SECONDARY SCIENCE TEACHERS’ USE OF SOCIOSCIENTIFIC ISSUES IN THE TEACHING AND LEARNING OF CHEMISTRY: AN INTERPRETIVE STUDY

by

GERRI LYNN COLE

(Under the Direction of Deborah J. Tippins)

ABSTRACT

Socioscientific issues (SSI) can serve as a basis for designing lessons that provide opportunities for students to make informed decisions about the world around them. Through the use of interpretive research and case study methods, this study aimed to explore why secondary chemistry teachers incorporated socioscientific issues into the curriculum and how their beliefs influenced the way in which they planned for and enacted socioscientific issues in their teaching of high school chemistry. Data included interviews, direct observations, and the collection of documents and archival records. Inductive analysis was used to reveal themes from the data collected. The findings of the study shed light on the following themes: (1) personal experiences were influential in the incorporation of socioscientific issues-based lessons, (2) SSI topics were chosen by the secondary chemistry teachers in order to maintain control of their classes and curriculum, (3) teachers’ attempts to foster socioscientific reasoning in secondary classrooms sometimes led to disconnections between the SSI issue presented and chemistry, and (4) secondary chemistry teachers’ uses of SSI were mediated by their beliefs that students should become informed decision makers. Implications from this study include the following: (1) teachers who included socioscientific issues-based lessons believed that chemistry was more
than a content-driven subject, (2) socioscientific issues-based lessons were used as a way to get rid of the stigma that chemistry is irrelevant, (3) teachers who incorporated socioscientific issues-based lessons understood the complexities of chemistry and therefore believed it was important for students to also understand these complexities, (4) teachers who incorporated socioscientific issues-based lessons were willing to wrestle with the uncertainties of SSI-lesson outcomes, and (5) teachers who incorporated socioscientific issues-based lessons were confident and flexible in their practice.

INDEX WORDS: Socioscientific issues, Socioscientific reasoning, Nature of science, Chemistry, Chemistry teaching, Chemistry learning, Secondary in-service teachers, Teacher beliefs, Situated learning, Schwab’s notion of curriculum, Case study, Interpretive research
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by

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DEDICATION

All glory belongs to you, God.

For your unconditional love, patience,

faithfulness and guidance,

I dedicate this piece of work to You.
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CHAPTER 1

BACKGROUND OF THE STUDY

Introduction

Over the past two decades, science education reform recommendations have been quite evident. Influential policy reports recommending comprehensive changes in science teaching and learning were issued by the American Association for the Advancement of Science (1993) and the National Research Council (1996). Together, these recommendations aimed to prepare a scientifically literate national work force equipped to compete in an increasingly scientifically and technologically oriented global economy (Lumpe, Haney, & Czerniak, 2000). According to Anderson (2007), scientific literacy refers to the science-related knowledge, practices, and values that students acquire as they learn science. Zeidler, Walker, Ackett and Simmons (2002) have argued that in order to achieve scientific literacy, it is necessary to include moral and ethical issues in an interdisciplinary science curriculum. For the purposes of this study, the researcher defined morals as prescriptive judgments of right and good applied to social situations that reflects an individual’s rules and principles in situations of conflict (Zeidler & Keefer, 2003). The researcher defined ethics as uniform rules and behavioral standards that inform individuals of what is considered acceptable behavior for the purposes of regulation (Loving, Lowy, & Martin, 2002). This argument is based on the premise that students ought to be provided with the necessary experiences that will allow them to make rational and informed decisions about their society (Zeidler and Keefer, 2003). Therefore, Abd-El-Khalick (2003) argued that bringing socioscientific issues into the science classroom would give science educators the opportunity to
engage learners in real world problem-solving in which scientific knowledge and ways of thinking are evident in the discussion of issues that are immediately relevant to students’ lives.

**Statement of the Problem**

Socioscientific issues consist of social dilemmas, with moral and ethical components, that are used to promote scientific literacy (Sadler, 2004). However, exactly what role these issues should play in secondary classrooms is not clear. While some studies have investigated socioscientific issues in secondary science, these primarily have been done in the context of biology and environmental education (Kolstø, 2006; Sadler, Chambers, & Zeidler, 2004; Sadler & Zeidler, 2003a). Few studies have been conducted to understand what socioscientific issues might look like in a chemistry classroom. In fact, some researchers have reported that chemistry teaching is unpopular and irrelevant in the eyes of many students (Kracjik, Mamlok, & Hug, 2001; Osborne & Collins, 2001; Pak, 1997), does not promote higher order cognitive skills (Anderson et al., 1992; Zoller, 1993), leads to gaps between students’ wishes and teachers’ teaching (Hofstein, Carmini, Mamlock, & Ben-Zvi, 2000; Yager & Weld, 2000), and remains the same because teachers are afraid of change and need guidance (Aikenhead, 1997; Bell, 1998).

With many factors to consider when teaching science, why do chemistry teachers include socioscientific issues in their science curriculum, particularly in a time when emphasis is placed on the technical nature of the content of chemistry? By the technical nature of the content of chemistry, the researcher is referring to an emphasis placed on facts, vocabulary, definitions, algorithms, and basic skills (Gabel, 1999). Carlone (2004) argued that chemistry traditionally follows a pattern of prototypical science in which there is a focus on procedure and decontextualized problem-solving and an exclusion of socioscientific issues. According to Holbrook (2005), secondary chemistry curricula generally tend to put the subject first and the
applications second. Thus, this study aimed to explore why secondary chemistry teachers incorporate socioscientific issues into the curriculum and how their beliefs influence the way in which they plan for and enact socioscientific issues in their teaching of high school chemistry.

**Purpose and Rationale**

**Purpose**

The purpose of this study was to explore why and how chemistry teachers incorporated socioscientific issues into their curriculum in an era where much emphasis is placed on the technical aspects of chemistry. According to Parker and Gerber (2000), the challenge that many teachers have is making the subject relevant to their students while covering standards that they are required to teach. Teachers are further challenged to find ways for students to wrestle with ethical, moral, and social monetary issues inextricably linked to chemical realities of the world. Making chemistry relevant and sensitive to moral and ethical matters can come in the form of incorporating socioscientific issues in the curriculum.

**Rationale**

The inclusion of socioscientific issues in curricula is not an entirely new phenomenon in science education. Its roots can be traced back to the science/technology/society (STS) movement of the 1960s (Yager, 1990). However, the recent emphasis on socioscientific issues is somewhat different from the earlier STS movement. Whereas the STS movement sought to make science relevant to everyday lifeworlds of students, socioscientific reasoning places an additional emphasis on morals and ethics as part of how students learn science (Sadler & Zeidler, 2009; Zeidler, Sadler, Simmons, & Howes, 2005). As a result of this difference, there has been a shift towards the incorporation of socioscientific issues into science curriculum. Socioscientific issues center around the use of scientific topics that require students to engage in dialogue, discussion,
and debate (Zeidler & Nichols, 2009). For example, socioscientific issues that are explored in the context of high school science might include issues related to climate change (Sadler, et al., 2004), genetic engineering (Sadler & Zeidler, 2003a), and the construction of new power lines and their increased risk on childhood leukemia (Kolstø, 2006). Although socioscientific issues are usually controversial in nature, they require a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues (Zeidler & Nichols, 2009).

Zeidler and Nichols (2009) maintained that missing from most science classrooms are engaging activities that focus on contemporary social issues that require scientific knowledge for informed decision making. Aalsvoort and Huygenwaard (2004) noted this is particularly the case in chemistry courses where students do not see the connection between what they learn about chemistry at school and the chemical reality of the world around them. Accordingly, the rationale for this study is premised on the need to understand how and why chemistry teachers incorporate socioscientific issues into their classrooms in the context of a highly technical and content-driven subject. More specifically, this study aimed to understand why teachers plan for and how they enact socioscientific issues in their chemistry classrooms.

**Research Questions**

This study aimed to explore secondary chemistry teachers’ uses of socioscientific issues in their curriculum. More specifically, this study attempted to answer the following questions:

1) Why do chemistry teachers use socioscientific issues in their teaching?

2) How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about:

   a. Nature of science?
b. Chemistry?
c. Chemistry teaching?
d. Chemistry learning?

3) How do chemistry teachers plan for and enact socioscientific issues-based lessons in a secondary chemistry classroom?
   a. To what extent do chemistry teachers foster socioscientific reasoning in these lessons?

Overview of Salient Literature

The salient literature for this study drew from assumptions surrounding socioscientific issues and socioscientific reasoning.

Socioscientific Issues

According to Sadler (2011a), socioscientific issues (SSI) are “open-ended problems” that “tend to have multiple, plausible solutions that can be informed by scientific principles, theories, and data” (p. 4). They consist of social dilemmas that have conceptual or technological links to science (Sadler, 2004). Although socioscientific issues are usually multidimensional in nature, Zeidler and Nichols (2009) emphasized that they require a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding some possible resolution of the dilemmas embedded within them. Nuangchalerms (2009) explained that socioscientific issues are a way to explore the nature of science, bridge student and scientific literacy, and encourage the interdependence of science and society.

Pedretti (2003) argued that there are many advantages to incorporating socioscientific issues-based lessons. These included: (1) a means for developing and exploring further inquiry, (2) providing a rationale for the search for information, and (3) more accurately reflecting “the
multi-disciplined nature, discourse, and activities of the scientific pursuit” (pp. 220-221). More specifically, the SSI movement focuses 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”(Zeidler, et al., 2005, p. 357).

**Socioscientific Reasoning**

According to Sadler, Barab, and Scott (2007), socioscientific reasoning is a theoretical construct designed to “uniquely capture the array of practices fundamental to the negotiation of SSI” (pp. 377-378). Fowler, Zeidler, and Sadler (2009) argued that socioscientific reasoning involves wrestling with morals, ethics, and personal views. Mueller and Zeidler (2010) added that “socioscientific reasoning entails the recognition of complexity inherent in SSI, the consideration of issues from pluralistic perspectives, the recognition of ongoing inquiry relative to SSI, and the demonstration of a healthy degree of skepticism when confronted with evidence and data” (p.106)

Aalsvoort and Huygenwaard (2004) emphasized that one purpose of science education for the 21st century is the development of responsible citizenship for dealing with problems that have dimensions in science and technology such as those related to the environment, health, energy, and agriculture. They argued that an important aspect of science content to be considered for inclusion within any curricula is the relevancy of the information to the personal lives of students. Additionally, Aalsvoort and Huygenwaard (2004) suggested that it is very difficult for pupils to grasp the relevance of science. Some curricula have attempted to place science in real-world contexts by linking it with environmental and societal issues. When science learning has been extended to applications in the real-world context, public awareness and enthusiasm for science have been evident. For example, in a study conducted by Parker and
Gerber (2000) middle-grade students who had typically performed below average in school became more knowledgeable of science content and process skills when the curriculum was relevant to their life experiences and connected to socioscientific issues. Holbrook (2005) maintained that in today’s world, in order for chemistry to be relevant, teachers must provide a context for students to wrestle with the ethical, moral, and political dimensions of socioscientific issues. The researcher assumed this may be a challenge for many teachers, particularly those teaching chemistry.

**Overview of Theoretical Framework**

The theoretical framework for this study drew from assumptions surrounding: (1) the nature of teacher beliefs (2) situated learning, and (3) Schwab’s notion of curriculum. It also drew from the epistemology of constructionism.

**Teacher Belief**

Researchers (Kagan, 1992; Pajares, 1992) have found that teachers’ beliefs are closely linked to their curriculum platform. Pajares (1992) maintained that beliefs are based on values and judgments, and all teachers hold beliefs about their work, their students, their subject matter, and their roles and responsibilities. Belief structures play a major role in teacher decision making about curriculum and instructional tasks (Nespor, 1987; Pajares, 1992; Richardson, 1996). Furthermore, research in science education has demonstrated that teachers’ beliefs and experiences strongly influence their science teaching and the implementation of alternative forms of practice (Bryan & Abell, 1999; Gess-Newsome, 1999; Luft, 1999; Simmons et al., 1999; Tobin & LaMaster, 1995; Tobin & McRobbie, 1996; Yerrick, Parker, & Nugent, 1997). Thus, it was important to explore how chemistry teachers’ uses of socioscientific issues reflected their underlying beliefs about science teaching and learning.
**Situated Learning**

Situated learning is a theoretical framework that focuses on the nature of knowing and learning. It emphasizes learning activity within a specific context (Barab & Plucker, 2002; Cobb & Bowers, 1999; Greeno, 1998; Lave & Wenger, 1991). This framework has become useful for designing learning interventions (Tinker & Krajcik, 2001), investigating educational environments (Cobb, Stephan, McClain & Gravemeijer, 2001), and theorizing about the improvement of teaching and learning (Barab, Barnett & Squire, 2002). Situated learning theory was useful in this study because it provided the researcher with a lens to view the contexts in which SSI lessons were situated as they related to contemporary societal issues.

**Schwab’s Notion of Curriculum**

According to Schwab (1983), “What should be taught, how teaching should run, who is available to do it, which students most need the change in question, are each matters requiring their own expertise or experience” (p. 244). Therefore, the curriculum should be “open to a great variety of values and visions, including those that rub against the grain of society” (Schwab, 1973, p. 514). In this respect, Schwab indicated that the curriculum is not to conform to the material but that the material is to be used in the service of the student (Schwab, 1973). Thus, the inclusion of socioscientific issues into chemistry classrooms is a way that the curriculum can be designed and used in the service of the student.

Within his work, Schwab (1971a) stressed the importance of the planned and the enacted curriculum. Schwab (1971a) believed these components were important in curriculum design because they promoted knowledge (facts, ideas), skills (induction, deduction, physical skills), and attitudes (values, feelings, sensitivities). Schwab’s work was useful in providing a
framework for this study because it provided the researcher with a lens to interpret the planned and enacted curriculums of the secondary chemistry teachers in this study.

**Epistemology**

Crotty (2003) stated that an epistemology is a way of understanding and explaining how we know what we know. The epistemological commitments that influenced what the researcher brought to this study were grounded in constructionism. Constructionism is the view that “all knowledge is contingent upon human practice, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context” (Crotty, 2003, p. 42). More specifically, constructionism claims that meanings are constructed by human beings as they engage with the world they are interpreting” (Crotty, 2003, p. 43). It enables researchers to become immersed and engaged with a particular group of individuals who experience a phenomenon, so that they can begin to interpret meanings of experiences within that particular group. In this study, as the researcher became engaged with the participants, she attempted to interpret the meanings of their experiences in order to see what beliefs emerged in planning for and enacting socioscientific issues-based lessons in their chemistry classes.

**Overview of Methodology**

The overall methodological framework that was used for this study was interpretive research. According to Erickson (1986), interpretive methodology allows researchers to “examine (a) science classrooms as socially and culturally constructed environments for learning, (b) the nature of teaching as one feature of that learning environment, and (c) the ways in which teachers and students make sense of, and give meaning to, their interactions as the central element of the educational process” (p. 120). Gallagher (1991) maintained that
interpretive researchers desire to understand the specific details of interactions that constitute effective teaching and learning which occur between teachers and students. Furthermore, Gallagher (1991) noted, “The researcher’s intention is to learn about the teacher’s knowledge, values, and beliefs as they are and not to influence teachers by his or her actions” (p. 11).

Within the overall framework of interpretive research, this study drew upon the use of case study methods. Case study research involves the study of an issue or phenomenon explored through one or more cases within a bounded system. More specifically, the researcher explores the bounded system through detailed, in-depth data collection involving multiple sources of information (Creswell, 2007). Patton (2002) stated that the purpose of a case study is “to gather comprehensive, systematic, and in-depth information about each case of interest” (p. 447) and that a case study illustrates “the value of detailed, descriptive data in deepening our understanding of individual variation” (p. 16). According to Spillane and Zeuli (1999), in-depth case studies of classrooms play an important role in developing an “understanding of patterns of practice in classrooms” (p. 20).

For this study, the researcher used a multiple-case study design (Yin, 2009). The researcher’s intent was to investigate each of the three secondary chemistry teachers and their school contexts as separate case studies. The three participants chosen for this study taught chemistry in two different school districts in Georgia. The participants were selected based on the following criteria: (1) the participants were secondary level chemistry teachers, (2) the participants taught on a block schedule, and (3) the participants were known for their commitment to including socioscientific issues in their teaching of chemistry.

Data collection techniques consistent with interpretive research were used in this study. More specifically, the researcher used in-depth, semi-structured interviews, classroom
observations, and the collection of artifacts and documents as the techniques through which data was accessed.

For the first two research questions, inductive analysis (Charmaz, 2006) was used in this study. The inductive analysis consisted of line-by-line coding, in-vivo coding, and focused coding. In line-by-line coding, each line of written data was named. After completion of the line-by-line coding, in-vivo coding was then used to analyze the data. In this process, the participants’ terms were used as codes. Lastly, focused coding was employed. In this process, the most significant codes made earlier were used in order to arrange the different codes into meaningful categories and to build a systematic account of what had been observed and recorded (Ezzy, 2002). The researcher then analyzed the categories in order to develop emergent themes.

For the third research question, data analysis occurred through the use of a modified version of Sadler’s (in press) model of assessment of socioscientific reasoning practices. This modified version of Sadler’s (in press) model was used as a heuristic or tool to understand how the secondary chemistry teachers in this study fostered socioscientific reasoning. Within this portion of the data analysis, an emergent analysis was used. In this process, the researcher employed steps of: (1) coding the data, (2) grouping the codes into categories, and (3) identifying the categories and themes. With regards to coding, line-by-line coding, in-vivo coding, and focused coding were used. The researcher then determined to what extent the themes reflected Sadler’s (in press) modified framework for the assessment of socioscientific reasoning.

Once the emergent themes were established, the individual cases were then written in the form of narratives. In order to represent the thoughts, ideas, and beliefs of participants, narratives were embedded from interview talk.
After the completion of within-case analysis, a cross-case analysis was employed. The purpose of the cross-case analysis was to look for patterns that cut across individual cases (Merriam, 1998; Patton, 2002). This resulted in a unified description of the cases and the identification of emerging themes, categories, and typologies (Merriam, 1998).

After completion of the within-case and cross-case analyses, the researcher engaged in interpretive analysis where the data was interpreted in light of the theoretical frameworks and salient literature.

**Definition of Salient Terms**

In this study, there were several terms that needed to be defined for the purpose of clarity. The terms to be defined included the following: socioscientific issues, socioscientific reasoning, issues-based science, teacher belief, nature of science, chemistry, chemistry teaching, chemistry learning, planned curriculum, enacted curriculum, and relevance.

In the context of this study, *socioscientific issues (SSI)* refer to social dilemmas with conceptual or technological links to science (Sadler, 2004). They center around the use of scientific topics that require students to engage in dialogue, discussion, and debate. Socioscientific issues are also generally controversial topics in nature, and they require a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues (Zeidler & Nichols, 2009). Kohlberg (1976) defined moral reasoning as a process in which individuals incorporate problem-solving strategies learned at earlier stages as they continue to develop. Ethical concerns are defined as dilemmas that enable individuals to arrive at decisions by taking into account their background beliefs, conflicting moral feelings, conflicting thought processes, and professional expectations (Loving, Lowy, & Martin, 2002).
**Socioscientific reasoning** is a theoretical construct that is designed to “uniquely capture the array of practices fundamental to the negotiation of SSI” (Sadler, Barab, & Scott, 2007, pp. 377-378). The premise behind socioscientific reasoning is to develop practices that can be transferred from one socioscientific context to another (Sadler, in press). According to Sadler, Barab, and Scott (2007), socioscientific reasoning consists of four practices that are fundamental in the negotiation of SSI. These four practices include: (1) recognizing the inherent complexity of SSI, (2) examining issues from multiple perspectives, (3) appreciating that SSI are subject to ongoing inquiry, and (4) exhibiting skepticism when presented with potentially biased information.

**Issues-based science** is a subset of the Science-Technology-Society (STS) movement. It is defined as education that emphasizes the impact of scientific and technological development on society but does not focus on the moral and ethical issues embedded in decision-making (Zeidler et al., 2005).

