is so far-reaching (Pedretti & Nazir, 2011). The findings illustrate that a more pertinent question for educators is: what does your definition of STSE look like in practice? Both Matt and Grace displayed an excellent grasp of their working definition of STSE. The working definition of STSE forms the foundation for their teaching philosophy, and ultimately their pedagogy.

There are several STSE ‘currents’ that Pedretti & Nazir (2011) have classified in their meta-analysis: application/design, historical, logical reasoning, value-centred, sociocultural, and ecojustice. The findings below illustrate that Matt and Grace prioritize one or two currents significantly above the others. Additionally, the findings reveal participants prioritize currents based on their strengths, experiences and/or interests.

Matt emphasizes the logical reasoning current and the value-centred current. His definition of STSE emphasizes critical thinking, reasoning, and decision-making informed by evidence. This definition of STSE is consistent with the literature’s definition of the logical reasoning (Pedretti & Nazir, 2011). Matt wants his students to, “Look at data, evaluate, and say this is what [they] really think about it.” In effect, Matt is interested in getting his students to think rationally, using a positivist philosophical framework.

Matt’s teaching practice also illustrates the use of the values-centred current and the logical reasoning current. The values-centred current recognizes that when individuals make a decision about a socioscientific issue, values are an inherent part of
the decision-making process (Zeidler, 2005). For example, Matt assigned his grade 12 class a project on Truvada – a prophylactic drug for the treatment of HIV. At this time, Health Canada was deciding whether it wanted to make the drug available to Canadians. This project utilized the logical reasoning current (students had to perform a cost-benefit analysis on Truvada) and the values-centred current (the decision was inherently value-laden).

Matt is a strong advocate of allowing students’ personal belief systems to enter their decision-making as long as students can properly reason and justify their arguments. Matt often encourages students to make up their own minds using reasoning, but by the same token, Matt is respectful of their belief systems (values-centred current). Within his classes, Matt illustrates the use of the values clarification approach (Pedretti & Nazir, 2011). He recognizes value systems to be a valid, and personal choice. Students’ belief systems will invariably influence the opinions that they will form. Matt believes the final opinion is less important than thinking students do to arrive at their opinions. “The question is, how are you making up your mind? What are you going to weigh? Because at the end of the day, you have to be your own person.” One limitation of the logical reasoning current as pointed out by Pedretti and Nazir (2011) is that values, cultural norms, and politics significantly impact one’s reasoning on contentious issues. This limitation of the logical reasoning current can be effectively negated, in some cases, through the simultaneous use of the values-centred current.

Grace, in contrast, relies heavily on the socio-ecojustice current. Hodson (1999, p.789) states the goal of the socio-ecojustice current is to create “People who will fight for what is right, good, and just.” Grace exemplifies these characteristics through her deep concern for water quality, grassy narrows, fish populations, aboriginal
issues, and wetlands. Grace explained: “Ultimately these are the things that we need to make a decision about.” Her biology classrooms are framed with these topical socioscientific issues at the vanguard. In contrast to many teachers, the curriculum expectations are covered, but they are ancillary to these socioscientific issues.

Additionally, the findings illustrate how motivating an STSE framework can be for students who are less interested in science. Grace uses socioscientific issues to get kids who are not “sciency”, interested in science. “They are, on a daily basis, worried about water pollution or water quality. Give them a case-study as context and it really motivates them.” Additionally, the findings are consistent with the literature in illustrating the importance of topics being experiential (Pedretti & Nazir, 2011). Grace noted that experiential topics (such as water quality) garnered a stronger response from the student population. However, she also stated that important topics – such as aboriginal rights – which can be more removed from students’ lives, also need to be introduced in a way to make students care about these topics.