**Teacher belief** is defined as “pre-service or in-service teachers’ implicit assumptions about students, learning, classrooms, and the subject matter to be taught” (Kagan, 1992, pp. 65-66). Beliefs are based on values and judgments that all teachers hold with regards to such factors as their work, their students, their subject matter, and their roles and responsibilities (Pajares, 1992). In the present study, the terms beliefs and knowledge were not used synonymously, but were recognized by the researcher as closely related constructs. The researcher treated beliefs as the secondary chemistry teachers’ premises and propositions about socioscientific issues resulting from personal experiences that were mostly emotionally-laden, whereas knowledge was defined as the factual information that comes about as a result of the secondary chemistry teachers’ formal learning (Alexander & Dochy, 2005; Southerland, Sinatra, & Matthews, 2001a).
Although there is no general consensus concerning the definition of the *nature of science*, for this study it is defined as consisting of the following assumptions: (a) Scientific knowledge is tentative (subject to change), (b) empirically based (based on and/or derived from observations of the natural world), (c) subjective (theory laden), (d) necessarily involves human inference, imagination, and creativity (involves the invention of explanations), (e) necessarily involves a combination of observations and inferences, and (f) is socially and culturally embedded (American Association for the Advancement of Science, 1993; Lederman, 1992; National Research Council, 1996). The assumption is that by students understanding the nature of science, they will become “more informed consumers of science, which will empower them to make more informed decisions when scientific claims and data are involved” (Lederman, 1999, p. 916).

For the purposes of this study, *chemistry* is defined as a body of knowledge and way of thinking that is reliable and tentative. It involves “the chemists” demand for naturalistic explanations supported by empirical evidence and involving observation, rational argument, inference, skepticism, creativity, and the importance of being able to replicate work” (Holbrook, 2005, p. 2).

In this study, *chemistry teaching* is defined as promoting scientific literacy skills that are acquired through engaging in the subject matter of chemistry. This approach to teaching involves relating the issues and concerns of society to the subject matter, which in turn leads to socioscientific decision-making. It also consists of the teacher encouraging student involvement by building on prior constructs held by students (Holbrook, 2005).
Chemistry learning is defined as making sense of and applying concepts learned in chemistry (Anderson & Krathwohl, 2001; Bransford, Brown & Cocking, 2000). This type of learning occurs when students “seek to relate new concepts and propositions to relevant existing concepts and propositions in their cognitive structure” (Minzes, Wandersee and Novak, 2000, p. 3).

Planned curriculum is also known as “planned learning experiences” (Schwab, 1971a, p. 11) or the “official curriculum” (Jackson, 1992). It is “what is intended, and usually has to do with the formal schooling that goes on in the classrooms- with subject matter, or with the sequence of desired outcomes” (Schwab, 1971a, p. 11).

Enacted curriculum is also called the delivered curriculum (Jackson, 1992). It includes “what actually happens” or the “formal content of instruction of what goes on in classrooms” (Schwab, 1971a, p. 11). It is the curriculum that is taught (Jackson, 1992). It is the ongoing process of implementation that emphasizes the educational experiences that students and teachers jointly undergo as they determine what the curriculum will be like in each classroom (Marsh, 2004). Implementation refers to the actual use of the curriculum (Fullan and Pomfret, 1977). According to Marsh (2004), it is the beliefs and values of stakeholders, which are socially shared and shaped, that ultimately affect what happens in classrooms.

Relevance is defined as teaching material that relates to societal situations in the everyday lifeworlds of the students. Everyday lifeworlds include topics related to the home, the environment, future employment, and future changes and developments within the society. Teaching for relevance in chemistry involves addressing the skills of scientific problem-solving and socioscientific decision-making (Holbrook, 2005).
Subjectivity Statement

As a former high school chemistry teacher, the researcher has a huge interest in the education and success of students. Helping students to learn and excel in science is a huge task, and the researcher has observed and seen many instances where this task is done effectively. However, the researcher has concluded that through her experiences and observations, the most effective way that she has witnessed students learn science is through the incorporation of relevant, real-world examples into lessons that allow students to rely on their morals and ethics to make informed decisions about dilemmas presented. Socioscientific issues are indeed real-world examples that can capture the attention of students and can get them interested in discussing the topics in more depth than what the state standards call for. The researcher also believes that applying real-world examples through the use of socioscientific issues allows for a deeper understanding of scientific concepts because it allows students to make connections between context and content. Thus, the researcher believes that integrating socioscientific issues into science curriculum is an important way of teaching science.

However, the researcher has experienced the challenges of incorporating socioscientific issues-based lessons. These challenges included her struggles with balancing socioscientific-issues based lessons with state standards, especially since the chemistry courses she taught included a standardized testing component at the end of the course. Another challenge the researcher had with incorporating socioscientific issues was finding the time to plan the lessons. The researcher found that it took a lot of time to plan lessons, and this was extremely difficult for her because of the extra teaching duties that she was required to perform. Thus, the researcher has a vested interest in this study because of the personal struggles that she has experienced.
Researcher Subjectivities. It was important for the researcher to be cautious of the fact that she was an outsider when she studied these secondary chemistry teachers. As such, it was the researcher’s duty to allow the teachers to speak honestly about their experiences without trying to incorporate her beliefs and perspectives into the research. As stated earlier, the researcher believes in using socioscientific issues in lessons as a way of engaging students in social dilemmas that have conceptual or technological links to science. The researcher believes that even though teachers are required to teach the state and national standards, it is possible to develop curricular approaches and instruction centered around socioscientific issues. Although this may be difficult to achieve at first, the researcher believes that it is possible. Even though the researcher holds these beliefs, it was important that these beliefs did not interfere with the participants’ opinions of using socioscientific issues in their lessons.

Preview of Subsequent Chapters

This dissertation is written in what is considered to be a formal or traditional dissertation format in that it is organized into five chapters. Chapter 1 is the introduction, and it consists of the background for this study, the purpose and rationale for the study, a discussion of the research questions, an overview of the salient literature, an overview of the theoretical framework and methodology, definitions of salient terms, and researcher subjectivities. Chapter 2 is divided into two sections and presents a review of literature and the theoretical framework of the study. The first section of chapter 2 focuses on literature salient to socioscientific issues and socioscientific reasoning. The second section of chapter 2 focuses on literature salient to the theoretical frameworks of teacher beliefs, situated learning, and Schwab’s notion of curriculum. It also includes literature related to the epistemology of constructionism. Chapter 3 describes the methodology employed in the study. This chapter also describes the participants, contexts, and
specific methods and procedures used in this study. Chapter 4 consists of the findings, analysis, and interpretation with respect to the three individual case studies. Each case is presented through (1) a description of the context, (2) a narrative account, (3) a closing narrative, and (4) a summary discussion and preliminary interpretation of themes. Chapter 5 provides a cross-case analysis, elaborates on the interpretation relative to the three research questions, discusses implications of the study, and suggests areas for future research.
CHAPTER 2
REVIEW OF LITERATURE AND THEORETICAL FRAMEWORK

Introduction

Many researchers have found that chemistry classes at the secondary level are unpopular among students (Black & Atkin, 1996; Gräber, 2002; Osborne, 2003). Marks and Eilks (2009) believed that one reason for this unpopularity stems from the belief that most chemistry lessons use an “overly content-driven approach” (p. 231). Accordingly, such chemistry classes lack personal relevance for students, and this leads to low levels of motivation and a general lack of interest in chemistry (Morell & Lederman, 1998; Osborne, 2007; Osborne, Driver & Simon, 1998). Because of this unpopularity, secondary chemistry teaching has been characterized as ineffective in promoting higher-order cognitive skills, such as students’ skills in evaluating socioscientific issues (Gräber, 2002; Fischer et al., 2005). Thus, according to these researchers, secondary chemistry teaching does not focus enough on incorporating socioscientific issues with regards to local issues, public policy-making, and global problems (Eilks, 2000; Eilks, Marks, & Feierabend, 2008; Gräber, 2002). This remains the case, despite science educators emphasizing the need to prepare students for opportunities to participate in socioscientific controversies in order to enhance the development of scientific literacy in learners (Bybee, 1997; Driver, Leach, Millar, & Scott, 1996; Eilks, 2000; Holbrook, 2003; Osborne, 2007; Pedretti & Hodson, 1995). Therefore, the argument made for this literature review is that because chemistry teaching is often characterized by content-driven techniques, students do not see the relevance in the subject matter, and thus it becomes increasingly important for teachers to plan and enact socioscientific
issues-based lessons as a means of engaging and helping students develop meaningful understandings of the content.

Barrett (2008) noted that socioscientific issues have become an increasingly important focus in the field of science education, and there is a growing movement to incorporate them into the school science curriculum. In this study, the researcher attempted to limit her search to relevant literature that pertained to educational contexts. Therefore, this chapter aimed to present a synthesis of this literature in light of the research questions for this study. These research questions were:

1) Why do chemistry teachers use socioscientific issues in their teaching?

2) How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about:
   a. Nature of science?
   b. Chemistry?
   c. Chemistry teaching?
   d. Chemistry learning?

3) How do chemistry teachers plan for and enact socioscientific issues-based lessons in a secondary chemistry classroom?
   a. To what extent do chemistry teachers foster socioscientific reasoning in these lessons?

This chapter is composed of two parts. The first part is the review of the literature, which is what was used by the researcher to situate this study. The literature review was organized into two important topics that informed the study: socioscientific issues in secondary school settings and socioscientific reasoning. The section on socioscientific issues in school settings was
organized with the following components: (1) categories of SSI, (2) what research says about the inclusion of SSI in science curricula, and (3) dimensions of SSI. The section on socioscientific reasoning was organized with the following components: (1) characteristics of socioscientific reasoning and (2) what research says about ways of fostering socioscientific reasoning.

The second part of this chapter explained the theoretical framework. As such, this portion of the chapter discussed the different theoretical underpinnings that informed this study. The theoretical frameworks of this study included teacher beliefs, situated learning, and Schwab’s notion of curriculum. The epistemology used for this study was constructionism.

Relevant literature was located through the use of online library databases that included Academic Search Complete, EBSCOHost, ERIC, Education Full Text, Educational Research Complete, Google Scholar, and JSTOR. The terms used in the researcher’s search included “socioscientific issues”, “socioscientific issues in secondary schools”, “socioscientific reasoning”, “fostering socioscientific reasoning”, “nature of science”, “informal reasoning”, “decision-making”, “inservice teachers’ beliefs”, “teacher beliefs”, “science teacher beliefs”, and “constructionism”.

**Review of Literature**

**Socioscientific Issues in Secondary School Settings**

**Categories of SSI.** This section of the literature review references the different approaches in science education that prioritize socially relevant issues and the science related to these issues. The three categories addressed are: (1) science-technology-society, (2) socioscientific issues, and (3) *les questions socialement vives*.

**Science-Technology-Society.** The inclusion of socioscientific issues in curricula is not an entirely new phenomenon in science education. Its roots can be traced back to the
science/technology/society movement (STS) of the 1960s (Yager, 1990). According to the National Science Teachers Association (1996) position statement, STS is defined as: “a focus on real-world problems which have science and technology components from the students’ perspectives”. The STS movement sought to make science relevant to everyday lifeworlds of students. A subset of the STS movement was issues-based science. This was defined as education that emphasizes the impact of scientific and technological development on society but does not focus on the moral and ethical issues embedded in decision-making (Zeidler, Sadler, Simmons, & Howes, 2005).

**Socioscientific Issues.** Socioscientific issues encompass social dilemmas with conceptual or technological links to science (Sadler, 2004). According to Sadler (2011a), they are “open-ended problems” that “tend to have multiple, plausible solutions that can be informed by scientific principles, theories, and data” (p. 4). More specifically, as Zeidler and Nichols (2009) pointed out, socioscientific issues center around the use of scientific topics that require students to engage in dialogue, discussion, and debate. Although socioscientific issues are usually multidimensional in nature, Zeidler and Nichols (2009) emphasized that they require a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding some possible resolution of the dilemmas embedded within them.

**Les questions socialement vives.** Simonneaux and Simonneaux (2005) offered another way to describe work in this area: *les questions socialement vives* or socially acute questions (SAQ). The SAQ approach is very consistent with the SSI framework in that it analyzes the source and social implications of controversy. Socially acute questions are used as a means of describing reasoning patterns that emerge from a group of students engaged in the negotiation of SSI. Simonneaux (2007) described these questions as “socio-sociological issues such as
globalization, immigration and unemployment, or socio-scientific issues” (p. 180). Furthermore, Simonneaux (2007) found these questions to focus on the areas of society, research fields, and the classroom. He noted:

In society: Because they are in relation to the social practices of teachers and students, influenced by their social representations and their value systems. They are covered in the media and students have some knowledge of them. In research fields: Because there are competing points of view on them. In sciences, they are part of the frontier science. In classrooms: Because they are “acute” in the spheres of research and society. Teachers often feel that they are not capable of dealing with them (p. 180).

Sadler (2009b) however, believed that socially acute questions do not demonstrate ways for students to transfer processes and practices developed in one context to another.

In summary, three different categories were used to describe the different approaches in science education that incorporate socially relevant issues with science content. For the purposes of this study, the researcher will focus on the idea of socioscientific issues, and the following sections will provide literature relevant to this construct.

**What Research Says About the Inclusion of SSI in Science Curricula.** Recently, researchers (Kolstø, 2001; Zeidler and Keefer, 2003; Zeidler et al, 2002) have argued that socioscientific issues (SSI) should be an important component in preparing a scientifically literate citizenry because SSI more accurately portrays science in the real world. Research has reported that teaching science through SSI can increase learning of content (Dori, Tal, & Tsaushu, 2003). Also, according to Nuangchaler (2009), socioscientific issues are a way to explore the nature of science, bridge student and scientific literacy, and encourage the interdependence of science and society.
According to Pedretti (2003), socioscientific issues present many advantages such as presenting a point of departure for developing and exploring further inquiry, providing a rationale for the search for information, and more accurately reflecting “the multi-disciplined nature, discourse, and activities of the scientific pursuit” (pp. 220-221). More specifically, Zeidler et al (2005) noted that the SSI movement focuses 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).

Literature in this section emphasized the importance of incorporating socioscientific issues in the context of science subject matter. This review supported the researcher’s argument that it is increasingly important for chemistry teachers to plan and enact lessons involving socioscientific issues as a means of engaging and helping students better understand the content.

**Dimensions of SSI.** According to Sadler (2011a), the SSI movement has arisen within the science education field as researchers have focused on using these complex issues as contexts for science teaching. Some have argued for the conceptualization of science education as a form of education for citizenship as necessary for the cultivation of scientifically literate citizens engaged in thoughtful decision-making (Aikenhead, 2000; Driver et al, 2000; Driver, Leach, Millar, Scott, 1996; Zeidler & Keefer, 2003). According to Osborne and Collins (2000), the premise for this argument is that separating the learning of science content from its applications and implications makes school science seem irrelevant and fails to develop the skills and expertise needed for citizenship.

Socioscientific issues have been connected to important aspects of science education such as argumentation (Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; Sadler & Donnelly, 2006; Walker, & Zeidler, 2007; Zohar & Nemet, 2002), informal reasoning (Kolstø, 2006; Wu & Tsai,
2007), and the acquisition of conceptual knowledge (Dawson & Schibeci, 2003; Fowler, Zeidler, & Sadler, 2009; Lewis & Leach, 2006; Klosterman & Sadler, 2010). According to Fowler, Zeidler, and Sadler (2009), student learning and development in these areas are standard expectations in the classrooms of today.

The purpose of this section of the literature review is to organize, integrate, and summarize studies with regard to socioscientific issues in the context of argumentation, informal reasoning, and acquisition of conceptual knowledge. The review explored the research related to these themes in order to assess the significance of existing research. The sections that follow are organized according to the dimensions of SSI described earlier, and a graphic organizer (Figures 2.1-2.3) is presented for each topic. The graphic organizers present a summary of the studies reviewed. Following the graphic organizer for each section is a description of the literature reviewed.

**Classroom Discourse and Argumentation.** Simmons and Zeidler (2003) emphasized that many teachers are hesitant to implement the use of socioscientific issues in their classes due to the uncertainty regarding how students might react to such controversial issues. However, according to Berkowitz and Simmons (2003) it is possible for educators to select topics that fit their levels of comfort without necessarily becoming “lightning rods for rancor and divisiveness” (p. 123). Zeidler and Keefer (2003) stated, “Discourse issues hold the key to how students frame their positions, build a case for argument, become aware of fallacious reasoning, and consider how belief convictions influence their emotions and moral commitments to moral issues” (p. 13). According to Zeidler and Nichols (2009), ways of implementing socioscientific issues in classroom discourse include the use of argumentation and debate. Zeidler and Nichols (2009) also suggested that by using argumentation and debate, teachers are engaging thinking
and reasoning processes and are mirroring the discourse practices used in real life in the advancement of intellectual and scientific knowledge.

According to Zeidler, Osborne, Erduran, Simon, and Monk (2003), argumentation should be used as a vehicle in helping students come to terms with socioscientific issues because it gives students the opportunity to engage in active dialogue as they ponder evidence, apply critical thinking skills, and formulate positions on various topics. Argumentation features the opportunity to reason, to criticize, to justify, to find opposing views, and to generate a new perspective in social interaction or in self-deliberation (Laius & Rannikmäe, 2011). Kuhn (1992) and Zeidler, Lederman, and Taylor (1992) believed that this ability to argue in an effective manner becomes a central component to scientific literacy. Wickman and Ostman (2002) added that argumentation should be acknowledged in science education in order to further understand “how esthetical and moral relations are construed as a part of the scientific discourse and how questions of power influence meaning making” (p. 621). Figure 2.1 is a graphic organizer related to research on socioscientific issues and argumentation.
A study by Jiménez-Aleixandre, Rodríguez, and Duschl (2000) explored classroom argumentation in the context of genetics within a ninth-grade biology class. Students worked in small groups to engage in a socioscientific issue involving genetic and environmental variability of farm-raised chickens. Qualitative analysis was used to examine transcripts recorded from small-group discussions. Results indicated that students’ argumentation was limited, many students did not contribute to the discussions, and many students appeared unequipped to participate in discussions. Most of the argumentation focused on causality and appealed to analogies. Researchers concluded that the concentration on causality was due in part to the
nature of the assignment as the students appeared less concerned with issues of consistency and plausibility.

In Sadler and Donnelly’s (2006) study, the researchers investigated how content knowledge and morality contributed to the quality of socioscientific issue argumentation among 56 high school students. A mixed-methods approach was employed in this study in which the participants completed tests of content knowledge and moral reasoning as well as interviews. Results from multiple regression analysis revealed no statistically significant relationships among content knowledge, moral reasoning, and argumentation quality. Qualitative analyses of the interview transcripts showed that the participants very infrequently revealed patterns of content knowledge application.

In a multiple case study, Walker and Zeidler (2007) investigated the implementation of an inquiry-based curricular unit designed to promote student discourse and debate with regards to the socioscientific issue of genetically modified foods. Two high school science classrooms participated in the study that took place over seven consecutive 90 minute periods. Qualitative procedures were used to analyze students’ answers to online and interview questions. Their analysis indicated that students utilized more factual-based content of the evidence, and this ultimately led to numerous instances of “fallacious reasoning and personal attacks” (p. 1387). These findings suggested that socioscientific issues-based approaches to teaching should explore aspects that allow students to apply their conceptions within a decision-making context.

Zohar and Nemet’s (2002) study examined the outcomes of the teaching of argumentation skills in the context of dilemmas in human genetics in a ninth grade classroom. Before instruction, it was found that only 16.2% of the students referred to correct, specific biological knowledge in constructing arguments in the context of dilemmas in genetics.
However, after instruction, it was found that approximately 90% of students were successful in formulating simple arguments. An increase in the frequency of students who referred to correct, specific biological knowledge in constructing arguments and the quality of students’ argumentation was also found. More specifically, researchers found that students were able to transfer the reasoning abilities taught in the context of genetics to the context of dilemmas taken from everyday life.

The literature reviewed in this section demonstrated the varying degrees of argumentation among students who experienced socioscientific issues-based lessons. Two of the four articles reviewed showed an increase in the level of argumentation. One article showed no statistical significance in the relationship of argumentation skills with other constructs. Another article reported limited argumentation by the students who participated in the study. These articles demonstrated the need to further study the impact of argumentation on socioscientific issues-based lessons. Thus, the researcher argues that this present study of how secondary chemistry teachers use socioscientific issues in their lessons will add to the literature on how argumentation plays a role in the context of these lessons.

**Informal Reasoning.** According to Sadler (2002), informal reasoning “involves the generation and evaluation of positions in response to complex issues that lack clear-cut solutions” (pp. 3-4). Informal reasoning enables individuals to ponder causes and consequences, pros and cons, and positions and alternatives (Means & Voss, 1996; Zohar & Nemet, 2002). Perkins, Farady, and Bushey (1991) added that this allows for premises to change as additional information becomes available. Kuhn (1992) argued that socioscientific issues are ideal for the application of informal reasoning because they are complex, open-ended dilemmas with no definitive answers. Furthermore, informal reasoning can be used to bring clarity to controversial
decisions (Sadler, 2002). Figure 2.2 is a graphic organizer that summarizes research related to socioscientific issues and informal reasoning.

Figure 2.2: Graphic Summary of Research Related to SSI and Informal Reasoning

Kolstø (2006) conducted a qualitative study on students’ informal reasoning in relation to the local construction of new power lines and the possible increased risk of childhood leukemia. Twenty-two students from four science classes in Norway were interviewed for this study. The focus of the study was to determine what arguments the students employed when asked about their decision-making and the interplay between their knowledge and personal values. Five different arguments were identified, and they included: (1) the relative risk argument, (2) the precautionary argument, (3) the uncertainty argument, (4) the small risk argument, and (5) the
pros and cons argument. In all of the cases, the students made use of a range of both scientific and non-scientific knowledge.

Wu and Tsai (2007) conducted a study in which 71 grade 10 students’ informal reasoning about nuclear energy usage was explored qualitatively and quantitatively. Their findings indicated that students in this study tended to process reasoning from multiple perspectives and were prone to making evidence-based decisions. It was also found that less than 40% of the participants were able to construct rebuttals against counter-arguments. In addition, it was revealed that students’ abundant use of supportive arguments did not guarantee their counter-argument or rebuttal construction. However, the researchers concluded that their use of counter-arguments might act as precursors to their construction of rebuttals. The researchers also concluded that the students’ use of multiple reasoning modes might help them propose more arguments and generate more counter-arguments, which may act as precursors to their rebuttal construction. The researchers also believed that this study showed evidence that the students’ knowledge construction and understanding could serve as an important foundation for better informal reasoning and decision-making of socioscientific issues.

The literature reviewed in this section illustrated how the incorporation of socioscientific issues-based lessons encourages students to process reasoning from multiple perspectives. As no literature with respect to teachers’ planning for and fostering informal reasoning were found, the researcher’s study was influenced by the literature on informal reasoning as she explored the beliefs and actions of secondary chemistry teachers.

Acquisition of Conceptual Knowledge in the Context of SSI Instruction. According to Orpwood (2001), scientific content knowledge remains the most important science education outcome as reflected in standards and assessments. Driver, Newton, and Osborne (2000) argued,
“To provide adequate science education for young people, it is necessary to reconceptualize the practices of science teaching so as to portray scientific knowledge as socially constructed” (p. 289). Figure 2.3 provides a summary of literature reviewed as it pertains to the acquisition of conceptual knowledge in the context of SSI instruction.

Figure 2.3: Graphic Summary of Research Related to SSI and Acquisition of Conceptual Knowledge

Dawson and Schibeci (2003) conducted a study in which 1,116 15-year old students from eleven Western Australian schools were surveyed in order to determine their conceptual understanding of and attitudes towards recent advances in modern biotechnology, genetic engineering, cloning, and genetically modified foods. Results showed that approximately one-third of students had little or no understanding of biotechnology and that many students...
overestimated the use of biotechnology in society by confusing current uses with possible future applications.

Lewis and Leach (2006) aimed to investigate students’ discussion of the social consequences of gene technology and the role played by formal scientific knowledge in this discussion. Participants included over 200 students, who were between the ages of 14 and 16. This study was conducted in two phases. In phase one, the researchers assessed the extent to which the students could engage with issues arising from specific applications of gene technology and formulate an opinion about this topic. This phase also identified the information, support, and guidance needed by the students in order to do this. Data was collected through paired discussions of written questions and small group discussions in the presence of an interviewer. Results from the paired discussions indicated that students generally had a limited understanding of the contexts and the science on which they were based. In phase two, the outcomes of phase one were used to examine the ways in which students drew upon scientific concepts in order to examine issues arising from the use of gene technology. Data collection methods included the use of video clips and a card sort activity in order to engage small groups of students in a discussion of the dilemmas presented to them. Findings from phase two confirmed the findings from phase one. Most of the students who were asked about a specific context and provided with a basic explanation of the underlying science were able to engage in a reasoned discussion of key issues and formulate an opinion that they could justify.

Klosterman and Sadler (2010) explored the impact of using a socioscientific issues-based curriculum on global warming in order to develop science conceptual knowledge. A total of 108 chemistry and environmental science students from two high schools participated in this mixed-methods study. Student conceptual knowledge gains were measured through pre- and post-test
scores. Quantitative analysis indicated that student post-test scores were statistically significantly different than their pre-test scores. Qualitative analyses of student responses to the post-tests indicated that students, on average, expressed more accurate, more detailed, and more sophisticated understandings of global warming, the greenhouse effect, and the controversies and challenges associated with these issues. The researchers concluded that this study offered evidence in support of using SSI as a context for learning science content.

In summary, the literature reviewed on SSIs and the acquisition of conceptual knowledge illustrated the different ranges of student understanding when presented with science concepts linked with SSIs. Though inservice secondary science teachers were instrumental in incorporating socioscientific issues into their science curriculum, their personal participation with respect to planning and enacting SSIs have not been fully examined in light of the use of socioscientific issues in the classroom. Therefore, the researcher’s study helps to shed light on how secondary chemistry teachers’ incorporation of socioscientific issues is used as a means for students to develop conceptual knowledge.

**Socioscientific Reasoning**

*Characteristics of Socioscientific Reasoning.* According to Sadler, Barab, and Scott (2007), socioscientific reasoning is a theoretical construct designed to “uniquely capture the array of practices fundamental to the negotiation of SSI” (pp. 377-378). Fowler, Zeidler, and Sadler (2009) argued that socioscientific reasoning involves considering morals, ethics, and personal views. Thus, Sadler and Zeidler (2005) described socioscientific reasoning as the evoking of imaginative thinking in order to navigate through the landscape of ill-structured problems.
According to Sadler, Barab, and Scott (2007), socioscientific reasoning consists of four practices that are fundamental in the negotiation of SSI, and these four practices include: (1) recognizing the inherent complexity of SSI, (2) examining issues from multiple perspectives, (3) appreciating that SSI are subject to ongoing inquiry, and (4) exhibiting skepticism when presented with potentially biased information. Sadler (in press) provided definitions for complexity, perspectives, inquiry, and skepticism. He defined complexity as a sophisticated conceptualization that recognizes the various interrelationships among issues. He defined perspectives as students actively seeking to analyze issues by taking into account various viewpoints that may be adopted in response to the issues. He defined inquiry as the notion of always having “unanswered questions related to SSI in terms of the underlying science, social implications, or both” (p. 5) and the desire to identify the kinds of investigations needed to answer these open-ended questions. He defined skepticism as a scientific habit of mind that causes individuals to examine information presented about an SSI from sources with vested interest, especially in the face of potentially biased information (Sadler, in press).

**Fostering Socioscientific Reasoning.** Mueller and Zeidler (2010) noted that socioscientific reasoning is fostered as SSI pedagogy guides students through “epistemic and ontological or character development” (p. 106). This section is organized into five sections where literature is reviewed with respect to the fostering of socioscientific reasoning. These sections are: (1) transfer, (2) nature of science, (3) ethics and morals, (4) higher order thinking, and (5) decision-making.

**Transfer.** Sadler (2009b) defined transfer as “the extent to which and how students leverage experiences and practice relative to the exploration of one socioscientific issue to inform their negotiation of another” (p. 697). According to Hughes (2000) and Roth, McGinn,
and Bowen (1996), many teachers fear that extensive coverage of socioscientific issues devalues the curriculum, alienates traditional science students, and jeopardizes their own status as gatekeepers of scientific knowledge. Indeed, it can be argued that young children might not fully appreciate or be able to engage in activities that require empathy and understanding of multiple points of views and complicated relationships. However, studies (Cheek, 1993; Pedretti, 1997; Pedretti, 1999; Torney-Purta, 1983) suggested that it is possible for children and adolescents to possess different views with regards to social institutions, democratic life, and social inequalities. According to Zeidler and Lewis (2003), “Students who are able to negotiate competing scientific claims will necessarily debate not only the claims themselves but also competing scientific evidence, competing inferences drawn from evidence, and competing conclusions resting on those inferences” (p. 290). Figure 2.4 is a graphic organizer that summarizes research related to socioscientific reasoning and transfer of knowledge.
Laius & Rannikmäe (2011) engaged in a longitudinal study that examined the impact on ninth grade students’ change in socioscientific reasoning and scientific creativity skills as a result of their science teachers’ professional change. Eight chemistry and four biology teachers participated in two consecutive, eight-month intervention courses that were designed to guide teachers in promoting scientific literacy in their students. During the intervention courses, teachers created materials for four integrative modules and taught their students using a designed scientific and technological literacy (STL) teaching approach. Through the use of a pre-test and a post-test, students’ development was determined with regards to socioscientific reasoning skills and scientific creativity. Results revealed that the degree of teachers’ professional level in promoting problem solving and decision making had a significant impact on their students’ improvement in skills associated with socioscientific reasoning and scientific creativity.
Sadler and Fowler (2006), in a mixed-methods study, explored how individuals made use of scientific knowledge for socioscientific argumentation. They investigated how learners applied genetics content knowledge as they justified claims relative to genetic engineering. Participants included 45 individuals characterized into three distinct groups: (1) high school students with variable genetics knowledge, (2) college nonscience majors with little genetics knowledge, and (3) college science majors with advanced genetics knowledge. Interviews were conducted in order to solicit the participants’ views concerning three scenarios dealing with gene therapy and cloning. Arguments were assessed on a five-point rubric that focused on the number of justifications offered and the quality of them. Multivariate analysis of variance results reported that college science majors outperformed the other groups in terms of justification quality and frequency and that argumentation did not differ among nonscience majors or high school students. Follow-up qualitative analyses of interview responses suggested that all three groups tended to focus on similar, sociomoral themes, but the science majors frequently referenced specific science content knowledge in the justification of their claims. The authors concluded that the results supported the Threshold Model of Content Knowledge Transfer, which proposes two knowledge thresholds around which argumentation quality can be expected to increase.

Literature reviewed in this section indicated that there is an increase in the transfer of knowledge as socioscientific issues are incorporated into the curriculum. In this study, the researcher was influenced by the literature on transfer of knowledge as she explored the beliefs and actions of secondary chemistry teachers.

**Nature of Science.** According to Lederman (1992), nature of science is defined as “science epistemology, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development” (p. 64). Driver et al. (1996) stated:
There is an important argument that school science, if it is to contribute effectively to improve public understanding of science, must develop students’ understanding of the scientific enterprise itself, of the aims and purposes of the scientific work, and of the nature of the knowledge it produces. Such an understanding, it is argued, is necessary for students to develop an appreciation of both the power and the limitations of scientific knowledge claims, an appreciation which is necessary for dealing appropriately with the products of science and technology as informed citizens who can participate fully in a modern democracy (p. 1).

Simmons and Zeidler (2003) wrote that using socioscientific issues in the daily curriculum is “another means of eliciting NOS beliefs in students in a manner that serves as a basis for continued dialogue, student interaction, and in-depth research into familiar real-world issues” (p. 85). More specifically, Simmons and Zeidler (2003) suggested that by engaging in carefully selected moral problems in the domain of science, students can and will develop logical and moral reasoning skills while they gain a deeper understanding about important aspects of the nature of science. Figure 2.5 is a graphic organizer that summarizes research related to socioscientific reasoning and nature of science.
Forty-two ninth grade students enrolled in an environmental science class participated in a six-week study conducted by Khishfe and Lederman (2006) in which the aim was to investigate the influence of two different explicit instructional approaches in promoting more informed understandings of nature of science as related to the socioscientific issue of global warming. Participants were divided into two groups in which one group was designated the “integrated group” and had lessons presented in which nature of science instruction was related to the science content of global warming. The second group was designated the “nonintegrated group” and had lessons presented in which nature of science was taught through a set of activities that specifically addressed NOS issues and were dispersed across content about global warming. An open-ended questionnaire and semi-structured interviews were used to assess...
students’ views before and after instruction. Results indicated improvements in the students’ views of nature of science, regardless of whether or not nature of science was integrated within the regular content about global warming. However, there was a slightly greater improvement in the informed views of the integrated participant group. There was also a greater improvement in the transitional views of the nonintegrated group of participants as compared with the integrated group of participants. The researchers concluded that the overall results did not provide any conclusive evidence in favor of one approach over the other.

Sadler, Chambers, and Zeidler (2004) investigated student conceptualizations of the nature of science and how students interpreted and evaluated conflicting evidence regarding a socioscientific issue. Eighty-four high school students were asked to read contradictory reports about the status of global warming and to provide written responses to questions designed to elicit ideas pertinent to the research goals. A subsample of 30 students was interviewed in order to triangulate the data. Analysis indicated that the participants displayed a range of views of three distinct aspects of nature of science: empiricism, tentativeness, and social embeddedness. Findings also concluded that the interpretation and evaluation of conflicting evidence in a socioscientific context was influenced by a variety of factors related to the nature of science such as data interpretation and individuals’ own responses of personal beliefs and scientific knowledge.

Literature reviewed with regards to socioscientific reasoning and nature of science indicated that the incorporation of SSIs resulted in improvements of students’ views of NOS. The researcher’s study adds to this body of literature by examining secondary chemistry teachers’ beliefs with respect to SSI and the nature of science and how they enact lessons in relation to these views.
Ethics and Morals. The Kohlbergian paradigm suggested that the most efficient way to stimulate moral development is through the presentation of dilemmas for learners to work through (Kohlberg, 1985). Zeidler and Lewis (2003) discussed the value of cased-based approaches to science instruction that consider the underlying ethical and moral dimensions of science in stimulating and nurturing the moral development of the child. Sadler and Zeidler (2003b) argued that science educators should share the cases of triumphs as well as the cases of failures of the scientific field. By including examples of “bad” science, teachers could address the nature of science and the relationship between science and morality.

Witz and MacGregor (2003) stated, “Children and adolescents need to engage in science in a way that involves them as whole (including moral, aesthetic and spiritual) persons, so that their relation to science can become part of their ‘deeper subjective (including moral) being’, part of the core of their self” (p. 166). Witz and MacGregor (2003) also emphasized the major role that teachers have in helping students examine what roles morals and ethics play in their learning. This is because, according to Witz and MacGregor (2003), teachers often have a deeper intuitive understanding of their students. They point out that, “The reason that an intuitive understanding of the student’s individual nature is so important for a teacher is that such an understanding enables her to estimate the student’s real moral engagement and facilitate his/her moral engagement and unfolding” (p. 171).

The opening lines of the vision laid out in American Association for the Advancement of Science (1990) stated:

Education has no higher purpose than preparing people to lead personally fulfilling and responsible lives. For its part, science education…should help students to develop the understandings and habits of mind they need to become compassionate human beings
able to think for themselves and to face life head on. It should equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital (p. xiii).

Incorporating socioscientific issues in classroom science is one path towards realizing the lofty goals laid out in the reform documents. Figure 2.6 is graphic organizer that summarizes research related to socioscientific reasoning and ethics and morals.

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**Figure 2.6: Graphic Summary of Research Related to Socioscientific Reasoning and Ethics and Morals**

In Barrett’s (2008) exploratory study, she sought to compare the beliefs of physics and chemistry teacher candidates in a nine-month teacher education program to the beliefs of their instructors on teaching ethics through socioscientific issues in the physical sciences. Fifty-five
preservice teachers and three instructors participated in the study, and data collection included surveys and semi-structured interviews. Results indicated that the attitude of preservice teachers did not change from the beginning to the end of the course. Most were in favor of including ethics and socioscientific issues in their teaching. However, results also indicated that the instructors held back on the discussion of socioscientific issues because they felt that there were other more important topics that needed to be taught and also felt that the preservice teachers were not interested or were resistant to the idea of discussing the possibility of teaching about socioscientific issues.

The purpose of Barrett and Nieswandt’s (2010) qualitative study was to identify and explain the origins of physics and chemistry teacher candidates’ beliefs as related to teaching about ethics through socioscientific issues and the relationship of those beliefs to subject discipline identity. After purposeful selection of participants chosen in an open-ended questionnaire, twelve individuals took part in this study. Data collection methods included a series of three 1- to 2-hour semi-structured interview of each participant. The first interview focused on the participants’ backgrounds, while the second interview focused on experiences, and the third interview focused on reflection. Data analysis revealed that beliefs about teaching physics and chemistry using socioscientific issues could be characterized into four different archetypes: Model Scientist/Engineer, Model Individual, Model Teacher, and Model Citizen. Two participants were considered to be Model Scientists/Engineers, and this meant that they did not believe that socioscientific issues should be included in science education or should be included when teaching. Two participants were classified as Model Individual, and they believed that socioscientific issues should be included in science education, but that it was unlikely that they would include socioscientific issues in their teaching. Thus, those individuals characterized
as Model Scientist/Engineer and Model Individual felt that they had a responsibility to individuals and did not see personal ethics and the ethics of science as overlapping. Four individuals were considered to be Model Teachers, and they believed that socioscientific issues should be included in science education and they would maybe include socioscientific issues when teaching. Four individuals were Model Citizens, and these participants believed that socioscientific issues should be included in science education and that they would include socioscientific issues in their teaching.

Cross and Price (1996) conducted a study in which they examined the social conscience of science teachers as it bears on their teaching of controversial issues. Twelve inservice secondary science teachers of all subjects in Scotland and the United States participated in the study, which consisted of semi-structured interviews. Results indicated that all teachers reported dealing with controversial issues in their teaching. However, a spectrum of approaches was reported, and this reflected different value positions. For instance, at one end of the spectrum, a Scottish physics teacher indicated that she only dealt with one issue and that this issue was a result of a curriculum requirement. On the other end of the spectrum, an American biology teacher discussed how she felt that science teachers had a tremendous responsibility to present scientific issues to future citizens in her courses. The researchers concluded that while teachers indicated that they were teaching about controversial issues to varying extents, this was being done within the context of traditional science teaching, and students were given little opportunity to develop skills necessary to formulate questions, search for and evaluate evidence, and grapple with the difficulty of making practical decisions based on controversial issues.

In a study by Sadler, Amirshokoohi, Kazempour, and Allspaw (2006), teacher perspectives on the use of socioscientific issues and on dealing with ethics in the context of
science instruction were explored. Twenty-two middle and high school teachers of all science subjects from three different states participated in this study, which consisted of semi-structured interviews. Inductive analysis was employed in order to explore emergent patterns. Five different profiles were developed in order to capture the views and reported practices of the teachers in relation to the place of ethics in science and science classrooms. Profile A participants consisted of teachers who embraced the notion of incorporating socioscientific issues into the science curricula and cited examples using controversial topics in their classes. Profile B participants supported infusing socioscientific issues into science curricula in theory but reported significant constraints which prohibited them from actualizing these goals. Profile C participants were non-committal with respect to focusing instruction on socioscientific issues and ethics. Profile D participants believed that science and science education should be value-free. Profile E participants felt very strongly that all education should contribute to their students’ ethical development. The researchers concluded that the findings challenged the assumption that science teachers are unwilling or unable to transform their curricula to initiate more relevant and meaningful learning experiences.

Literature reviewed in this section indicated that teachers have different views and approaches to presenting moral and ethical issues in science classrooms. The researcher’s study adds to this body of literature by examining the beliefs of secondary chemistry teachers as they incorporate socioscientific issues which have ethical and moral components into their teaching of chemistry.