4.2.2 Science as a Human Endeavour & the Flawed Nature of Science

As stated by numerous STSE researchers, our definition of science has undergone substantial revision over the past decade. For example, Hodson (2003) points to an increasing recognition among science educators that science is sometimes uncertain, contentious, and unable to provide a clear answer. Matt covers STSE by prioritizing the methods by which scientific knowledge is created and validated, with an emphasis on how science is ‘flawed’. For example, Matt stated that “Science is the best tool we have” but at the same time recognizes, “It has all the failings that humans generally have.” Grace agreed: “The biggest problem with science is that it’s done by humans and we’re insanely biased.”
4.2.3 Equity in Science

Matt is passionate about minorities – particularly females – and their role within science. Matt takes the responsibility of bringing gender equity – a topic on the back burner for many biology teachers – to the forefront of his classrooms. This responsibility has been shaped by the multiple female role models Matt has had throughout his science career. On the recognition of Watson and Crick – and the lack of recognition for Rosalind Franklin - he says, “Just as these people – Watson and Crick – and their work around DNA is what gets talked about. Who are the people that didn’t get talked about - that missed out?” Grace brings Aboriginal issues into the biology classroom by giving them a scientific context. She gave an example of mercury poisoning in the grassy narrows and its effect on local aboriginal communities.

4.2.4 Neutrality in instruction and assessment:

When implementing STSE and socioscientific issues into his classrooms, Matt recognizes that moral ambiguity is predestined and learning to embrace that ambiguity is the way forward. “In terms of implementing STSE, I think the important thing is to not look for a particular answer.” Additionally, Matt strongly believes in coming to class with a blank slate, and acknowledges any viewpoint that students may have as a valid viewpoint, provided they can support their arguments. “In terms of implementing STSE, I think, the most important thing is to not look for a particular answer.” Furthermore, Matt attempts to assess students by being “almost dispassionate” about the socioscientific issue when grading. He says, “I don’t grade them on my bias, but on whether the child’s reasoning and support for their arguments [are] really what drives them.” He does this to portray someone who is fair and just. It is interesting to note that the majority of the
STSE literature focuses on instruction. Fewer qualitative studies exist on the assessment of STSE-laden topics in science, and how this differs from traditional assessment.

Matt’s philosophy on socioscientific issues is consistent with the SSI framework developed by Zeidler (2005). For example, Zeidler (2005) states that even though understanding the interconnectedness of science, technology, society, and environment (STSE) are important, they do not exist independent of students’ personal beliefs. Matt attempts to remain neutral in his instruction and assessment because he does not want “a whole bunch of kids saying something they don’t actually believe in.” In effect, Matt is prioritizing and differentiating for each student’s intellectual and moral development. He recognizes that each student is going to be starting at a different place based on their belief systems. Finally, Matt illustrates that defending one’s point of view, and perhaps even changing one’s point of view, is more valuable than defending a prescribed point of view.

4.2.5 Summary of Teacher Philosophies

Matt and Grace differ considerably in their definition of STSE. Both participants have made a conscious effort to consider their own working definition of STSE. Matt primarily uses the logical and values-centred currents in his classrooms. He prioritizes critical thinking and decision-making, but also believes in students arriving at an ‘authentic decision’ that is an amalgamation of their research and personal belief systems. Additionally, Matt is cognizant of his own personal biases and points to the importance of delivering instruction and evaluating assessments from a more neutral position. In contrast, Grace primarily uses the socio-ecojustice current when implementing STSE. Grace uses socio-ecojustice topics in science as a framework for discussing the senior biology curriculum. Grace also believes in including topics that are more removed from
the student population and inserting them into the high school biology curriculum by adding a scientific context. Additionally, both participants believe in raising awareness of the flawed nature of science, and equipping students with the understanding of how scientific knowledge is constructed. Finally, both participants believe that the biology classroom can be a place for raising issues surrounding equity.

4.3 Teacher Pedagogy

Although STSE is a well-developed theory, and an initiative that should be commended, it is not without its flaws. Even the most zealous supporters of STSE recognize that there is an absence of a unifying coherent framework (Zeidler, 2005). For example, Ziman (1994, p. 22) notes, “The fundamental purpose of STS[E] education is genuinely and properly diverse and incoherent.” The plurality of STSE, with the day-to-day demands of a public school teacher, makes it difficult to implement as an effective pedagogical strategy. In this section, we will look at how teachers apply the STSE framework within their classrooms to teach students about socioscientific issues. What follows are pedagogical practices my participants used when implementing socioscientific issues within their classrooms.