Higher Order Thinking. Sadler (2009a) described higher order thinking as a broad set of constructs related to complex reasoning and practices. According to Resnick (1987) development of higher-order thinking practices is a common goal for most educators. Within science
education, researchers use terms such as argumentation (Driver, Newton, & Osborne, 2000), critical thinking (Bailin, 2002), informal reasoning (Sadler, 2004), problem solving (Chapman, 2001), and scientific reasoning (Hogan, Nastasi, & Pressley, 1999) to reference aspects of higher order thinking. According to Sadler (2009a), all of these frameworks share common features. Zeidler and Nichols (2009) pointed out that one of the benefits of including socioscientific issues in the curriculum is that the discussion and debate of these controversial issues allows for students to develop many of the skills and dispositions associated with critical thinking. For instance, Facione (2010) explained how the core creative thinking skills of analysis, inference, explanation, evaluation, interpretation, and self-regulation will all be encouraged by SSI units as will the dispositions associated with them. In a study conducted by Pedretti (1999), student gains in argumentation practices associated with socioscientific issue interventions were documented, providing support for Zeidler and Nichols’ (2009) claim that “incorporating SSI can therefore help to produce students who are truth-seeking, open-minded, analytical, systematic, judicious, and increasingly confident in their reasoning” (p. 53). Figure 2.7 provides a summary of the literature reviewed on socioscientific reasoning and higher order thinking.
Tal and Hochberg (2003) conducted a study that aimed to assess the higher-order thinking skills of ninth grade students participating in the Web-based Inquiry Science Environment (WISE) Project in Israel. WISE is an online science-learning environment that enables students to work on inquiry projects on topics such as genetically modified foods, earthquake prediction, and malaria. The researchers chose to assess higher-order thinking skills within the context of the Malaria Project. Students were asked to engage in three main activities; each included a series of readings, discussions, and writing assignments. Data was collected through pre- and post-test questionnaires, portfolios, and class discussions. Results indicated that students applied higher order thinking while being engaged in the Malaria Project as they had many opportunities to explain their claims or “decisions”. The researchers noted that the students...
reflected on their learning in all of their assignments, and that their reflections deepened in the more advanced stages of the learning process. The researchers concluded that although the Malaria Project enabled fruitful collaboration, this one isolated experience of examining higher-order thinking was not enough. They recommended that schools and teachers provide more experiences for learning in such environments.

Yang’s (2005) study examined tenth grade students’ understanding of the nature of science by analyzing their thinking about a socio-scientific issue. Students were administered an open-ended questionnaire within the context of a socio-scientific issue: the cause of a flood disaster. Students’ responses to the open-ended questions indicated that when thinking about the flood issue, most students relied heavily on direct and numerical data to draw their conclusions. Their statistical analysis suggested that views towards evidence and expert were associated with personal epistemology.

In summary, literature examined in this section indicated that incorporating socio-scientific issues-based lessons may result in an increase in students’ higher order thinking skills. Although teachers were not specifically addressed in the literature reviewed in this section, these studies indicated that the incorporation of socio-scientific issues-based lessons by teachers played an integral role in increasing the higher order thinking skills of students.

**Decision-Making.** The “messiness” of decision-making regarding socio-scientific issues is well recognized (Pedretti, 1999; Zeidler & Keefer, 2003). By definition, real-world science and technology-based issues do not involve simple solutions with single right answers. Bell (2003) emphasized that there are always multiple benefits to weigh against multiple costs. Abd-El-Khalick (2003) suggested that this “messiness” results from utilizing scientific knowledge and
ways of thinking to confront real, science-related everyday life problems. Figure 2.8 provides a summary of literature reviewed with respect to socioscientific reasoning and decision-making.

Figure 2.8: Graphic Summary of Research Related to Socioscientific Reasoning and Decision-Making

Molinatti, Girault, and Hammond (2010) analyzed decision-making and argumentation by seven science classes of high school students in France within the context of the use of embryonic stem cells in research and therapy. Their study was designed so that the researchers could comparatively assess debate situations within two frameworks: the effects of the location of the debates and the effects of the contextualizations of the debates. Both frameworks were analyzed in light of students’ decision-making and argumentation. Data collection consisted of
pre-and-post tests and observations. Researchers performed a general analysis of the pre-and post-tests in order to quantify decision-making with regards to human embryonic stem cell usage. A detailed qualitative analysis of the discourses of the debates was also performed by the researchers. Findings indicated that some decision-making lacked justifications or restrictions, but the arguments given were rarely simple as they relied on many linearly linked justifications. The researchers concluded that for most students, the place where the debate was organized and the choice of scientific experts (contextualizations) probably had an impact on their decision-making.

Patronis, Potari, and Spiliotopoulou (1999) examined a class of 14-year-old students who were given an ethical problem to consider. The problem was the planning of a major road, which was a real-world problem for the area where the school in the study was situated. From this study, the researchers concluded that students were able to develop arguments and reach decisions when faced with a situation in which they were authentically involved.

The literature reviewed demonstrated that as students were exposed to the “messiness” of science, they had the potential to realize that answers in the real world are not often clear-cut. The literature reviewed also demonstrated the teachers’ willingness to engage students in the messiness of socioscientific issues-based lessons in order for students to understand the components involved in thoughtful decision-making. Bell (2003) noted that this could help students accept the inevitable situations in which scientists and other experts fall out on opposing sides of science and technology based issues. As no literature was found with respect to teachers and their decision-making practices in the context of SSI, the researcher’s study adds to this literature by examining how secondary chemistry teachers plan for and enact socioscientific issues-based lessons that enable students to participate in decision-making.
In summary, the literature reviewed in light of fostering socioscientific reasoning in the context of school science provided a background for the researcher’s study. Although researchers have indicated that there are positive results to fostering socioscientific reasoning, more research needs to be done that addresses how teachers play a role. Thus, this researcher’s study fills in the gap of literature by providing a context where secondary chemistry teachers are examined in order to understand how they plan and enact socioscientific issues-based lessons in light of fostering socioscientific reasoning. The next section addresses the theoretical underpinnings that informed the researcher’s study.

**Theoretical Framework**

A theoretical framework is a collection of interrelated concepts that guides the research (Doney, 2010). According to Merriam (1998), theoretical frameworks provide scaffolding or frame that function to support any research study. As such, these frameworks provide a lens through which researchers can approach research questions and the interpretation of results. Williamson (2003) argued that research problems can be addressed in many ways depending on the orientation of the researcher and that there must be some entry point for understanding. In this study three theoretical frameworks provided the foundation through which to view this work. They were: (1) teacher beliefs, (2) situated learning, and (3) Schwab’s notion of curriculum.

**Teacher Beliefs**

Researchers (Kagan, 1992; Pajares, 1992) have found that teachers’ beliefs about education- about schooling, teaching, learning, and students- are closely linked to their curriculum platform. Beliefs are based on values and judgments, and all teachers hold beliefs about their work, their students, their subject matter, and their roles and responsibilities (Pajares, 1992). According to Yerrick et al. (1997), the ways in which science teachers think about their
practice and about student learning are more closely linked to their belief systems than to new curriculum mandates. Furthermore, Blake (2002) contended:

What teachers believe in, as it relates to their philosophy of teaching, their role within that process, the role and expectations of the students for learning, and the role of the school, science curricula, and context for instruction, will be an essential foundation for what occurs in the classroom (p. 36).

According to Mansour (2009), research into teachers’ beliefs forms part of the process of understanding how teachers conceptualize their work, and this is important in understanding teachers’ practices and their decisions in the classroom. Lumpe, Haney, and Czerniak (2000) noted that both preservice and inservice teachers develop their beliefs about teaching from years spent in the classroom as both students and teachers and these beliefs are not necessarily consistent with the literature about best practices in teaching. Bybee (1993b) maintained that since teachers’ beliefs appear to be stable and resistant to change, problems may arise if classroom teachers and their beliefs about reform are ignored.

According to Pajares (1992), “All teachers hold beliefs, however defined and labeled, about their work, their students, their subject matter, and their roles and responsibilities, but a variety of conceptions of educational beliefs has appeared in the literature” (p. 314). The following sections aim to discuss various assumptions and definitions about teacher beliefs and how they informed this study. The sections are divided into the following components: (1) definition of belief, (2) belief vs. knowledge, (3) teacher belief, and (4) the researcher’s working definition and use of belief in this study.

**Definition of Belief.** The construct of belief has been defined as “an inference made by an observer about underlying states of expectancy” (Rokeach, 1968, p. 2). According to
Simmons et al. (1999), beliefs support and reveal a person’s world. Pajares (1992), reviewing the literature, asserted that beliefs are “the best indicators of the decisions individuals make throughout their lives” (p. 307). According to Pajares (1992), the earlier a belief is incorporated into the belief structure, the more difficult it is to alter this belief because these beliefs subsequently affect perception and strongly influence the processing of new information. Thus, according to Pajares (1992), it is for this reason that newly acquired beliefs are most vulnerable. With time and use, they become robust, and individuals hold on to beliefs based on incorrect or incomplete knowledge even after scientifically correct explanations are presented to them.

**Belief vs. Knowledge.** Pajares (1992) explained that beliefs are often disguised behind a variety of aliases, including knowledge, attitudes, values, judgments, opinions, ideology, perceptions, conceptions, conceptual systems, dispositions, implicit theories, explicit theories, internal mental processes, action strategies, rules of practice, and perspectives. Other terms included teaching knowledge (Buchmann, 1987), personal practical knowledge (Clandinin, 1985), implicit theories (Clark, 1988), teacher personal perspective (Clark & Peterson, 1986), personal theories (Cole, 1990), personal practical theories (Cornett, Yeotis, & Terwillinger, 1990), practical knowledge (Elbaz, 1983), professional perspectives (Goodman, 1988), personal knowledge (Kagan, 1992), craft knowledge (Leinhardt, 1990), theory of action/espoused theory (Marland & Osborne, 1990), professional orientation or orientations to teaching (Porter & Freeman, 1986), and teaching perspectives (Zeichner & Tabachnick, 1985). While beliefs are the focus of this study, the use of knowledge in relation to beliefs is examined.

The wide variation in the use of the terms knowledge and belief is indicative of a general state of confusion about these constructs within science education (Southerland, Sinatra, & Matthews, 2001a). Alexander and Dochy (1995) concurred, saying that “explicit definitions or
explanations of these terms are rarely offered” and that “it is unclear where the boundaries of these two fundamental concepts lie” (p. 414). In teacher research, knowledge and belief can be very difficult to distinguish because one teacher’s knowledge (non-emotional, empirically-derived, based on outside research and personal data) can appear to be largely equivalent to another teacher’s belief (emotionally laden, subjectively-derived, based on significant teaching episodes) (Southerland, Sinatra, & Matthews, 2001b). Cobern (2000) argued that for most people, including scientists, knowledge implies certainty and is something that one knows (for good reasons) to be true, and belief on the other hand implies uncertainty. In essence, knowledge is based on objective fact and belief is based on evaluation and judgment (Pajares, 1992).

According to Alexander and Dochy (1995):

> Both knowledge and beliefs were seen as arising from experience, whereas beliefs were seen as emanating from school or formal experience. That is, knowledge was described as factual or objective information that comes about as a result of formal learning, and beliefs were seen as subjective, idiosyncratic, personal, and involving feelings (p. 334).

Nespor (1987) noted that there were four features that can be used to distinguish beliefs from knowledge, and these features include: (1) existential presumption, (2) alternativity, (3) affective and evaluate loading, and (4) episodic structure. Existential presumption asserts the existence or nonexistence of entities, such as teachers’ beliefs in the causes of attainment of children as being the result of characteristics of ability or maturity. Alternativity is associated with incorporating a view of an ideal or alternative state that contrasts with reality and provides a means for summarizing goals and paths. Beliefs involving affective and evaluative loading are associated with strong feelings about what children ought to learn. Episodic structure is associated with particular, well-remembered events. In summary, literature reviews and analyses contributed to a
consensus that beliefs are psychological constructions that (a) include understandings, assumptions, images, or propositions that are felt to be true (Kagan, 1992; Richardson, 1996); (b) drive a person’s actions and support decisions and judgments (Goodenough, 1963; Pajares, 1992); (c) have highly variable and uncertain linkages to personal, episodic, and emotional experiences (Nespor, 1987); and (d) although undeniably related to knowledge, differ from knowledge in that beliefs do not require a condition of truth (Dewey, 1933; Richardson, 1996).

In the science education community, there is also discord among those attempting to distinguish beliefs and knowledge. Southerland et al (2001a) suggested that many educational researchers see knowledge and beliefs as overlapping because they both arise from experiences. However, Southerland et al (2001a) also saw knowledge as emanating from more formal, school-based experiences and beliefs emanating from everyday experiences. Oliver and Koballa (1992) indicated that beliefs are oftentimes equated with knowledge, attitudes, and personal convictions, or reflect a person’s acceptance or rejection of a proposition. Cobern (2000) argued that constructivist science educators maintained that knowledge and belief are inextricably intertwined and that “for all practical purposes belief and knowledge both represent what one has reason to believe is true or valid” (p. 235). However, as a group, science educators tend to view knowledge as “evidential, dynamic, emotionally-neutral” in contrast to belief which is described as “both evidential and non-evidential, static, emotionally-bound” (Gess-Newsome 1999, p. 55). According to Southerland et al (2001a), knowledge is “understood to be based on an assessment of evidence (in the case of scientific knowledge, the evidence would be judged using scientific epistemic criteria), whereas belief does not have the same empirical requirement” (pp. 337–338). Therefore, for the purposes of this study, the researcher defined knowledge as separate from, but related to beliefs.
Definition of Teacher Belief. According to Kagan (1992), “teacher belief is a particularly provocative form of personal knowledge that is generally defined as pre- or inservice teachers’ implicit assumptions about students, learning, classrooms, and the subject matter to be taught” (pp. 65 – 66). Pajares (1992) defined teacher belief as “teachers’ attitudes about education- about schooling, teaching, learning, and students” (p. 314). In a review of the literature, Calderhead (1996) identified five areas in which teachers have been found to hold significant beliefs. These areas included: (1) beliefs about learners and learning, (2) beliefs about teaching, (3) beliefs about subject, (4) beliefs about learning to teach, and (5) beliefs about self and the teaching role. As defined by Calderhead (1996), beliefs about learners and learning can be understood as the assumptions teachers make about their students and how their students learn. It is Calderhead’s (1996) view that teachers’ beliefs about learners and learning influence how they approach learning tasks and how they react with their students. Beliefs about teaching, from Calderhead’s (1996) perspective, were defined as beliefs about the nature and purposes of teaching. For instance, some teachers may view teaching as a process of knowledge transmission whereas other teachers may view teaching as a process of guiding children’s learning. Beliefs about subject encompass the range of beliefs concerning epistemological issues such as what the subject is about, what it means to know the subject, or what it means to be able to carry out tasks effectively within the subject domain. According to Calderhead (1996), beliefs about learning to teach can be defined as teachers’ beliefs about their own professional development and how one learns to teach. For instance, Calderhead (1988) argued that many experienced teachers believe that they learn from their own experiences in the classroom and that teaching is the result of personality and managerial tactics that can be learned from observing other teachers. Beliefs about self and the teaching role include requiring teachers to use their personality in order to
project themselves in particular roles so that relationships can be established within the classroom. This leads to maintaining the interests of the children and a productive working environment. In essence, according to Calderhead (1996) “the teacher relies on his personality and his abilities to form personal relationships in order to manage the class and ensure its smooth running” (p. 720). Research on teacher beliefs broadly includes studies in all areas of education. Several researchers (Bybee, 1993a; Cuban, 1990; Haney, Czerniak, & Lumpe, 1996; Tobin, Tippins, & Gallard, 1994) supported the notion that teacher beliefs are precursors to change and that the teacher is the crucial change agent in paving the way to reform. In this study, the researcher focused primarily on science teachers’ beliefs as a construct for understanding why and how they incorporated socioscientific issues-based lessons in their classrooms.

Research in science education demonstrated that teachers’ beliefs and experiences strongly influence their science teaching and the implementation of alternative forms of practice (Bryan & Abell, 1999; Gess-Newsome, 1999; Luft, 1999, 2001; Simmons et al., 1999; Tobin & LaMaster, 1995; Tobin & McRobbie, 1996; Yerrick et al., 1997). More specifically, the ways in which science teachers think about their practice and about student learning are more closely linked to their belief systems rather than to new curriculum mandates (Yerrick et al, 1997).

Researcher’s Use and Working Definition of Teacher Belief. The definitions, characterizations, and assumptions of scholars about teacher beliefs theoretically informed the present study in a way that these were elaborated by the secondary chemistry teachers through their discourses. In this study, there was no category coding protocol used to distinguish beliefs from other constructs. This is because according to Kagan (1992), “Beliefs cannot be inferred directly from teacher behavior, because teachers can follow similar practices for very different reasons. Moreover, much of what teachers know or believe about their craft is tacit” (p. 66).
Thus, in the present study, beliefs were primarily inferred from the available data, which included the secondary chemistry teachers’ thinking, understanding, and ideas about the subject matter they expressed. Their expressions were assumed to have been drawn from their personal, social, and academic experiences. In the present study, the terms beliefs and knowledge were not used synonymously, but were recognized by the researcher as closely related constructs. The researcher treated beliefs as the secondary chemistry teachers’ premises and propositions about socioscientific issues resulting from personal experiences that were mostly emotionally-laden. The researcher treated knowledge as the factual information that comes about as a result of the secondary chemistry teachers’ formal learning (Alexander & Dochy, 2005; Southerland et al, 2001a). However, this stance does not intend to place belief as a more inferior construct than knowledge. Instead, the above characterization of belief provided clarity for the present study, and aligned with the theoretical notions of Southerland et al (2001a) and Gess-Newsome (1999) in noting the use of the term in the field of science education.

Teacher belief provided a framework because the researcher used it as a lens in order to examine the secondary chemistry teachers’ personal, emotionally-laden perspectives, such as their skills, habits, and values, with regards to incorporating socioscientific issues-based lessons. Data from this study was best analyzed in light of the body of existing research knowledge related to teacher beliefs.

**Situated Learning**

Situated learning, or situated cognition, is a theoretical framework that focuses on the nature of knowing and learning. It emphasizes the situatedness of learners in specific environments (Barab & Plucker, 2002; Cobb & Bowers, 1999; Greeno, 1998; Lave & Wenger, 1991). Situated learning addresses the notion that many processes interact to produce learning
According to Druckman and Bjork (1994), what is learned is heavily dependent on the social situation in which the learning occurs. Brown, Collins, and Duguid (1989) added, “The activity in which knowledge is developed and deployed…is not separable from or ancillary to learning and cognition. Nor is it neutral. Rather, it is an integral part of what is learned” (p. 32). This framework has become useful for designing learning interventions (Tinker & Krajcik, 2001), investigating educational environments (Cobb, Stephan, McClain & Gravemeijer, 2001), and theorizing about the improvement of teaching and learning (Barab, Barnett & Squire, 2002).

Situated learning builds on Vygotsky’s (1962) theory of social development, which suggests that learning is a function of the activity, context, and culture in which it occurs (Greeno, 1998; Lave & Wenger, 1991). According to Anderson, Reder, and Simon (1996), situated learning theory has an emphasis on the mismatch between typical school situations and real world situations.

Some researchers (Aikenhead, 2006; Tal & Kedmi, 2006) have suggested that classroom instruction in science should move away from strictly content-based and value-free instruction and toward a sociocultural approach where students are active participants in decision-making processes. Sadler and Zeidler (2005) maintained that school science should be situated in contexts that support social negotiation of contemporary issues and development of competencies and practices that afford active and socially responsible civic engagement. Socioscientific issues-based instruction offers learning contexts that include both conceptual connections to science and ill-structured and compelling problems that engage learners in discussion, critical thinking, and decision-making (Klosterman & Sadler, 2010). According to Schunk (2008), “the instructional implication is that teaching methods should reflect the outcomes we desire in our learners. If we are trying to teach them inquiry skills, the instruction
must incorporate inquiry activities. The method and the content must be properly situated” (p. 240).

Situated learning provided a framework for the present study in that it was used as a way to examine the teaching methods of secondary chemistry teachers who planned and enacted socioscientific issues-based lessons. This theoretical underpinning helped the researcher focus on the actions of these teachers as they situated their lessons in the context of contemporary issues related to the subject matter of chemistry.

**Schwab’s Notion of Curriculum**

Joseph J. Schwab studied physics in his undergraduate years at the University of Chicago and earned a Ph.D. in genetics under Sewell Wright, a population geneticist. Early on in his career, his interest in science education was evident as he held a position as a postdoctorate at Teachers College in New York (Rudolph, 2002). According to Rudolph (2002), Schwab shared a lot of the same beliefs as John Dewey. Both appreciated and strongly advocated a central role for science in society. In fact, Schwab believed that the active process of inquiry was central to science. Secondly, in their educational recommendations, both Dewey and Schwab placed a distinct emphasis on process over content. Thirdly, both sought to convey to students an understanding of traditional science. Like Dewey, Schwab (1962) rejected traditional science teaching because he felt that it resulted in “a rhetoric of conclusions” and imposed “a false impression of literal and irrevocable truth” (p. 25). Schwab (1958) explained that scientific conclusions “are unintelligible or misleading unless they are known in the context of inquiry which structured and bounded the matters to which they refer” (p. 375).

In 1957, the Russians launched the Sputnik satellite, which among other advances, helped to spur the growth of scientific discovery around the world. Schwab (1962) noted that as a result
of this event, science underwent a lot of growth and development in the United States while it appeared that science education began to take the opposite path. Accordingly, Schwab made an appeal to scientists and to science educators to address the growing schism in the way science was being done and the way schools were teaching science. Schwab (1962) proposed that in order to fill this widening gap between science and science education, that “science be taught as science” in what he termed “science as a product of fluid enquiry” (p. 4). Schwab (1960) stated, “We are asked to discover, select, motivate, and launch an increasingly large group of fluid inquirers and original engineers and to help develop a non-science public which understands the nature and consequence of the work these scientists do” (p. 184). According to Rudolph (2002), Schwab did not expect that through classroom activities students would learn the skills necessary to pursue real scientific work themselves; instead, the primary goal was to convey to students the nature of science.

It was Schwab’s belief that the inquiry classroom was characterized by two components: materials and discussion. According to Schwab (1960), together these two components allowed for a “secondary inquiry” or “an inquiry into inquiries” (p. 188). He felt that materials should consist of reports, problems, data, and the interpretive processes by which conclusions were reached. Schwab also felt that materials should include contrasts in order to widen the scope for secondary inquiry. These contrasts could include alternative formulations of problems, alternative experimental patterns, and debates about assumptions, principles, and interpretations. Schwab (1960) believed that these materials provided the basis for secondary inquiry.

Schwab also advocated the use of discussion in science classrooms. He defined discussion as “an engagement in and a practice of the activities of thought and communication” (Schwab, 1954, p. 51). According to Schwab (1960), discussion was concerned with the
“elucidation, the understanding, and the attempt at critical evaluation of the materials at hand” (p. 188). He also felt that the questions that came about through discussion should center on the actions, judgments, and decisions of the scientists which the book or lecture described (Schwab, 1960). Thus, Schwab felt that including discussion in lessons is what every good teacher did if he or she was given the appropriate climate in which to function and if he or she was given a curriculum that allowed for discussion. According to Schwab (1954), this type of curriculum would include problems to be solved, instances that would allow for deliberation on policy and action, and occasions for apprehension of works of art. He explained that a teacher should value and utilize discussion because:

He wants something more for his students than the capacity to give back to him a report of what he himself has said. He wants them to possess a knowledge or a skill in the same way that he possesses it, as a part of his best-beloved self. He does not want his teaching to be mere phonography, although the administrative structure of education often prevents his being more. He wants to convey not merely what he knows but how he knows it and how he values it. He wants to communicate some of the fire he feels, some of the Eros he possesses, for a valued object (Schwab, 1954, p. 65).

Schwab saw discussion as having three functions in the classrooms. He called these three functions the substantive, the exemplary, and the stimulative functions. He felt that these three functions served as three criteria by which teachers could judge the efficacy of a proposed plan or query. The criteria included: (1) whether discussion is an efficient means of arriving at a specific, planned goal; (2) whether discussion is a defensible instance of movement toward that kind of understanding; and (3) whether discussion would cause interests in students that would encourage them to act or move (Schwab, 1954). As a result, these criteria taken together,
“represent the three conjoint categories of the aims of liberal education: knowledge, power, and affection” (Schwab, 1954, p. 67).

With the changes that science had been undergoing, Joseph Schwab felt that science curriculum needed to be revised. He termed this “translation into curriculum” (Schwab, 1973). Schwab (1983) defined curriculum as:

What is successfully conveyed to differing degrees to different students, by committed teachers using appropriate materials and actions, of legitimated bodies of knowledge, skill, taste, and propensity to act and react, which are chosen for instruction after serious reflection and communal decision by representatives of those involved in the teaching of a specified group of students who are known to the decisionmakers (p. 240).

Schwab believed that theories of curriculum and of teaching and learning could not by themselves effectively communicate answers to the questions of what and how to teach. This was because, according to Schwab (1971b), these questions arose in concrete situations that were influenced by time, place, person, and circumstance. Therefore, Schwab (1983) argued that “what should be taught, how teaching should run, who is available to do it, which students most need the change in question, are each matters requiring their own expertise or experience” (p. 244).

Within his work, Schwab (1971a) stressed the importance of the planned and the enacted curriculum. He defined the planned curriculum as “planned learning experiences” that consist of “what is intended, and usually has to do with the formal schooling that goes on in the classrooms- with subject matter, or with the sequence of desired outcomes” (p. 11). He defined the enacted curriculum as “what actually happens” or the “formal content of instruction of what goes on in classrooms” (p. 11). Schwab (1971a) believed these components were important in
curriculum design because they promoted three outcomes: knowledge (facts, ideas), skills (induction, deduction, physical skills); and attitudes (values, feelings, sensitivities). This was important because Schwab (1978) proposed five core curriculum goals. These included:

1. An educated person must be able to think and write clearly and effectively.
2. An educated person should have a critical appreciation of the ways in which we gain and apply knowledge and understanding of society and of ourselves. Specifically, he or she should have an informed acquaintance with... the concepts and analytic techniques of modern social science; with philosophical analysis, especially as it relates to the moral dilemmas of modern men and women.
3. An educated American, in the last third of this century, cannot be provincial in the sense of being ignorant of other cultures and other times. It is no longer possible to conduct our lives without reference to the wider world within which we live. A crucial difference between the educated and the uneducated is the extent to which one’s life experience is viewed in wider contexts.
4. An educated person is expected to have some understanding of, and experience in thinking about, moral and ethical problems. It may well be that the most significant quality in educated persons is the informed judgment which enables them to make discriminating moral choices.
5. Finally, an educated individual should have achieved depth in some field of knowledge (pp. 4-5).

Thus, it was important to have the planned and enacted curriculum so that these goals could be carried out.
Schwab felt that five agents were necessary in order for curriculum revision to occur. These five agents included: (1) subject matter; (2) learners; (3) the milieu; (4) teachers; and (5) curriculum making. Subject matter consisted of having some familiarity with the scholarly materials under treatment and with the discipline from which they come. Learners consisted of individuals familiar with the children who are to be the beneficiaries of the curricular operation. According to Schwab (1973), those individuals should possess certain characteristics. These characteristics included having general knowledge of the age groups of students who would be affected by this curriculum. This general knowledge consisted of: (1) what the students already know; (2) what the students are ready to learn; (3) the level of ease or difficulty of the curriculum for the students; (4) the aspirations and anxieties that may affect learning; and (5) what will appear to the child as contributing to an immediate desire or need. In other words, this general knowledge included intimate knowledge of the children under consideration and this could only come by having direct involvement with the students. Milieu refers to community. It encompasses such things as family, the community, and the particular groupings of religious, class, or ethnic genus. It also includes, according to Schwab (1973), “what aspirations, styles of life, attitudes toward education, and ethical standards characterize these parents and, through their roles as parents, affect the children” (p. 503). For Schwab (1973) teachers were an important component to curriculum revision. In identifying teachers ready to revise curriculum, Schwab felt that it was important to understand what teachers know and how flexible and likely they are to learn new materials and new ways of teaching. Schwab also felt that it was important to know something of their backgrounds, such as what biases the teachers bring with them and what political affiliations they advocate. Schwab (1973) described curriculum-making, the final agent for curriculum revision, as the process in which “each representative of a body of
experience must discover the experience of the others and the relevance of these radically different experiences to curriculum making for a partial coalescence of these bodies of experience to occur” (p. 504).

In summary, Schwab (1960) believed that a curriculum that presented science as a static body of knowledge, regardless of how accurate and up to date, contributed to “a climate of opinion inimical to science” (p. 185). With science now being at the forefront of growth in the United States due to competition with other countries, Schwab felt that it was essential for the public to be aware of the conditions and character of scientific inquiry. Schwab (1962) believed it was important for the public to understand “the anxieties and disappointments that attend it, and which is, therefore, prepared to give science the continuing support which it requires” (p. 18). Schwab (1962) asserted, “Bringing the public to this enlightened view- developing a public which can support science- constitutes the main burden of the secondary school” (p. 44).

One implication of Schwab’s notion of curriculum for this study is that he provided an alternative way of teaching science, which primarily involves discussion. Schwab’s alternative view stands in stark contrast to views which maintain that science should be taught as a content-driven subject where topics are to be memorized. Another implication of Schwab’s work for the present study is his ideas of the planned and enacted curriculum. Schwab’s notion of the planned and enacted curriculum promoted knowledge, skills, and attitudes, which are also intended goals of socioscientific issues-based lessons. The implications of the planned and enacted curriculum informed this study by providing a lens through which the researcher could examine these different components in the secondary chemistry teachers’ curriculum design.
Epistemology of Constructionism

According to Crotty (2003), epistemology is a way of understanding and explaining how we know what we know. The epistemological commitments that influenced what the researcher brings to this study are grounded in constructionism. Constructionism is the view that truth or meaning, comes into existence in and out of our engagement with the realities in our world. It is the view that “all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context” (Crotty, 2003, p. 42). Philosophers Heidegger (1977) and Merleau-Ponty (1962) argued that meaning resides in individuals’ interactions with the world. More specifically, Crotty (2003) emphasized that constructionism claims that meanings are constructed by human beings as they engage with the world they are interpreting. According to Floridi (2011), constructionism is the belief that “We do not and cannot gain knowledge by passively recording reality in declarative sentences, as if we were baskets ready to be filled. Instead, we must handle it interactively” (p. 291). Floridi (2011) emphasized that from the constructionist point of view, knowledge is a modeling process and it shapes and edits reality in order to make it intelligible. Crotty (2003) noted that there are no true or valid interpretations. Instead, there are useful interpretations, liberating forms of interpretations, fulfilling interpretations, and rewarding interpretations and these types of interpretations stand over against interpretations that appear to serve no useful purpose.

Harris (2010) highlighted two categories for constructionism: interpretive social constructionism (ISC) and objective social constructionism (OSC). Interpretive constructionists believe that researchers ought to study the meanings people live by and how those meanings are created. On the other hand, objective constructionists believe that researchers should create “real
things” as opposed to “meanings” (Harris, 2010, p. 5). This study drew upon the ideas of interpretive social constructionism.

Interpretive social constructionism (ISC) is the idea that “the meaning of things is not inherent” (Harris, 2010, p. 2). This assumption draws upon the works of Herbert Blumer (1969) and his thoughts on symbolic interactionism in which he argues that meanings are created, learned, used, and revised in social interaction and that all objects derive their meaning from the purposes and perspectives that people bring to them. Thus, according to Harris (2010), ISC analyses tend to assume or argue that social phenomena are interpreted entities whose existence and qualities are dependent in large part on people’s meaning-making practices. In essence, “Human beings are construction workers in the sense that they create (or assemble, build, manufacture) meaning” (Harris, 2010, p. 4). Berger and Luckmann (1966) emphasized that interpretive constructionists are not concerned with discovering what things mean in order to dispel myths or correct misunderstandings. Instead, according to Schutz (1964) they try to suspend belief and disbelief in reality. Garfinkel (1967) noted that this is in order to examine how meaning and reality are produced by and for members of various social settings.

Constructionism theoretically informed this study by providing a framework to explain the nature of secondary chemistry teachers’ mental construction of their beliefs about the use of socioscientific issues in their teaching of chemistry. This allowed the researcher to interpret the inservice chemistry teachers’ beliefs.

**Summary of the Chapter**

This chapter discussed the literature and theoretical underpinnings that informed the present study. The review of literature focused on two areas of scholarship: socioscientific issues in secondary school settings and socioscientific reasoning. The literature review helped the
researcher in identifying the gaps that provided an opportunity to design this study. The second part of the chapter discussed the different theoretical perspectives that informed the study. They included teacher beliefs, situated learning, and Schwab’s notion of curriculum. The epistemology of constructionism was also used as a framework for this study. The next chapter discusses the methodological framework that guided the researcher’s study in the collection and interpretation of data.
CHAPTER 3

METHODOLOGY

Introduction

According to Crotty (2003), the methodology of a study elaborates the plan of action, process, or design that informs the methods chosen. The researcher believed that a plan of action was necessary in order to answer the questions raised in this research. This study attempted to answer the following research questions:

1) Why do chemistry teachers use SSI in their teaching?

2) How do chemistry teachers’ use of SSI reflect their underlying beliefs about:
   a. Nature of science?
   b. Chemistry?
   c. Chemistry teaching?
   d. Chemistry learning?

3) How do chemistry teachers plan for and enact socioscientific issues-based lessons in a secondary chemistry classroom?
   a. To what extent do chemistry teachers foster socioscientific reasoning in their lessons?

Therefore, this chapter provides a detailed description of the methodology employed in this study. More specifically, this chapter discusses the context of the study, the sample/participant selection, the participants of the study, the methodology employed, the methods, including data collection and analysis techniques, the procedures followed, viability and trustworthiness, methodological limitations, ethical considerations, risks, and benefits. Each section includes a
detailed elaboration of the process, context, and persons involved. Pseudonyms of persons or places were used in the following discussion so as to keep with the ethical standard of protecting the identities of research participants and locations.

**Context of the Study**

**Research Sites**

This study took place in two research sites: Eastern High School and Clearview High School, title I schools that are located in Georgia. The U.S. Department of Education (2011) website states that title I schools are funded by the Elementary and Secondary Education Act (ESEA) and are provided with financial assistance due to high numbers or percentages of children from low-income families. This funding is to help ensure that all children meet challenging state academic standards.

Eastern High School is a public school with approximately 1600 students. According to the Georgia Department of Education’s (2011) report, student ethnicity is broken down as follows: approximately 67% of students are classified as White (not Hispanic), approximately 15% of students are classified as Black (not Hispanic), approximately 10% of students are classified as Hispanic, approximately 8% of students are classified as Asian/Pacific Islander, and less than 1% of students are classified as American Indian/Alaskan native. With respect to student subgroups, 38% of students are classified as economically disadvantaged, 12% of students are classified as having disabilities, and 4% of students are classified as having limited English proficiency. Also according to the Georgia Department of Education’s (2011) report, Eastern High School has a student-to-teacher ratio of 15-to-1. The average teaching experience is 11 years with 35% of all teachers at the school holding at least a Bachelor’s Degree, 51% of all teachers holding a Master’s Degree, 12% of all teachers possessing a Specialist’s Degree, and
less than 1% of the teaching population having a Doctorate Degree. During the 2010-2011 school year, Eastern High School did not meet Adequate Yearly Progress (AYP) goals and had a graduation rate of 75.4%.

Clearview High School is also a public school with approximately 1400 students. According to the Georgia Department of Education’s (2011) report, student ethnicity is broken down as follows: approximately 53% of students are classified as White (not Hispanic), approximately 42% of students are classified as Black (not Hispanic), approximately 3% of students are classified as Hispanic, approximately 2% of students are classified as Asian/Pacific Islander, and less than 1% of students are classified as American Indian/Alaskan native. With regards to student subgroups, 43% of students are classified as economically disadvantaged, 13% of students are classified as having disabilities, and 1% of students are classified as having limited English proficiency. Also according to the Georgia Department of Education’s (2011) report, Clearview High School has a student-to-teacher ratio of 16-to-1. The average teaching experience is 12 years with 38% of all teachers at the school holding at least a Bachelor’s Degree, 52% of all teachers holding a Master’s Degree, 7% of all teachers possessing a Specialist’s Degree, and 3% of the teaching population having a Doctorate Degree. Clearview High School also did not meet Adequate Yearly Progress goals and had a graduation rate of 71.9% during the 2010-2011 school.

**Instructional Contexts**

Two types of chemistry courses were observed during this study: Honors Chemistry and Conceptual Chemistry. Honors Chemistry was observed at Eastern High School while Conceptual Chemistry was observed at Clearview High School.
According to the course description at Eastern High School, Honors Chemistry is an introductory chemistry class taught mainly to tenth grade students. Only students who take Honors Biology during their ninth grade year are allowed to take this course. Therefore, it is the second course in a sequence of four required science courses for students opting to follow the Honors track at this school. It is considered to be a hands-on, student-centered class that covers science process skills, stresses laboratory safety, and infuses technology into the curriculum. This course also places an emphasis on the relationship between science, the environment, and the everyday world. The units covered in this course include: atomic structure and theory, periodicity and bonding, compounds and reactions, characteristics of states of matter, acid/base chemistry, chemical dynamics and equilibrium, and solutions.

Conceptual Chemistry is a newly developed course at Clearview High School. The class consists of mainly juniors and a few sophomores, and it counts as a physical science credit for all students who elect to take this course. This course explores major topics within chemistry such as atoms, nature of matter, classification of matter, IUPAC nomenclature, chemical equations, radioactivity, Periodic Table, and gas behaviors, as well as the characteristics and nature of science. The course is designed to take a theme-based approach that integrates content with real-world applications. As such, the semester-long course is divided into six themes: (1) Water-Exploring the Issues, (2) Materials- Structure and Uses, (3) Petroleum- Breaking and Making Bonds, (4) Air- Chemistry and Atmosphere, (5) Atoms- Nuclear Interactions, and (6) Food-Matter and Energy for Life. The course is aligned to the Georgia Performance Standards (GPS), which are designed to provide students with the knowledge and skills necessary for proficiency in science. For the Spring 2011 semester, the teachers relied more on the Physical Science Georgia Performance Standards as a basis for teaching the course, whereas during the Fall 2011
semester, the teachers focused on using the Chemistry Georgia Performance Standards as a guide for teaching the course. A Conceptual Chemistry map for how the course was designed during the 2010-2011 school year is included in Appendix D. Ongoing assessment of student progress is accomplished through common departmental unit assessments. Unit post-tests serve as assessments of student learning and consist of a combination of multiple-choice items, essays, short answer items, and performance assessments.

**Sample/Participant Selection**

For this study, the researcher included three secondary chemistry teachers who incorporated socioscientific issues into their curriculum. In order to select the participants, a purposeful sampling approach (Patton, 2002) was employed. In purposeful sampling, which is also called criterion-based selection, the qualitative researcher sets up a list of attributes and characteristics the participants must possess in order to participate in the study (LeCompte & Preissle, 1993). In this study, the criteria included: (1) the participants must be secondary chemistry teachers, (2) the participants must teach on a block schedule, and (3) the participants must be known for their commitment to including socioscientific issues in their teaching of chemistry.

With those criteria in mind, professors and a doctoral student in the science education department of a large Southeastern university were asked to identify potential participants. In this process, a snowball/chain sampling approach (Patton, 2002), which is sometimes called a network selection (LeCompte & Preissle, 1993) was used. In this approach, the researcher initiated the process of selection by asking key informants. These individuals helped the researcher to identify four potential participants.
Next, the potential participants identified by science education professors and a doctoral student were interviewed by the researcher through the use of a questionnaire. The questionnaire is included in Appendix B1. The purpose of the questionnaire was to give the researcher a better understanding of the potential participants’ uses of socioscientific issues in their secondary chemistry classes. After the potential participants answered the questions in the questionnaire, the researcher looked at the responses in order to select the three secondary chemistry teachers who could possibly participate in the study.