4.3.1 Prioritizing Critical Thinking over Memorization

The curriculum has recently pushed STSE to the forefront, with the development of scientific literacy as the purported goal. However, the curriculum is still largely content-dominated (Saunders & Rennie, 2011). Matt recognizes that for students to develop scientific literacy, the way in which student learning takes place must change. More emphasis must be placed on thinking, and less on memorization. “It’s not sort of important to memorize facts and terms, it’s also learning about how they come to be, and how do I critique it.” Although the senior biology curriculum is content-heavy, covering
the curriculum through a critical thinking lens allows teachers to instill more scientific literacy. Matt noted he had an epiphany when he realized he had to alter the way in which he delivered the curriculum. “But then as you start to realize that, you know, it’s not important getting them through the curriculum. What’s more important is being at the side, and letting the kid try.” He also noted that switching from teacher-centred to student-centred lessons helped with the change in how the curriculum was delivered: “I didn’t feel like I needed to be in control.”

When critical thinking is a component of the biology classroom, it can be perceived as a culture shock for teachers, as well as students. Teachers have to undoubtedly assess and instruct differently when critical thinking is at the forefront. Additionally, students have to adapt to new expectations surrounding assessment, which are oftentimes more rigorous. Matt noted, that these expectations have to be clearly and explicitly modelled by the teacher. Additionally, Matt stated that raised expectations can frustrate students when they receive a subpar mark. Matt was meticulous when it came to marking. His students were required to either: form their own opinion, critique or evaluate an opinion. He gave an example of one unsatisfied student: “She was quite unhappy because I had not given her full marks. All she did was state a summary…she didn’t have her own opinion, or critique, or evaluation of it.”

4.3.2 Critical Thinking Pedagogy

Critical thinking on its own is difficult, let alone critical thinking within biology. As Gelder (2005) states, humans are not naturally inclined to think critically. For example, when asked to justify their opinion with evidence more than half of the population flounders (Gelder, 2005). Matt uses heterodox opinions – opinions that are unconventional or unorthodox – to make students better critical thinkers. Prior to his
classes, he has a good idea of the ‘consensus stand’ and the ‘heterodox stand’ to better navigate the classroom dynamic. He asks students to take different points of view and sometimes he intentionally plans for the consensus stand to be wrong. This strategy of encouraging critical thinking aligns with Gelder (2005), who states: “We like things to make sense and we find it most easy to grasp onto familiar patterns and narratives. The problem is when we don’t question the validity of the pattern or narrative.”

Additionally, Gelder (2005) states that humans generally lack the notion of what actually counts as evidence when forming opinions. According to Gelder (2005), the intuitive feel of something often suffices. Matt recognizes the ease with which students can form opinions, and, therefore, structures his classroom using evidence-based argumentation. Students in his classes are given pieces of evidence piecemeal and students have to then use this evidence to find weaknesses in each other’s arguments. Ultimately, they have to reconcile these arguments into an opinion.

**4.3.3 Perspective Analysis & Empathetic Intelligence**

Perspective analysis, or shoe-shifting, was a large talking point shared by both Matt and Grace. They both believe in morally educating students and developing empathetic intelligence. They do this through the use of case-studies. The decision made for each case-study will often impact a variety of stakeholders. Grace stated, “We can’t just go into and make these decisions willy-nilly, we’re going to need to think about aboriginal voices, women, children, and future children.” Sometimes, Grace illustrated the use of perspective analysis by presenting a scenario which requires students to explore ideas beyond the familiar Eurocentric experiences. For example, Grace explained a karyotyping activity in which students have to write a letter – from the point of view of a medical professional – to South-Asian parents, based on a diagnosis of Klinefelter’s
syndrome. In this scenario, not only are students exposed to the science of Klinefelter’s syndrome, they also develop empathetic intelligence by learning about other cultures and religions. Grace included parents of different ethnicities, cultures, and religions, forcing students to more holistically consider all factors before writing the letter. In this activity, students are exposed to unconventional ideas and students also learn to consider multiple perspectives.

Perspective analysis was also vital for Matt’s pedagogical strategy. Matt held a mock trial for the Percy Schmeiser v. Monsanto case, which dealt with genetically modified crops. Matt mirrored the Supreme Court case within the classroom by appointing judges and lawyers fighting for and against Monsanto. Students had to provide an evidence-informed argument for each side to support their beliefs. Before starting the court session, Matt explicitly told the class that they could arrive at a different decision from the Supreme Court – which in fact did happen in the classroom. By not having any prior convictions, students were able to openly consider all perspectives without any repercussions. Furthermore, by arriving at a different decision from the Supreme Court, students were able to do a comparison of values. “So the comparison allowed them to see, where is the value system? These are the things that we value as kids but these are the things that the court argues.” By realizing that things important to the students are not necessarily important to the court, students are able to compare and critique their value system against someone else’s value system. The Supreme Court’s value system may or may not change their own value system. Ultimately, this encouraged students to examine multiple perspectives and arrive at their own value system, a process called values clarification.
4.3.4 Authentic Problem

For the following subsection, an ‘authentic problem’ is defined as a topical socioscientific issue that teachers are able to organically implement into the classroom. Matt recognizes that creating an authentic STSE problem for students can be difficult. Relevance and timeliness are two qualities that Matt and Grace found to be important. Matt stated, “The challenge is always to find something that is both relevant and timely.”

Both participants agreed in finding an authentic problem that is local. Matt does this by looking at socioscientific issues from a Canadian perspective. For example, Matt discussed thalidomide from the perspective of a Canadian scientist working for the FDA who prevented thalidomide from being used. He noted that discussing issues from a Canadian perspective also makes it easier to access the resources needed. Grace also agreed: “I would rather have an issue that is on the kids’ radar, or should be on the kids’ radar.” Grace, for example, discussed how benthic vertebrates as an indicator of water quality in urban v. suburban areas around Toronto. “That’s why we should care. There is a context. It’s all about water quality.”

Matt believes that an authentic problem that spans weeks can be benefited from an authority figure on the topic. For example, on the Percy Schmeiser case, he says, “Hearing from Percy Schmeiser is way more interesting than having a teacher talk about these things.” It is interesting to note that authority figures did not appear in my review of the literature, yet, Matt stated that it adds a lot more credibility to the projects. Matt also noted that bringing authority figures into class can be very time-consuming. “I spent probably like two-and-a-half to four hours trying to negotiate with Bayer who makes neonicotinoids.”
Matt noted that authentic problems which are important to society are easier to use within the classroom since more resources are available. Additionally, this makes it easier to find authority figures. Grace agreed, stating that the importance of benthic vertebrates to society make it very easy to find resources and data from the United States Geological Survey (USGS).

Matt also noted that an authentic socioscientific problem will be multi-faceted, allowing teachers to provide choice – and differentiation – for students. For example, Matt would give an overall question of: “In a publicly funded system, does it make sense for everyone to have an MRI scan, or is an x-ray sufficient?” The open-ended nature of the problem allows students to choose the type of cancer they want to study, the method in which they will study the cancer, and how in-depth they want to get into the technology. Matt discussed another example of choice. On the topic of population dynamics, he gave students two radically different choices. Students had the option of researching the ecological effects of neonicotinoids on bees (for students that were ecologically inclined), or the effects of Truvada on humans (for students who were more medically inclined).

Grace believes that socioscientific issues should be as realistic as possible. For example, on the topic of benthic invertebrates, she showed the students Jackson Creek, Peterborough on a map. She then asked the students where along Jackson Creek she should collect samples. The next day she brought those samples into class where students identified, collected, and interpreted the data. Enthusiastically she said, “We had real samples from that very stream…with real specimens. It was completely authentic. The kids found it so motivating.”
4.3.5 Summary of Teacher Pedagogy

Matt and Grace differ considerably in their implementation of STSE. Matt places a heavy emphasis on making critical thinking the foundation of his implementation of socioscientific issues. He encourages students to think critically through the use of heterodox opinions. Grace, in contrast, places a heavy emphasis on morally educating students by discreetly allowing them to consider a variety of perspectives through case-studies. Both participants recognize the importance of providing students with the opportunity to explore multiple perspectives and arrive at their own decision. Additionally, both participants believe in using local and topical socioscientific issues that are open-ended to allow students the freedom to explore the issue and form their own opinions.
Chapter 5: DISCUSSION

5.0 Introduction

This chapter describes the study’s overall findings and implications. First, I begin by presenting a synopsis of the study’s key findings. Next, I describe the implications of this study for educators. Subsequently, I outline didactic recommendations that arose from the study of STSE and socioscientific issues. Finally, I identify questions for the future and conclude with the significance of this study.