**Participants of the Study**

The three participating teachers in this study were Christopher, Shelly, and Linda (all were given pseudonyms for confidentiality). Christopher was in his second year of teaching at Eastern High School. Shelly was in her first year of teaching at Clearview High School. She previously taught for two years at the college level. Linda was the veteran teacher of the group with 11 years of teaching experience. She currently teaches at Clearview High School, where she has worked for the past eight years. Table 3.1 provides background information of the three participants.
<table>
<thead>
<tr>
<th>Ethnicity/Age/Gender</th>
<th>Christopher Kelly</th>
<th>Shelly Thomas</th>
<th>Linda Greene</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Caucasian/28/Male</td>
<td>Caucasian/30/Female</td>
<td>African American/35/Female</td>
</tr>
<tr>
<td>Education</td>
<td>B.S. in Psychology; M.Ed in Secondary Science Education</td>
<td>B.A. in Anthropology and a minor in Military History; MSc in Forensic and Biological Anthropology with a specialty in Human Osteology and Genetic Anthropology; Teaching Certification</td>
<td>B.S. in Biology; M.Ed in Secondary Science Education; Gifted Certification; EdS in Teacher Leadership</td>
</tr>
<tr>
<td>Current Teaching Subject</td>
<td>Honors Chemistry</td>
<td>Conceptual Chemistry</td>
<td>Conceptual Chemistry</td>
</tr>
<tr>
<td>Teaching Experience</td>
<td>2 years (both at Eastern High School)</td>
<td>3 years (2 years as a college instructor and 1 year at Clearview High School)</td>
<td>11 years (3 years in another high school setting and 8 years at Clearview High School)</td>
</tr>
<tr>
<td>Other Work Experience</td>
<td>Sales Representative</td>
<td>Researcher; Lecturer</td>
<td>Researcher</td>
</tr>
</tbody>
</table>

The researcher believed that it was pertinent to hear the participants’ stories of their learning and teaching of chemistry at the onset of the study to get a glimpse as to who they were as chemistry teachers. The researcher felt that the personal experiences of the teachers needed to be considered in order to create a better understanding of them as teachers as well as individuals. Literature in teacher education reported that lifetime experiences influence both teachers’ beliefs about teaching and learning (Pajares, 1992) as well as their professional knowledge construction (Bryan, 2003; Bryan & Abell, 1999). In this chapter, narratives are used to more fully introduce the three participants. The stories that follow address how the participating teachers became
science teachers and the experiences they had in relation to learning and teaching science. The narratives also revealed each teacher’s view of science teaching.

The following stories were constructed in light of Polkinghorne’s (1995) notion of narrative analysis in which researchers synthesize and organize the data elements into a coherent account. According to Kramp (2004), it is important to hear participants’ voices. Thus, the researcher decided to use the participants’ words as they were. In this way, all of the words in the stories came directly from the teachers’ voices through the interviews, even though they may not have told the stories in the same order. On some occasions, the researcher added some words for readability and coherence because spoken language is different from written language. In these cases, the researcher bracketed her words. All italicized words, except for the bracketed ones, come directly from the participants.

Christopher’s Story

I started off, in terms of college-wise, I wanted to go into the pharmacy field. [However], I kind of felt like I was underserved in terms of my science background from high school. When I got to [name of university] and started on that track, especially in the biology area, I really kind of noticed that I wasn’t where I needed to be compared to a lot of the other people coming in. So the pharmacy thing didn’t quite work out because of that. At that point I was just like, you know, alright, I gotta do something to get out of college and get my degree and all that, so I ended up with a psychology degree from [name of university]. It’s one of those things where everybody talks about the only thing you can do with a psychology degree is get a job or go to grad school and so I used it. I didn’t really want to do the psychology in terms of a grad school student point, but I knew that it had applications to so many different things, so I started working sales and realized that quickly that just wasn’t my thing. Sales just wasn’t it.
They [psychology courses] were interesting, to say the least, because you learn a lot about, you know, read me and figure me out and those kinds of things. And it’s not all about that but it’s just learning how peoples’ thought processes kind of come about. I took learning psychology [and] social psychology, and so you get the social norms and what people do and a situation where certain social norms apply but maybe someone is not doing that. You study just a bunch of different things and you get into the anatomy, the human anatomy aspect and how that contributes to psychology. So, they [psychology classes] were interesting. I learned a lot of stuff. You know, it’s not necessarily I can walk up and just okay, you know, I know everything about you, but [it’s] how to handle people in terms of customer service and handling students and parents and those kinds of things. It really does pay dividends on that.

I had a bunch of friends that were teachers and they were really enjoying it. The only thing that really held me back from teaching from before was honestly the concept of pay. They [teachers] don’t make that much, and that’s what most undergrads do coming in. I want the job that pays the most money right now and you don’t really think about happiness, and so I’ve looked at my friend’s parents who were both teachers. They taught, both of them, for 30 years, just retired and in terms of money, first of all, they made it work. It’s not like they were living in shacks or something somewhere. They live in a really nice house. They just bought their daughter a Lexus after she graduated from grad school. It’s not all about material things but at the same time if I want those things later on, if I do things the right way, I can get what I want out of this.

In terms of why did I go into the master’s program, it was one of those things where in order to get certified to teach, you know, you have the [name of program] program, I think it’s called, and then there’s a different one, I can’t remember what the other one is. But there are
two different alternative certification programs. It was one of those things where you could get in to it, but you really don’t have a support system right after the bat. That was the other problem. Because my bachelor’s was in something else. I could have jumped straight into psychology. I couldn’t jump straight into teaching science. So, while I was doing my Master’s I was actually getting certified at the same time. Even if I could get the certification done, start teaching, and then for some reason I did not like it or whatever, I could just stop in the master’s program and all that. But it turns out that I really enjoyed it and that wasn’t the issue. It was also one of those things that I knew that if I was going to make this a career and be able to support family those kinds of things that the Master’s is kind of a no brainer. You know, you do the program, you become a better teacher in my opinion, and you make more money just for doing it. It was a no brainer at that point. So that’s kind of what led me to go into the master’s program here [at the name of university], kind of blindly. I mean I started off with a Master’s before I even knew whether or not I wanted to teach. It was a big gamble but it was worth it in the end. So that kind of put me to where I am today. I started teaching.

I didn’t have a problem with that [taking extra science courses to get certified to teach science]. I needed them. I honestly [did] because when you go through it [the courses] the first time, your mindset, whenever you are sitting in a class, is how is this going to be useful to me? This is true for high school students, anybody that takes any kind of class. What am I going to get out of this? When I was going through the classes the first time, I’m like, I want to be a pharmacist. That’s what I’m getting out of it. So, you’re taking the mindset, I need to learn this to learn this to apply it to be a pharmacist. You’re not taking the mindset I need to learn this so I can teach somebody this. And so by going with that different mindset and taking those additional classes, I went in there with, okay, I’m going to have to teach someone. This is why I need to
know this. This is what I need to learn. You actually, with the pressure of knowing that you have to teach somebody else how to do it, you learn more by doing that.

I would honestly define it [socioscientific issue] as a logical tie in between science and basically politics where it comes down to a certain extent. It’s usually there’s some kind of political issue that someone that is trying to accomplish and then there’s the science behind it. So, it’s the matter of taking those two things and tying them together. You get into situations like Libya and you’ve got all the fighting over there, and so you have the politics behind it, but then you have the science of okay, you’ve got oil, and then it gets into our foreign dependence and those kinds of things. But, yeah, I mean, that’s the basics of it. That’s how I would define it. How I use it, I try to make them see the political issues inside it and make them care. Not make them, but try to help them learn the scientific concepts behind it and usually they make the connections on their own. Then we try to get into, okay, now that we’ve got these two connections made, what can we do about it?

You know, you see right now all of these countries in North Africa uprising. People think, okay what does this have to do with me? My goal in anything is to make them [the students] realize, maybe they’re not fighting over here but this affects this, which affects this, which affects this, and that’s why you pay more to fill up your car at the pump right now. And so, that honestly leads into the question, okay, well, what can we do to relieve our dependence on that situation where a fight thousands of miles away isn’t going to affect our gas prices here and our economy? Then we start discussing those kinds of things. It’s naïve for people out there to think that we should, by throwing math and science down the throat all of the time, that we’re going to end up with tons and tons more mathematicians, and engineers, and all that. The idea is that it should be around and that by viewing this, perhaps, you will motivate more kids to go into these
areas that may not have otherwise. But you can’t expect every single student across the board to be interested in every single aspect of every single math and science ed. field. To be quite frank about it, you can’t expect them all to be 100% good at it. There’s a reason why we have people that are better at some things than others. If everybody could do every single thing out there, then we would all be professional athletes, we would all be doctors, and we would all be lawyers. That’s just not the way it is unfortunately.

**Shelly’s Story**

I have an undergraduate degree in anthropology with a minor in military history. I have a master’s in forensics and biological anthropology and a master’s in genetic anthropology. Most of mine [college courses] were social science perhaps but I had, let’s see I had my general biology in college, chemistry 101 and 102, organic [chemistry], 2 forms of organic [chemistry], osteology, biology, [and] human anatomy. I worked for four years abroad in [the name of the university]. I was doing post graduate research where I got my master’s and I was researching gypsy ancestry through mitochondrial DNA analysis and cultural anthropology forensics. I fell in it [this major] through the backdoor because my master’s research for my forensics degree was looking at the DNA stability of the Y chromosome of ancient remains through mass graves. So I actually worked with the cemetery outside of [the name of the location in England] and started teaching at the university, lecturing in osteology and forensic anthropology.

I was originally going to be a medic in the army, but I had a car accident and I couldn’t get into med school because I had limited use of my left hand. So I had to come up with plan B, and my father was a policeman, so I had been in forensics for all of my life. I used to hang out at the police station so I can work a sketch book very well. He showed me how to do fingerprint analysis with superglue by the time I was twelve. I just kind of fell into it.
[With regards to the accident] I was very young and in college. My senior year, I had gone to [name of state] because I had an interview with a potential grad school that I was applying to get in and they were interested in the work that I had been doing during my undergrad. So I and a bunch of my friends decided to make the road trip and drive all the way to [name of city] for this interview. On the way back I was on the phone talking and speeding, not seeing. Even though I was an excellent driver, I thought I was at the time, I didn’t have the maturity or let’s just be honest, it’s hard to talk, concentrate, drive, and people being in the car at the same time. The car in front of me on the interstate slammed on brakes because something was in the road. So I slammed on brakes and tried to get out of the way. Unfortunately when you’re driving an SUV, that does not always happen. When it did, my car started to flip and as it flipped, it flipped me half way out. I was wearing my seatbelt and have always been wearing my seatbelt. Not only do I wear my seatbelt, but everybody in my car wears their seatbelt. But my seatbelt actually broke off. It broke off from the car, and I had the sunroof open and it threw me out of the sunroof. I had reached over to grab to make sure that the person in the front seat, a friend of mind, he stayed in. If I had not have done that I probably wouldn’t have been here today because it didn’t throw me as far. Specifically, my entire left side, my hand was actually ripped off of my body. I crushed both of my knees. I broke my right ribs. I was cut up from head to toe. I had a bad concussion. I remember every single moment of it. There was not really a moment that I don’t remember. So they said I blacked out from about the time we landed finally. Just literally, we were in the middle of the road and we actually needed to get off the road so no other cars could hit us. It was in [name of state], and I was in [name of town], which is smaller than [name of small town in the county where she currently resides]. They had one ambulance that was on another call. So it took them almost 45 minutes to get us, and we were on the major,
major interstate. So, luckily I had four other people in the car with me. They all got out of the car with just minor scrapes and bruises. So I got the worst of it, which if you are driving, I’m glad I was the one hurt because I don’t think I could live with myself if somebody else was hurt in my car. So they finally pulled me out of the car and I was missing most of my left hand, my left knee was shattered completely. I kept going in and out. They had to put a tourniquet on, and I had severed both veins and arteries so I was bleeding out profusely. When you sever a vein that bad, if you sever a vein and an artery, you’ve got two different flows of blood coming out. So by the time they finally got me to the hospital, luckily for me, two people that stopped behind me, one was a nurse and one was actually a medic on his way back to [name of army base], who just actually happened to be in the same unit that my dad was in. So I had known him all my life, and he happened to be two cars behind me. So they put a tourniquet on and saved as much of my hand as they could. They finally came and got me, took me to the hospital where when as soon as they unwrapped my hand, the nurse passed out. She had never seen anything this bad. They then had to airlift me to [name of city] because that hospital didn’t have a trauma center. They [the hospital] take care of births, colds, and flu, and they had never had a traffic accident come through there, major traffic accident come through here, so we made the front page of the newspaper. When I got there, they had every intention of completely amputating my left hand, literally my left arm up to my elbow. What actually happened was when the car flipped, it took most of my fingers. It was literally like they took a peeler and unpeeled it and they shoved it right back into my arm. So they were able to pull my fingers out of my arm. Unfortunately, I had lost all of the bones. I was actually there, because I hated to fly, so I was actually on the helicopter counting the bones that I was missing. I was still awake enough to tell the nurse, I’m missing this bone, this bone, this bone, this bone, you’re never going to find them so you need to do this, this,
and this. They managed to save my hand as much of it as possible. They reconstructed it later. I spent almost 2 ½ months in the hospital. Everything here is completely reconstructed. There are no bones in my hand. There is plastic and metal in my hand. I have maybe one or two filanges left. These are all my bones [points to areas on left hand], the only ones they were able to pull out of my arm. The rest of it is, all of this is skin or tissue transplanted from other parts of my body. My left knee is like a bionic knee. It’s got pieces of bone. It’s got plastic. So that’s why I can no longer run like I used to. I still do not like to drive to this day. I hate driving long distances. As much as I hate flying, I’d rather fly. I hated, hated, hated working a crime scene where there was a car accident. It took me a long time to get back into a car. I still, my hand, still hurts to this day. So you’ll see me some days in class doing this right here [rubs her left hand] because it is aching, especially when it’s going to rain. I was 22 when this happened. I had to literally quit school for about 3 to 6 months while I went into rehab. I had to completely learn how to rewrite because I was left-handed. I had to learn how to write with my right hand. They told me I would never play the piano again. Unfortunately, I can’t. I can play with my right hand. They said I would never learn the guitar. I would never be able to play the guitar again. I had to learn how to play it left-handed, like switch it around. They said I would never swim again because they had to take multiple muscles out of my back to replace my hand muscles. Then what made it really bad was I was in a hospital in [name of city] and caught a very bad staph infection from the fact that I had pieces of the road still inside of my arm. Even to this day, like for instance, a couple of weeks ago, my hand was itching. Now I thought I was going to win some money, but that’s why I don’t play the lottery, but it turns out a piece of glass was still making its way out of my hand. They said that would happen through the years. It’s now been 8 years this November. It can happen in the blink of an eye. We were laughing and joking and
going down the road. We had had a great time in [name of city]. I had an awesome interview. I had everything set to start grad school literally that fall, the next fall. I was going to med school. I was going to be an army medic. I had every intention of going into the military. The army said since I couldn’t hold a gun and couldn’t pass the PT test, I couldn’t get into med school. I couldn’t hold an instrument, so you do what you have to do. I completely refugured my life and went into a direction I never thought I’d go into it and love it. I’m here now. I was very, very fortunate that nobody else in that car was severely hurt. I don’t know how I could have lived with myself. I was 22. I had everything looking out for me. I thought I was invincible. I was not. It took a long time, it really took a long time. Now I’m used to it. I’ll joke around and call it “the hook”. My brother gave it that name.

I fell into that too [becoming a chemistry teacher]. I moved back to the states after my dad got sick and I was supposed to have a job with the GBI, but it was the lab in [name of city], the one they closed. So I got and lost a job within about 36 hours. So there wasn’t a lot of forensics jobs going in this area and I really wanted to stay with this area while my dad was sick, so I thought, well I had taught while I was abroad, why not get my teaching certificate. It’s a good idea. It’s stable until the economy gets better. I have a double certification. So I am broad-field history and broad-field science. So right now I am actually teaching two different chemistry courses and a US History class at the same time. I’m a little behind in my grading. My room is a little bit of a mess. I don’t sleep very well, but it’s been an adventure. I will definitely say that much. But I have a conceptual chemistry class, which is mostly a trial and error class because most people teach it as just the chemistry portion of physical science, but I’m trying to tweak it and actually teach it as just a maybe lower level general chemistry class, which is what we really
hope to eventually be the standard for next year. And then I have my general class, my general chemistry, which is old school chemistry.

My main goal last semester was getting through last semester. I had never taught chemistry in my life. I had not had chemistry since I was in undergrad. So I mean I used it obviously with my genetics research, and I taught students in the lab how to do, but it was mostly practical, you know, this is how you do this. If you’re extracting this, this is how you do the extraction. It wasn’t so much the knowledge behind it as opposed to step-by-step, and we do this, and the results, and blah, blah, blah. So I was literally learning it the night before I taught it. So my main goal was to one, get through [and] two, yes I wanted a lot of students to pass because even the people say, well it doesn’t really matter, it doesn’t mean you aren’t a good teacher if kids don’t pass. But, if 90 percent of your class fails, something is wrong somewhere. Now, granted it could be that 90 percent of the kids aren’t turning in their work. Now this semester, I’m just trying to make it through three preps. The same goals still apply. Still, I want them to actually learn even if they come out of this only remembering one key thing. That’s one more thing than they learned before and you never know five years down the line, it could be that make or break question for them. That’s kind of my goals.

I would define it [a socioscientific issue] as no definition at all. At least not one that is black and white. I would define a socioscientific topic as open to interpretation depending on the interpreter’s view and background and really what’s happening in the world at that time. I was very lucky to come in from a researcher’s point of view, having been a researcher for so many years and knowing that depending on what happens today in the lab, it can totally change. And [as] I told them from the first day, is if nothing, what I do [is] just to give you an example. The first day of class, all of my classes, science and chemistry classes, I give them a lateral thinking
quiz and they are riddles like “If you’re in a house with all windows facing south and a bear walks by, what color is the bear”? And they [the students] are all like, Are you serious? Things like that, just so that they start to think that what they’re so used to being memorizing, because that’s not necessarily the case and they have to start thinking outside the box or realizing that there’s other ways to look at something because for instance, the old adage of is a zebra a white horse with black stripes or a black horse with white stripes, it’s all in your interpretation of the data. So for socioscience, I would say there is no solid definition. It’s all bound to the interpretation of the researcher.

Linda’s Story

I got my undergraduate degree in Biology from [name of university] in 1998. Well, coming out of high school, that [biology] was just the one area I was interested in. It was actually my high school biology teacher. She asked me to tutor somebody and at first, I was just like, why do you want me to tutor somebody? I don’t want to tutor anybody. She asked me to tutor this girl that was in my class who was having trouble, and she just wanted me, she was like, use this as an opportunity to make sure you understand. And it just turned out that that’s all I did. I would just tutor her. I tutored her the entire year. But, she just kind of opened up for me a little bit, you know.

All before, I would just take a class and do well in the class. I was like, okay, I’m going to take this class and make a good grade and that’s what you do. You make A’s. Then I was just like, “Wow, I actually understand this and it makes sense.” And so, when I took my other science courses, like chemistry and anatomy, and the little bit of time I spent in physics when I realized that it wasn’t really a science course. That’s a math class. Well it really is. As I tell my students, it’s a math class in the science department. But, it was just like, I just saw it differently and all of
the other courses, I wasn’t interested in history or English and math, no! Definitely not interested in math. So, it was just a natural fit. It was just like, I’ll major in Biology and I was headed on the path to research. That’s what I did every summer in college. I would go somewhere and do, you know, have an internship, until I had to do it for real. It’s fine to do it over the summer because you can, you know 8 weeks, you know you work with something, you write a little paper, you do a presentation at the end, you get a certificate, and then you go back to school.

Well, let’s see, [I took classes in] zoology, microbiology, cell biology, botany. Those types of classes [are classes that were taken in undergraduate studies]. I mean everything that I could take I did take. I took so many courses that the spring quarter, yes this is how long it’s been, we were on the quarter system. The spring quarter, I had too many hours for [name of scholarship], because I was also, my sophomore year, I decided that I thought I wanted to be an athletic trainer. So I took classes in athletic training. I went through that whole process. I was a trainer my junior and senior year. Then I realized quickly that it was not a career path I wanted to take. So, yeah, I had so many hours that they were like, you should have graduated. So, yeah, I didn’t get [name of scholarship] the spring quarter of my senior year.

After I graduated, in Spring 1998, and it wasn’t until Fall 1999 that I came to [name of university]. I worked for a company called [name of company]. I had to travel between [name of small town] and [name of another small town] to the chicken processing plant. I tested the chickens for salmonella. That was my job. I couldn’t talk to the people at the plants because I was separate from quality control from the plant and [another major division in the company]. I was part of an independent company, and so I’m by myself and having to go in, and I would have to alternate working day and night shift. So, I was just like, this is great. Well, no it wasn’t great.
I stayed in a hotel. I had to stay in the hotel because I wasn’t driving from [small town] to [another small town]. Do you know where [small town] is? It’s on the eastern part of [name of state] near [name of another town]. So, I’m going to [name of small town] and [name of another small town] and I’m staying in hotels. You know, they pay for the hotels, they pay mileage, they pay food, and then they pay your salary. So I was like, this is wonderful at first, and then it was like, no this isn’t.