5.1 Overview of Key Findings

For this study, I interviewed two intermediate/senior biology teachers with at least 5 years of teaching experience, and a passion for incorporating STSE into their classrooms. Two overarching themes emerged: their teaching philosophy and their teaching pedagogy.

The STSE slogan is infamous for the confusion it brings to educators. The findings reveal that educators should focus on a working definition of STSE, which may be based to some degree on the scholarly definition. The question educators should ask themselves is: what does my definition of STSE look like in the classroom? The findings suggest that an educator’s definition of STSE comes from a combination of their belief systems, strengths, and experiences. Evaluating your own belief systems, strengths, and experiences can provide the foundation for one’s teaching philosophy, and ultimately one’s pedagogy. Although the far-reaching nature of STSE is regarded as a shortcoming, its flexibility also offers many advantages. The flexibility allows educators to infuse their lessons with their own unique strengths and interests.

The first major finding from this study was detailing each participant’s philosophy surrounding STSE and socioscientific issues. Firstly, both participants
reported implementing STSE currents which were consistent with the literature.

Secondly, both participants placed a heavy emphasis on either one or two currents out of the many currents provided by Pedretti and Nazir (2011). Matt (participant #1) placed a heavy emphasis on the logical reasoning current and the values-centred current. Grace, on the other hand, relied heavily on the socio-ecojustice current.

Neutrality was also a large part of the discussion, especially when discussing value-laden topics. Matt stated he believes in coming to class and delivering instruction with a blank slate. Moreover, he emphasized that the process a student uses to arrive at their decision is far more important than their position on an issue. In effect, Matt believes in allowing students to arrive at their own decision based on a combination of their personal belief systems and research.

Both participants recognized that moral ambiguity is predestined for the students and teachers alike. Matt also alluded to the importance of not looking for a particular answer which is typical for traditional science thinking.

The second major finding from this study was detailing the pedagogy teachers used to implement socioscientific issues within their classrooms. By examining the teaching practices of educators well-versed in implementing socioscientific issues, teachers new to implementing socioscientific issues can be provide with a skeletal framework. Firstly, both participants prioritize critical thinking over memorization. Both participants recognize that the curriculum is largely content-dominated, but chose to place a greater emphasis on thinking instead of memorization. Matt elaborated on one technique he uses to instill critical thinking: the use of two opposing viewpoints with one being a ‘consensus stand’ and the other being a ‘heterodox stand.’ He intentionally plans for the consensus stand to be wrong – on occasion – to provoke students to question
familiar patterns and narratives that they hold on to. Secondly, both participants recognized the importance of perspective analysis and empathetic intelligence. Grace and Matt foster empathetic intelligence through the use of case-studies involving multiple stakeholders. Grace uses case-studies as a stepping stone to expose students to a variety of ethnicities, cultures, and religions, and to encourage students to holistically consider all perspectives before arriving at their final stance. Thirdly, both participants alluded to the importance of creating an authentic problem for students to grapple with. Participants defined an authentic problem to incorporate the following three essential criteria: locality, relevance, and timeliness. Matt and Grace described an authentic problem as providing a rich context for the learning that takes place.

5.2 Implications for Educators

In this section, I will describe the implications of the study for teachers and the educational community at large. The implications that arise from this study relate to our understanding of a traditional versus non-traditional science classroom, each with its own culture. Border crossing – a concept coined by Glen Aikenhead (1996) – is a fitting analogy to portray the implications of this study. Aikenhead suggests that students’ life-world subcultures and science subculture are oftentimes vastly different (Aikenhead, 1996). Additionally, he suggests that we need to develop curriculum and instruction with this explicitly in mind to ensure the science curriculum is accessible for all. This metaphor of border crossings, comes from the idea of crossing physical borders. Sometimes individuals may cross physical borders, say from Spain to North America, but they may not cross cultural borders. This is because cultural borders are more implicit and subconsciously shape the way we think.
Just as students cross physical borders to come into the science classroom, they may or may not cross the cultural borders into the subculture of science. I propose that just as students move from their own life-world culture into the subculture of science, students (and teachers) must then move from the subculture of science into the subculture of non-traditional STSE-based science. As Aikenhead notes (p. 6, 1996): “Crossing over from one domain of meaning to another is extremely difficult.”

Many teachers espouse the belief that science is a process that is isolated from humanity and society. They believe science to be cold, rigid, and calculated, existing in a domain sequestered from the rest of civilization. Before teachers are able to implement STSE, they must ‘cross borders’ into the messiness of science, and its overlap with politics, ethics, economics, and society. Crossing borders into the messiness of science will require teachers to re-evaluate their entire beliefs surrounding science (their philosophy) and how to teach science (their pedagogy). For STSE to be truly implemented within high school science classrooms, there has to be a paradigm shift in the way teachers think about science and the science classroom. Science teachers need to stop thinking about science as being dominated by secure and factual knowledge, and they need to stop preaching science as an orderly and immaculate discipline. Additionally, educators have to approach the instruction and assessment of STSE with a blank slate and re-evaluate conventional science teaching practices.

Students need time – just as much as teachers, if not more – to adjust to the non-traditional classroom. Crossing borders into the unconventional science classroom may be intimidating and frightening at first. Furthermore, students may resist this new culture of science since students would much rather hold onto the commonsense and orderly conception of science, instead of a counter-intuitive abstraction proposed by STSE.
(Aikenhead, 1996). However, students who learn science in a non-traditional (STSE-based) classroom have an improved understanding of social issues, and attitudes towards science classes and learning (Aikenhead, 2006). Students learning science in non-traditional classrooms are equipped with a new vantage point from which to analyze familiar scientific issues. Therefore, students, like teachers, have to be encultured in this new way of looking at the science classroom, and science in general. Students will have to adjust to new expectations surrounding their role as a student, whether this is in class, or outside of class. Students will also have to adjust to different – and more rigorous – expectations surrounding assessment.

5.3 Recommendations for Educators

Based on the findings of this study educators should consider the following when implementing socioscientific issues into the classroom

- Significant time should be invested contemplating one’s working definition of STSE and which pedagogical techniques you will use to implement these socioscientific issues within your classrooms
- Focus your efforts on one or two STSE currents which align with your interests, experiences, and strengths
- Remain neutral – to the best of your ability – in your instruction and assessment
- Embrace the ambiguity associated with the implementation of socioscientific issues
- Emphasize critical thinking and student-directed lessons over memorization and teacher-directed lessons
- Educate students on value systems using perspective analysis
• For each unit, create an authentic problem that is topical, relevant, local, and/or open-ended
• Allow students – and yourself – ample time to adjust to the culture of the STSE-based classroom

If taken into account, these recommendations can help teachers design and implement lessons which are based on the principles of STSE.

5.4 Areas for Further Study

Although there is a sizeable amount of literature on the topic of STSE and socioscientific issues, the following questions represent avenues for future research which were less pervasive within the literature.

• How does formative and summative assessment change when implementing a curriculum centred around STSE?
• How do science students make sense of the culture of an STSE-based classroom and how can teachers best enculture students in this new type of classroom?
• What culture among students, teachers, and staff is conducive to learning about socioscientific issues?
• How do science teachers – and their students – transition from a conventional to an unconventional STSE-based science classroom?

5.5 Conclusion

In this study, I investigated how secondary-level biology teachers understand and implement socioscientific issues within their classrooms. Matt and Grace differ considerably in their definition of STSE. Both participants have made a conscious effort to consider their own working definition of STSE. Matt primarily uses the logical
reasoning and values-centred currents in his classrooms. He prioritizes critical thinking and decision-making, but also believes in students arriving at an authentic decision that is an amalgamation of their research and personal belief systems. Additionally, Matt is cognizant of his own personal biases and points to the importance of delivering instruction and evaluating assessments from a more neutral position. In contrast, Grace primarily uses the socio-ecojustice current when implementing STSE. Grace uses socio-ecojustice topics in science as a framework for discussing the senior biology curriculum. Grace also believes in including topics that are more removed from the student population and inserting them into the high school biology curriculum by adding a scientific context. Additionally, both participants believe in raising awareness of the flawed nature of science, and equipping students with the understanding of how scientific knowledge is constructed. Finally, both participants believe that the biology classroom can be a place for raising issues surrounding equity.