I remember looking back on a paper I wrote in high school. One of those what do you want to do. I was like, I want to be a teacher. I was just like, I like teaching. I like explaining stuff. I worked with my cousin. She ran a little after-school program at one of the churches in [name of town] and I would go and I would be their science person. So I would find little activities to do with the students, and so I would go in and do that. I was just like, maybe I should just go into education and everybody was like, “No, don’t do that. Don’t do that. Don’t waste your time. Don’t be a teacher. You’re wasting your time.” And I was like, that’s what I really want to do. So, I came and as they say, the rest is history. Eleven years later, here I am.

I came here the fall of 1999 getting my Master’s in Science Education. I was part of the last group that could do broad-field, so I’m actually, I came out broad-field certified. So, I didn’t concentrate on Biology or Chemistry or anything like that. I did broad-field certification, and I just stayed here in [name of city] and I ended up teaching in [name of town] for three years. I taught Biology, Physical Science, and then I came here. I came here Fall of 2004. So I’ve been in [name of town] since the Fall of 2004. Let’s see, I’ve taught Biology, Physical Science, and Chemistry in all of the levels of chemistry, [including] AP, advanced, [and] conceptual.

When I came here, I was talking to the department chair at the time and I was just like, “You know it would be great one day to teach chemistry, but I’ll wait my time. I’ll wait my time.”
There was somebody here that taught chemistry, and at that time he was the only teacher and they [the school where she currently teaches] only had two sections of the class. So, it’s hard to believe they [the school where she currently teaches] only had two sections of the class, so I was like I’ll wait my time. One of the former APs [assistant principals] came up to me as we were getting ready to get out for Christmas, and said, “You will be teaching chemistry when we come back.” And I was like, “What chemistry? Like the class?” And she said, “Yes.” And I was like, “Okay. Really? Like when we come back? When we come back I’m teaching chemistry?” And she was like, “Yes, you’re teaching chemistry.” I was like, “Wow, okay.” And that is how it happened. So now, we [the school where she teaches] have, in essence, we have 6 sections this semester and we will have, let’s see, I have 3, [name of another teacher] has 1, and another teacher, so we’ll have 5 sections. So we’ll have 11 sections for the entire year when we started out with 2 sections when I first came here.

[With regards to my first time teaching chemistry], I ran back to [name of former school where she taught for 3 years] and went to my mentor that I had when I first started teaching, and she was a chemistry teacher. And I was like, “They’re having me teach chemistry and they’re telling me I will teach it when we come back after Christmas.” She gave me some stuff to get started and she told me, she said, “Just follow the book. Don’t worry about it. Just follow the book. Do chapter 1, do chapter 2. Don’t worry about trying to put this stuff together. Just follow the book.” That’s what I did. I followed the book, and the retired chemistry teacher from this school brought me like a truckload of stuff, and it was just like overwhelming. I was like, “I don’t know what to do with all of this stuff. I don’t know what half of this stuff means.”. Yeah, it was 11th and 12th graders [students in her classes when she first started teaching chemistry] then. It was just like, “Wow!” I said, “I guess one day, I’ll get better”. That’s how it started. You know,
I was like, “Yes, that would be nice to teach chemistry. I’ve done Physical Science and I like it. Maybe a little chemistry.” I’ve always told them there’s no way I’ll do physics. There’s absolutely no way!” I wanted the challenge of it [chemistry]. Biology is, I’m not trying to be mean, I mean I did major in Biology, but Biology is vocabulary. If they know the vocabulary, then they’re okay. That’s kind of it. You can get them on their task with just vocabulary, but chemistry, the whole, to me at the time, it was a brand new world. I would always go to my mentor and be like, “What are you doing? What is that? How do you work this problem? How do you do this? How do you do that?” And it was just like, “Oh man, I wouldn’t mind teaching this class.” So that was easy. I just thought that I would always take that next progression except physics.

Actually, now I wouldn’t mind doing an elective but we don’t really have that many. [Name of another teacher] is doing [teaching] Forensic Science. I don’t think I’d want to teach environmental only because of the way they make that class. You end up getting a lot of behavior issues and stuff. We do have Zoology so that might be interesting. I remember taking that in college and it was like, eww, when you had to go through with the dissections and stuff. Really, this is a baby shark, for real? But, what else do we have? We have several electives that are in our course offerings so if we ever get to that point, since you know we [the school] have the 4 sciences they [the students] have to take. According to the state, they have to take Biology and they have to take a Physical Science course. And then the other two science courses could be anything. But I seem to be stuck with Chemistry, especially now. I’ve been gifted certified for about 7 years now, and since I’m gifted certified, I kind of get stuck with it.

How would I would describe a socioscientific issue? It’s something that deals with society, definitely.
Methodology

The overall methodological framework that was used for this study was interpretive research. According to Erickson (1986), interpretive research is the name given to a family of approaches that includes ethnographic, qualitative, participant observational, case study, phenomenological, symbolic interactionist, and constructivist research. Klein & Myers (1999) stated that the foundational assumption for interpretive research is that knowledge is gained, or at least filtered, through social constructions such as language, consciousness, and shared meanings. In addition to the emphasis on the socially constructed nature of reality, interpretive research acknowledges the intimate relationship between the researcher and what is being explored, and the situational constraints shaping this process. Gallagher (1991) argued, “The researcher’s intention is to learn about the teacher’s knowledge, values, and beliefs as they are and not to influence teachers by his or her actions” (p. 11).

Methods

Within the overall framework of interpretive research, this study drew upon the use of qualitative case study methods. A qualitative design was appropriate for this study because according to Patton (2002), it allowed the researcher to answer “questions about people’s experiences” and to “inquire into the meanings people make of their experiences” (p. 33). Thus, with a wealth of detailed data, the researcher was able to investigate teachers’ sense-making in great depth. Case study research involves the study of an issue or phenomena explored through one or more cases within a bounded system. More specifically, in a case study, the researcher explores the bounded system through detailed, in-depth data collection involving multiple sources of information (Creswell, 2007). Huberman and Miles (1994) defined a case study as:
A phenomenon of some sort occurring in a bounded context - the unit of analysis in effect. Normally there is a focus of attention and a more or less vaguely defined temporal, social, and/or physical boundary involved. Foci and boundaries can be defined by social unit size (an individual, a role, a small group, an organization, community, nation), by spatial location, or temporally (an episode, an event, a day). Cases may have subcases embedded within them (p. 440).

In this study, the unit of analysis was the individual. Three secondary chemistry teachers who incorporated socioscientific issues in their teaching practices participated in the study making this a multiple case study. Patton (2002) stated that the purpose of a case study is “to gather comprehensive, systematic, and in-depth information about each case of interest” (p. 447) and that a case study illustrates “the value of detailed, descriptive data in deepening our understanding of individual variation” (p. 16). According to Spillane and Zeuli (1999), in-depth case studies of classrooms play an important role in developing an “understanding of patterns of practice in classrooms” (p. 20). The researcher believed these statements accurately described the study of three chemistry teachers because each participant, as a case, was a rich exemplar for an in-depth exploration of their sense-making of their instructional practices and their students’ learning of the subject matter. Mayer (1999) argued that “Much of what the country currently knows about the instructional process comes from in-depth studies done in only a handful of classrooms” (p. 30). Since multiple cases were used in this study, the researcher provided a detailed description of each case and themes within the case, which is called a within-case analysis. Then, the researcher provided a thematic analysis across the cases, which is called a cross-case analysis. The researcher also provided assertions or interpretations of the meanings of the cases (Creswell, 2007).
Data Collection

According to Creswell (2007), “The data collection in case study research is typically extensive, drawing on multiple sources of information, such as observations, interviews, documents, and audiovisual materials” (p. 75). For example, Yin (2009) recommended six types of information to collect: documents, archival records, interviews, direct observations, participant-observations, and physical artifacts. For this study, the data collection methods employed included in-depth interviews, direct observations, documents, and archival records. Table 2 is a data matrix that indicates how the data collected related to each research question in this study.

Table 3.2: Data Matrix

<table>
<thead>
<tr>
<th>Research Question</th>
<th>In-Depth Interviews</th>
<th>Direct Observation Field Notes</th>
<th>Documents</th>
<th>Archival Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why do chemistry teachers use SSI in their teaching?</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. How do chemistry teachers’ use of SSI reflect their underlying beliefs about:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Nature of science?</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>b. Chemistry?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Chemistry teaching?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Chemistry learning?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. How do chemistry teachers plan for and enact socioscientific issues-based</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>lessons in a secondary chemistry classroom?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. To what extent do chemistry teachers foster socioscientific reasoning in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>these lessons?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**In-depth Interviews.** Seidman (2006) wrote that “At the root of in-depth interviewing is an interest in understanding the lived experience of other people and the meaning they make of that experience” (p. 9). This was important because “interviewing provides access to the context of people’s behavior and thereby provides a way for researchers to understand the meaning of the behavior” (Seidman, 2006, p. 10). More specifically, in this study, the researcher employed semi-structured interviews. Pre-established questions as well as follow-up questions and probes were used in order to clarify responses and obtain additional information from the participants in the study. According to Creswell (2007), it is important to design and use an interview protocol and to include questions that are a narrowing of the central question and subquestions in the research study. The interview protocols are included in Appendix B. During each interview, the researcher took notes when appropriate and audiotaped and transcribed them in full. The types of interviews conducted with each teacher were initial interview, pre-interview, post-interview, and final interview.

**Initial interview.** At the beginning of the study, the researcher conducted an initial interview with each participant. The purpose of the initial interview was to obtain background information about each chemistry teacher. In addition, this interview was used to understand each participant’s perspective about student learning in general, student learning in chemistry, and their experiences of examining their own teaching practices and student learning. The responses from this interview were used to construct narratives that introduced the participants in this study. The initial interview questions are provided in Appendix B2.

**Pre-Interview.** The researcher conducted a pre-interview with each participant before observation of each lesson or unit that included the use of socioscientific issues. Because the number of lessons or unit which included socioscientific issues varied per participant, the
number of pre-interviews also varied. During these interviews, the researcher asked the teachers to specify the learning goals of the lesson or unit to be observed. According to Hiebert, Morris, Berk, and Jansen (2007), a precise and explicit learning goal is a necessary condition in order to know “what counts as evidence of students’ learning, how students’ learning can be linked to particular instructional activities, and how to revise instruction to facilitate students’ learning more effectively in future lessons” (p. 51). The pre-interview questions are provided in Appendix B3.

**Post-Interview.** The researcher conducted a post-interview with each participant following the observation of each lesson or unit that included the use of socioscientific issues. Because the number of lessons or unit which included socioscientific issues varied per participant, the number of post-interviews also varied. During these interviews, the researcher asked the participants about the teachable moments in the lesson, their awareness of students’ learning, and any challenges that they may have encountered. Thus, the post-interviews were based on the secondary chemistry teachers’ retrospective views of their lessons. The post-interview questions are provided in Appendix B4.

**Final interview.** At the end of the study, the researcher conducted a final interview with each participant. The purpose of the final interview was to provide questions that allowed the participants to reflect on their experiences of planning for and enacting socioscientific issues in their chemistry classes. The questions also allowed the secondary chemistry teachers to discuss their awareness of students’ learning during the implementation of socioscientific issues and their future intended instructional uses of socioscientific issues. The final interview questions are shown in Appendix B5.
**Direct Observation Field Notes.** The purpose of classroom observations was to see how the secondary chemistry teachers approached socioscientific issues, how their beliefs were reflected through their actions in the classroom, and how they encouraged students to engage in the issues, including socioscientific reasoning. Each direct observation lasted the entire class period. The number of direct observations varied for each participant, depending on the quantity of lessons that the participants taught that included socioscientific issues. This is because two of the participants incorporated socioscientific issues on a per unit (thematic) basis while the other participant planned to incorporate socioscientific issues on a per-lesson basis. All direct observations were written as field notes in a designated notebook. Bogdan and Biklen (2007) argued that observation notes are necessary because they provide an account of what the researcher actually saw, heard, experienced, and thought in the course of collecting or reflecting on the data. Therefore, field notes were used to help the researcher examine the patterns of thinking and beliefs of the secondary chemistry teachers with regards to how they planned for and enacted socioscientific issues. Although field notes were taken during the times of observations, the researcher also wrote up extended field notes as soon as possible after each classroom observation. According to Esterberg (2002), extended field notes are the “most complete descriptions of what occurred during the period of observation” (p. 74).

**Documents.** Throughout this study, the researcher collected various documents, such as worksheets from the lessons and any reading materials that the teachers presented to their students as assignments. These documents were analyzed to shed light on how secondary chemistry teachers planned for and enacted socioscientific reasoning.

**Archival Records.** Although considered to be secondary data sources, archival records, such as email communication, were used in this study. The purpose of gathering all email
communications between the participants and the researcher was especially important in the instances where the participants incorporated socioscientific issues on a per-lesson basis.

Therefore, the purpose of email communication was to schedule dates for observations and to schedule dates for initial and final interviews.

**Logistics, Timeline, and Procedures Related to Data Collection.** Data was collected during the Fall 2010, Spring 2011, and Fall 2011 semesters. The overall procedures of the data collection are depicted in Table 3.3.

**Phases.** This study took place in four different phases. Table 3.3 gives the names and descriptions of the four phases of this study. Although the table appears in linear form, the phases occurred dialectically as preliminary interpretation of the data occurred after transcriptions.

**Table 3.3: Phases of the Study**

<table>
<thead>
<tr>
<th>Phase Number</th>
<th>Phase Title</th>
<th>Description of Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Pre-Field Work</td>
<td>1. Field and participant selection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. IRB approval</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Design of interview guides</td>
</tr>
<tr>
<td>II</td>
<td>Implementation of the Study- Data Collection</td>
<td>1. Initial interviews (biographical interviews)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Classroom observations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Pre- and Post-Interviews (before and after each lesson/unit taught)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Final Interviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Collection of Documents and Archival Records</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Transcription of audio tapes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Preliminary analysis of data occurred during coding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. Member checking and co-construction of data</td>
</tr>
<tr>
<td>III</td>
<td>Analysis and Interpretation</td>
<td>1. Inductive analysis (2nd level of in-depth analysis)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Interpretive analysis</td>
</tr>
<tr>
<td>IV</td>
<td>Writing It Up-Representation</td>
<td>1. Formal/traditional dissertation format</td>
</tr>
</tbody>
</table>
Logistics. Starting in October 2010, potential participants, nominated by science education professors and doctoral students, were asked to answer questions based on the questionnaire included in Appendix B1. This questionnaire gave the researcher a better understanding of the potential participants’ uses of socioscientific issues in their secondary chemistry classes. After the potential participants answered the questions, the researcher used their responses in order to select the three secondary chemistry teachers who would participate in the study. The participants were then contacted by the researcher to see if they were still willing to participate in the study.

In February 2011, the researcher began to establish interview and observation dates with the participants. The researcher began data collection with the initial interview of the participants. Data collection continued until September 2011. Transcriptions of the interviews and the writing out of extended field notes also took place during this time.

In September 2011, the researcher performed a comprehensive analysis of interview transcripts, extended field notes, documents, and archival records collected during the study. Then, using the codes from the interview transcripts, extended field notes, documents, and archival records, themes were assigned to the research questions.

From October 2011 through November 2011, the researcher engaged in interpretive analysis where the data was interpreted in light of the theoretical framework and salient literature.

Timeline. Table 3.4 is a timeline that provides a synopsis of the logistics which were described.
Table 3.4: **Timeline**

<table>
<thead>
<tr>
<th>Date(s)</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2010</td>
<td>Potential participants were contacted and asked to answer questions in the questionnaire for participant selection.</td>
</tr>
<tr>
<td>November 2010</td>
<td>Participants were selected based upon questionnaire responses.</td>
</tr>
<tr>
<td>February 2011</td>
<td>Interview and observation dates were established with participants.</td>
</tr>
<tr>
<td>February 2011</td>
<td>Data collection begins.</td>
</tr>
<tr>
<td>September 2011</td>
<td>Data collection ends.</td>
</tr>
<tr>
<td>February 2011 – September 2011</td>
<td>All interviews were transcribed. Extended field notes were written. Preliminary analysis of data occurred during coding.</td>
</tr>
<tr>
<td>September 2011</td>
<td>Comprehensive analysis of interview transcripts, extended field notes, documents, and archival records; themes assigned to research questions.</td>
</tr>
<tr>
<td>October 2011 – November 2011</td>
<td>Interpretive analysis of data</td>
</tr>
</tbody>
</table>

**Data Analysis**

According to Schwandt (1997), data analysis is defined as the process of making sense of the data. In this study, data analysis involved making sense of the interview data, direct observations data, document data, and archival records data. The preliminary analysis began while the researcher collected data, transcribed the interviews, and wrote out extended field notes. The preliminary analysis also consisted of looking over the field notes, listening to the audiorecorded interviews, reading the transcripts, and looking over any products handed over by the participants, such as worksheets and reading materials used in the lessons. Comprehensive data analysis occurred in September 2011, after all data had been collected. For the first two research questions, comprehensive data analysis occurred through the use of inductive analysis (Charmaz, 2006). The first two research questions for this study were:

1. Why do chemistry teachers use SSI in their teaching?
2. How do chemistry teachers’ use of SSI reflect their underlying beliefs about:
a. Nature of science?
b. Chemistry?
c. Chemistry teaching?
d. Chemistry learning?

The inductive analysis consisted of line-by-line coding, in-vivo coding, and focused coding. According to Patton (2002), the purpose of inductive analysis is to “discover important patterns, themes, and interrelationships” (p. 41) in order to understand the meanings that exist in the phenomenon being investigated.

As stated above, coding was employed by the researcher in order to gather important information from the interview transcripts, observation notes, and any other documents obtained. In order to carry out this process, the researcher first began with the method of line-by-line coding. In line-by-line coding, each line of written data is named. According to Charmaz (2006), line-by-line coding helps the researcher to remain open to the data being analyzed. Upon completion of the line-by-line coding, in-vivo coding was then used to analyze the data. In this process, the participants’ terms were used as codes. This was necessary because it was important to preserve the meanings attributed by the participants to the actions that they described in their interviews. Lastly, focused coding was employed. In this process, the most significant codes made earlier were used in order to arrange the different codes into meaningful categories and to build a systematic account of what had been observed and recorded (Ezzy, 2002).

After completing the process of putting together codes and categories that comprised each case, the individual cases were analyzed (within-case analysis) and written in the form of narratives where emergent themes were identified that allowed the researcher to make viable interpretations. The process of narrative analysis involves synthesizing the data “into a coherent
developmental account” that represents the experiences of the participants (Polkinghorne, 1995, p.15). In order to represent the thoughts, ideas, and beliefs of participants, narratives were embedded from interview talk.

For the third research question, data analysis occurred through the use of a modified version of Sadler’s (in press) model of assessment of socioscientific reasoning practices. This modified version of Sadler’s (in press) model was used as a heuristic or tool to understand how the secondary chemistry teachers in this study fostered socioscientific reasoning. It is to be noted that the researcher was in no way using this model as an evaluative measure of the participants’ teaching experiences. Instead, this model was used as a means of categorizing the extent to which socioscientific reasoning was fostered in the chemistry lessons of the participants. In essence, this model was used to describe the participants’ uses of socioscientific reasoning in the planning and enacting of chemistry lessons. The research questions were:

(3) How do chemistry teachers plan for and enact socioscientific issues-based lessons in a secondary chemistry classroom?

(3a) To what extent do chemistry teachers foster socioscientific reasoning in these lessons?