Matt and Grace differed considerably in their implementation of STSE. Matt placed a heavy emphasis on making critical thinking the foundation for his implementation of socioscientific issues. He encourages students to think critically through the use of heterodox opinions. Grace, in contrast, places a heavy emphasis on morally educating students by discreetly allowing them to consider a variety of perspectives through case-studies. Both participants recognize the importance of providing students with the opportunity to explore multiple perspectives and arrive at their own decision. Additionally, both participants believe in using local and topical socioscientific issues that are open-ended to allow students the freedom to explore the issue and form their own opinions.
REFERENCES


Appendix A: Letter of Consent

Date:

Dear ____________________________,

My Name is Abdul Shabbir and I am a student in the Master of Teaching program at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). A component of this degree program involves conducting a small-scale qualitative research study. My research will focus on the difficulties of incorporating socioscientific issues (STSE related) within the Biology classroom. I am interested in interviewing biology teachers who have at least 5 years of teaching experience and are passionate about topics relating to STSE. I think that your knowledge and experience will provide insights into this topic.

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

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

Sincerely,

Abdul Shabbir
289-988-4352
abdul.shabbir@mail.utoronto.ca

Course Instructor’s Name: Arlo Kempf

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

Signature: ________________________________

Name: (printed) ________________________________

Date: ________________________________
Appendix B: Interview Protocol

Hello and thank you for taking the time to contribute to my research. Before we begin the interview I would like to briefly review some of the most important parts of your consent form. This interview is a part of my Master of Teaching research project, and it will be recorded and transcribed in full. Your identity and information will be kept confidential through the use of a pseudonym. You have the contact information for my course instructor, my research supervisor and myself. If you have any questions or concerns, please do not hesitate to contact us.

In this interview, I will use the term ‘STSE’ to refer to issues in science that overlap with society. These issues are oftentimes ethically, politically, historically, and economically laden. As a researcher, I am not trying to make any particular conclusions, so please feel free to be honest and share as much as you feel comfortable with. Don’t feel like you have to give a certain response for my benefit.

Section 1: Background Information

1. What grade(s) and courses are you teaching this year/term?
2. How did you enter the field of teaching?
3. What subject(s) and grade level(s) are you currently teaching?
4. What are the demographics of your current classes?
   a. What cultural backgrounds are represented?
   b. What socioeconomic classes are represented?
5. For how long have you been teaching?
   a. For how long have you been teaching Biology class?
6. How did you come to be interested in STSE and/or integrating socioscientific discussions into your classrooms?
   a. For how long have you been incorporating STSE into your classrooms?
   b. What level of support have you encountered from your colleagues for incorporating STSE?

Section 2: Beliefs and Experiences (What/How)

7. What does the role of a science educator mean to you?
   a. To what extent do you incorporate student-centered lessons versus teacher-centred lessons within your classroom?
   b. To what extent [anywhere from very comfortable to not at all comfortable] do you feel comfortable with implementing student-centred lessons?
   c. Have you incorporated more student-centred lessons, as you became a more experienced teacher? Why or Why not?
8. What is your definition of STSE?
9. How often do you incorporate STSE within your biology classrooms?
   a. How often do you incorporate socioscientific discussions in your senior biology classrooms?
   b. Has this changed as you became more experienced?
10. What are some successes and challenges you’ve experienced as a learner of STSE?
11. What resources have you used that helped you incorporate STSE and/or socioscientific issues within the classroom?
12. What are some challenges you have encountered in infusing contentious STSE-based topics within the classroom?
   a. Which of these challenges were pedagogical in nature? Which weren’t?
   b. How did you overcome these challenges?
13. Can you give me an example of a lesson in which you incorporated a socioscientific issue within your classroom?
   a. How did the lesson go?
   b. How did it differ from a traditional lesson you would do from a pedagogical standpoint?
   c. How did you prepare for the lesson?
   d. How did the students respond to the lesson?

Section 3: Belief Questions (Why)
14. How effective was your pre-service program in preparing you to incorporate socioscientific discussions into the science classroom?
   a. Have you undertaken any professional development in this area?
15. Why do you believe it is important to incorporate socioscientific issues into the biology classroom personally?

Section 4: Next Steps
16. Do you have any goals to improve your ability to incorporate socioscientific discussions into your classroom? If so, what?
17. What do you think can be done to help ease teachers into making science more discussion oriented and less content oriented?
18. As a pre-service teacher what advice could you give me regarding having ethical discussions within the science classroom?

Probe questions: Was it helpful? Why was it helpful? How did this influence your teaching practice?