Sadler’s (in press) assessment was chosen because it is a new model that characterizes diversity of socioscientific reasoning practices, and it presented a range of practices observed. The researcher modified Sadler’s (in press) model because his assessment looked at students’ reasoning. In this study, the researcher looked at how teachers fostered opportunities for socioscientific reasoning through their planning and enacting of curriculum. As defined earlier, socioscientific reasoning is a theoretical construct designed to “uniquely capture the array of practices fundamental to the negotiation of SSI” (Sadler, Barab, & Scott, 2007, pp. 377-378).
According to Sadler, Barab, and Scott (2007), socioscientific reasoning consists of four practices that are fundamental in the negotiation of SSI, and these four assumptions include: (1) recognizing the inherent complexity of SSI, (2) examining issues from multiple perspectives, (3) appreciating that SSI are subject to ongoing inquiry, and (4) exhibiting skepticism when presented with potentially biased information. Sadler (in press) defined complexity as a sophisticated conceptualization that recognizes the various interrelationships among issues. The author defines perspectives as students actively seeking to analyze issues by taking into account various viewpoints that may be adopted in response to the issues. According to Sadler (in press), inquiry can be defined as the notion of always having “unanswered questions related to SSI in terms of the underlying science, social implications, or both” (p. 5) and the desire to identify the kinds of investigations needed to answer these open-ended questions. Sadler (in press) defined skepticism as a scientific habit of mind that causes individuals to examine information presented about an SSI from sources with vested interest, especially in the face of potentially biased information. Sadler’s (in press) framework addressed the four components of socioscientific reasoning, and thus the researcher felt that it should be used to analyze the way that secondary chemistry teachers in this study planned for and enacted socioscientific reasoning. The researcher also modified Sadler’s (in press) model and added an additional assessment entitled “Ethics and Morals” in order to reflect Sadler and Zeidler’s (2009) and Zeidler, Sadler, Simmons, and Howe’s (2005) notion that socioscientific reasoning places an additional emphasis on ethics and morals as part of how students learn science. For the purposes of this study, the researcher defined ethics as uniform rules and behavioral standards that inform individuals of what is considered acceptable behavior for the purposes of regulation. Ethics allow for individuals to arrive at decisions by taking into account their background beliefs, conflicting
moral feelings, conflicting thought processes, and professional expectations (Loving, Lowy, & Martin, 2002). The researcher defined *morals* as prescriptive judgments of right and good applied to social situations that reflects an individual’s rules and principles in situations of conflict (Zeidler & Keefer, 2003). Table 3.5 presents Sadler’s (in press) modified framework used in the assessment of socioscientific reasoning. The original version of Sadler’s (in press) model of assessment of socioscientific reasoning is included in Appendix C.

Table 3.5: *Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning*

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perspectives</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
<td>Teacher provides opportunities for students to assess the issue from a single perspective.</td>
<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
<td>Teacher provides opportunities for students to assess the issue from multiple perspectives.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inquiry</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher does not provide opportunities for students to recognize the need for inquiry.</td>
<td>Teacher provides opportunities for students to present vague suggestions for inquiry.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skepticism</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher does not provide opportunities for students to be able to declare differences among stakeholders.</td>
<td>Teacher provides opportunities for students to suggest that differences likely exist among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders and discuss the significance of differences among stakeholders.</td>
<td></td>
</tr>
</tbody>
</table>
Within this portion of the data analysis, an emergent analysis was used. In this process, the researcher employed steps of: (1) coding the data, (2) grouping the codes into categories, and (3) identifying the categories and themes. With regards to coding, line-by-line coding, in-vivo coding, and focused coding were used. The researcher then determined to what extent the themes reflected Sadler’s (in press) modified framework for the assessment of socioscientific reasoning.

After the completion of within-case analysis, the researcher employed a cross-case analysis. The purpose of the cross-case analysis was to look for patterns that cut across individual cases (Merriam, 1998; Patton, 2002). This resulted in a unified description of the cases and the identification of emerging themes, categories, and typologies (Merriam, 1998). Because the third participant in this study did not foster socioscientific reasoning in her lessons, she was considered an outlier in terms of the purposes and goals of this dissertation. Therefore, the third participant was not included in the cross-case analysis. Instead, the researcher only included the first and second participants in the cross-case analysis and showcased the third participant as an anomaly.

**Viability and Trustworthiness**

Multiple data sources can be used to enhance research viability (Mathison, 1988). This study used multiple data sources during the research process. These data sources included in-depth interviews, observations, documents, and archival records. The purpose of having multiple

| Ethics and Morals | Teacher provides no opportunity for students to raise ethical and/or moral issues. | Teacher provides little opportunity for students to consider ethical and/or moral issues. | Teacher provides ways for students to consider ethical and/or moral issues. | Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a way for students to discuss the significance of a moral or ethical stance. |

| conflicting interests. | | | | |
data sources was for data triangulation. According to Janesick (1994), in data triangulation, data is obtained through different research methods and is analyzed for consistency. Marshall and Rossman (2006) added that triangulation enhances a study by bringing together more than one source of evidence to corroborate, elaborate, or illuminate a research question under investigation.

According to Lincoln and Guba (1985), the goal of any qualitative researcher is to convince an audience that the findings of the study can be trusted and are worthy of attention. Multiple strategies were used in order to ensure trustworthiness. These strategies included conducting interviews in which the participants, and not the researcher, were doing the majority of the talking, tape recording all interviews, making verbatim transcripts, expanding fieldnotes as quickly as possible following observations, and member checking. With regards to member checking, participants were given transcripts between interviews to look over and the researcher asked clarification questions within interviews. The researcher also gave participants a copy of the narratives to look over, in order to give them a voice in how they were portrayed in the study. Tobin (2000) argued that member checking is an important part of interpretive research because it allows participants to critique the researcher’s interpretations and thereby provide additional rich layers of informative description.

**Methodological Limitations**

The first methodological limitation to this study could be the variation in the quality and amount of data collected from each participant. This could be due to time constraints placed on the secondary chemistry teachers. For instance, the researcher planned to interview all participants before and after each lesson or unit related to using socioscientific issues that they taught. The researcher realized how difficult this was in some cases due to teachers having other
commitments. Thus, at times, the researcher had to employ another method for interviews, which consisted of emailing the participants a copy of the pre-interview and post-interview questions and having the participants respond to these questions through email. Therefore, this limitation could have affected the study in that some of the responses obtained may not have been as rich or elaborated upon by the participants.

The second methodological limitation dealt with the interview questions. Since each teacher did not use the same topics for the inclusion of socioscientific issues, the interview protocol changed slightly in terms of the pre-interview and post-interview questions due to the researcher having to ask more probing and clarifying questions. However, the researcher believed that this variety was important and that this approach aligned with case-based methodology (Hays, 2004).

**Ethical Considerations**

According to Erickson (1998), “In order to negotiate entry and deal responsibly with the concerns of those who will be studied it is necessary to tell them how we plan to conduct the study so that they can consider and give us advice about what that will mean to them in convenience and in safety” (p. 1160). As such, prior to the study, the participants were made aware of a few things. First, the participants were made aware of the fact that the research was conducted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Science Education. Second, the participants were made aware that the interviews would be audiotaped and that upon the completion of the dissertation, the tapes would be destroyed. Third, the participants were made aware that any field notes, documents, or archival records obtained during the study would be kept strictly confidential and that their purposes were to be used in order to analyze how they planned for and enacted socioscientific issues. Last, the participants
were made aware that they were free to withdraw their participation at any time should they become uncomfortable with the study. After the participants were informed of these factors, they were asked to sign a consent form that signified that they understood what had been discussed with them in light of the research. Appendix A provides a copy of the consent form that was used in this study.

Confidentiality was retained at all times throughout this study. Pseudonyms were given to all participants in order to maintain their anonymity. Only audiotapes were used as the interviews were conducted. All field notes, documents, archival records, audiotapes, and transcribed interviews were placed in a locked filing cabinet. Only the researcher had access to this data. Upon the completion of the research, the documents and archival records will be shredded and the audiotapes will be destroyed.

Risks

No discomforts, stresses, or risks were expected in this study. However, the participants were informed that they could refuse to participate or stop taking part in the research without giving any reason and without penalty or loss of benefits to which they were otherwise entitled. The participants were also made aware that they could ask to have all of the information about themselves returned to them, removed from the research records, or destroyed.

Benefits

The benefits to the participants in this study included allowing them to be able to reflect upon their teaching practices, which is something that teachers do not always have an opportunity to engage in due to time constraints and various tasks placed upon them. The potential benefits to society or humankind included: (1) analyzing the efficacy of an alternative method for teaching high school chemistry, (2) giving science educators an opportunity to
examine the ethical and moral issues involved in teaching controversial topics, and (3) allowing for science educators to examine their own beliefs and how their beliefs influence their thinking about teaching and learning.

Summary of the Chapter

This chapter provided a detailed discussion of how the data was collected in this study. Multiple sources of data were used in order to allow the researcher to make a thick and rich description of the cases, or the individual participants. The data were managed, analyzed, and interpreted following the method of inductive analysis for the first two research questions and emergent analysis for the third research question. These methods of analysis preserved the integrity of the meanings provided by each participant and allowed for interpretation by the researcher that was based primarily on the data obtained. In summary, this chapter provided a description of the context, participants, steps followed, and the specific methods employed in obtaining rich data for each case. In the next chapter, findings resulting from these analysis procedures are presented.
CHAPTER 4
FINDINGS, ANALYSIS, AND INTERPRETATION

Introduction

This chapter is organized to chronicle, through cases, the experiences of the secondary chemistry teachers in their uses of socioscientific issues within the parameters of the three research questions. Narratives were used to organize and represent each case as a coherent whole. Pseudonyms were used to hide the participants’ identities. No real names of places that potentially identified the participants were mentioned in the narratives. However, all of the words in the narratives came directly from the teachers’ voices as reflected through interviews and artifacts, even though they may not have told the stories in the same order. On some occasions, the researcher added some words for readability and coherence because spoken language is different from written language. In these cases, the researcher bracketed her words. All italicized words, except for the bracketed ones, came directly from the participants.

Each case was developed with four parts: (1) a description of the context, (2) a narrative account, (3) a closing narrative, and (4) a summary discussion and preliminary interpretation of themes. The description of the context provides an overview of the chemistry class for each participant. The narrative account is organized into sections, and each section addresses a research question and is supported with texts and descriptions. The order of the three research questions is as follows:

1) Why do chemistry teachers use socioscientific issues in their teaching?

2) How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about:

...
a. Nature of science?
b. Chemistry?
c. Chemistry teaching?
d. Chemistry learning?

3) How do chemistry teachers plan for and enact socioscientific issues-based lessons in a secondary chemistry classroom?

a. To what extent do chemistry teachers foster socioscientific reasoning in these lessons?

The closing narrative describes the plans of the participants in their anticipated use of socioscientific issues in their classes. The summary discussion and preliminary interpretation of themes details the researcher’s synopsis of the major points gleaned from the study. In this section, a table is also included that summarizes the themes that emerged relative to each participant.

The Three Case Narratives

Narrative 1, Christopher Kelly: The Case of Christopher’s Dilemma of Reaching “Gifted Underachievers”

Context of the Honors Chemistry Class. During spring 2011, Christopher Kelly’s Honors Chemistry class consisted of nineteen sophomore students. Christopher stated, “It’s a nice-sized class” (Initial Interview, line 204). However, he felt that the ability level of the students in this class did not represent the academic make-up of an honors class. Christopher explained, “Well, first of all, this is my second year teaching. So I taught an honors class my very first semester teaching and I taught one in the fall and then now one in the spring. So, I’ve had the opportunity to work with, I guess three different groups of honors kids. In terms of this one
right now, I would say in terms of their work ethic and all that, they are probably one of my weaker honors classes that I’ve had of anybody. There are a couple of bright spots here and there. There are ones that still do the work that they’re supposed to do, and they ask the higher order questions and all that. We’ll have some good questions, but a lot of times it’s a struggle to get them to do anything, and that’s just not the way an honors class generally is. You know, we have two different levels of chemistry. We have advanced chemistry, which is regular chemistry, and we have honors chemistry. The advanced kids, you are used to, ‘Okay, why do I have to learn this? I don’t want to do any work.’ You are used to dealing with the students. Usually, in an honors class there’s a break from that. Now, I feel like that I guess maybe with the standards or the lack of standards that we have for honors students, that we are kind of like homogenizing everything and we’re not really getting the true split like we used to have in abilities, and it’s kind of more, just chemistry. It’s not really honors. It’s honors by name, but not really” (Initial Interview, lines 152-167).

Although Christopher believed that the classroom dynamics of his honors chemistry class was weaker than previous sections he had taught, he did not place all of the blame on the students for having lower ability levels. Instead, he attributed a lot of this change in dynamics to parental involvement in pushing children to take the more rigorous classes. He noted, “It used to be that if a kid was going to take honors chemistry, then they had to have an 85 or above in their honors biology class. In order to qualify for honors biology they had to be recommended by the middle school teacher. They had to generally show good math and science skills going through. But now what’s going to happen is that you’ll get parents that will get involved and say I want my kid to take all honors classes” (Initial Interview, lines 171-175).
As Christopher described how his students learned chemistry best, he stated, “I think hands-on helps them to a certain extent. I’m still trying to figure that out to be quite honest with you. There are some of them that it doesn’t really matter how you present it to them. They’re going to soak it up like a sponge. I’m still figuring out kind of the middle 50 percent of the class. I haven’t figured them out yet. I’ve tried some different strategies here and there. So far I’ve learned that they’re not going to learn anything unless they really feel like it. That’s what I’m trying to figure out. How do I motivate these kids that seem to be, there’s the common study concept of gifted underachievers? I feel like I have a handful of those right now. What do you do with those kids?” (Initial Interview, lines 189-196).

Christopher’s dilemma included how to reach and help a group of individuals succeed who had lower ability levels than students in his previous honors chemistry classes. Understanding how these current students learned best was difficult for him, and this caused him to question how to motivate these students. Thus, the next sections discuss Christopher’s beliefs about using socioscientific issues in his teaching of honors chemistry and what the incorporation of SSI looked like in his lessons.

**Narrative Description.** The following sections present narrative descriptions in light of the research questions in the study.

**Why SSI is used in Chemistry Teaching.** Christopher believed that it was important to incorporate socioscientific issues in his teaching of chemistry. This stemmed from personal experiences with his high school teachers as well as his philosophy/goals of teaching.

**Personal Experiences.** Christopher took several science courses while in high school. He stated, “I took your typical physical science, then biology, then chemistry, and I took physics as well” (Initial Interview, lines 67-68). Christopher attributed his love for science to the solid
teaching of some of his high school teachers. He emphasized, “I always felt like some of the teachers I had, my best teachers, would let us kind of figure things out for our own in a good way. You know they would kind of guide us along the way. They would give us different projects that we could work on and see how things work” (Initial Interview, lines 55-57). This love for science continued to grow as Christopher had the opportunity to tutor individuals. He noted, “I always kind of tutored people throughout high school, throughout college, and those kinds of things and you know, I enjoyed doing it” (Initial Interview, lines 47-49).

Taking extra science classes towards his teaching certification helped Christopher to develop an even greater love for science and encouraged him to “soak in” as much material as possible so that he could be an effective teacher to his students. He commented, “And so by going with that different mindset and taking those additional classes, I went in there with, okay, I’m going to have to teach someone. This is why I need to know this. This is what I need to learn. You actually, with the pressure of knowing that you have to teach somebody else how to do it, you learn more by doing that” (Initial Interview, lines 135-138).

However, of all of the science courses he had the opportunity to take and to tutor students in, chemistry was the subject where he excelled the most. He explained, “I knew chemistry is kind of my strong suit in terms of what I would teach” (Initial Interview, line 53). Even in his welcome letter to parents, he mentioned how after spending a year working in sales, he realized that this was not what he wanted to do and that his true interest was in teaching high school chemistry. Christopher’s desire for teaching chemistry was rooted in the fact that he wanted to give his students an opportunity “to learn things a little more in depth” (Initial Interview, lines 54-55) and to “make them think about their world in a different way” (Initial Interview, line 268). This was the type of learning that drew Christopher to chemistry in the first place. The in-
depth teachings of his previous chemistry teachers allowed him to explore more than just basic chemical concepts; instead they enabled him to use the foundational knowledge he received to explore topics in more detail. These teachings allowed him to “examine issues that were occurring in the world and make connections with the content he was learning in order to try to come up with solutions to the issues [he] examined” (Initial Interview, lines 292-294). This was how Christopher felt he was able to comprehend the material, and in turn, this was the experience that he wanted to give his students. For Christopher, this was the basis of what incorporating socioscientific issues was all about. He defined a socioscientific issue as “some kind of political issue that someone is trying to accomplish and then there’s the science behind it. So, it’s the matter of taking those two things and tying them together” (Initial Interview, lines 285-287). Thus, he wanted to make socioscientific issues an integral part of his lessons because of the personal success that he had experienced with learning through the incorporation of socioscientific issues.

Christopher did point to some negative experiences he associated with science teachers. He noted, “Perhaps, not as good teachers, instead of us kind of learning as we went along and figuring things out, if we had a question then even if it was higher order, we were told to kind of, you know, to look it up in the book or maybe find it on this page, and there was no, like, opportunity to do things hands-on” (Initial Interview, lines 57-61). He added, “I felt that the quality of teaching that I had, really in biology because my chemistry and physical science and physics teachers were excellent; I didn’t have any problems with them. It was really just my biology teacher, just to pick on her for a little bit. But, it was an honors biology class, but the way it was structured, you know, we did some dissections but there was no, like you know, why are we learning this kind of thing. It was more of here is some information. Take it. Go with it.
That’s just not how I operate. I want to know: Where is this useful? What is this used for? Why should I know this? Why should I take the time to learn this? Those kinds of things. But I took AP Chemistry as well so we had the offerings there and there were some really good teachers in the building, but I had the unfortunate opportunity to have a bad one or two in there” (Initial Interview, lines 68-77). For Christopher, these experiences with his high school teachers helped him to understand how he learned science best. He explained that he liked to learn through tying societal issues to the content introduced because this helped him to see where the information was actually useful. Therefore, Christopher advocated learning through the use of socioscientific issues because it allowed him to learn material beyond basic concepts and obtain a deeper understanding of how these ideas related to the dilemmas that were occurring in society. Thus, his own learning style has helped him to develop a philosophy with regards to his teaching practices.

Philosophy/Goals about Teaching. Christopher expressed a desire to help students learn and apply science to their everyday lives. He entered into the teaching profession because he wanted to encourage students to engage in science. He explained, “I wanted to give kids the opportunity to learn stuff, you know, a little more in depth” (Initial Interview, lines 54-55). Furthermore, he added, “The main thing that I want to do with the chemistry class, and I do this for my advanced class and my honors, is to make them think about their world in a different way (Initial Interview, lines 347-348). More specifically he stated, “My goal is to get them to think differently about the world. Think about different consequences and things that do happen. You know, when you get in that car, think about how it actually works and what has to work correctly in order to make you get to where you are going” (Final Interview, lines 104-107). Thus
Christopher also believed that it was important to incorporate socioscientific issues so that students could make connections between what was taught and what occurred in their lives.

In summary, two themes emerged as to why Christopher incorporated socioscientific issues into his chemistry lessons. Those themes were: (1) personal experiences as a student where he understood effective learning strategies through witnessing good and bad teaching styles and (2) developing a philosophy/goal of teaching that gave students the opportunity to learn concepts more in depth. In his view, by incorporating socioscientific issues into his lessons, Christopher was providing a way to tackle the dilemma of reaching a group of students who struggled with mastering the honors chemistry content. The inclusion of socioscientific issues in the curriculum, from Christopher’s perspective, was a way for students to take the knowledge that was being presented and apply it to current societal events that occurred both locally and globally.

**SSI’s and Underlying Beliefs about Nature of Science.** Bell (2003) argued that the nature of science can be thought of as “the process of teaching students to think about science” (p. 76). Christopher mentioned that his ultimate goal was to “make them think about their world in a different way” (Initial Interview, line 268). Christopher provided some examples for why he believed that it was important for students to think about their world in a different way. He noted, “For instance, we had snow storms back in January and so okay, they put salt down on the roads. I don’t want a kid just being like, okay they put salt down on the roads. I want them to know why. Think about why. Why do we do some of the things we do? Why does soap work better than just washing your hands with water? You know, those kinds of things. So more of learning about how their natural world works. I’ve got a bunch of students that are interested in cars. Maybe they want to go into being a mechanic or something like that. I try to make them think
about you know, not just thinking about, okay, this car, it costs this much money and looks like this. I want them to think about what goes in to getting them where they live, to where they go to school, to where they work. All the different processes and where all of these things are coming from and maybe what kind of impact it has in terms of getting these raw goods to here and how it might affect this village somewhere and all of that” (Initial Interview, lines 268-279). Thus, Christopher believed that socioscientific issues should be used as a means of making connections and thinking deeply about the events and dilemmas occurring in society.

The assumptions of the nature of science include scientific knowledge being: (1) tentative (subject to change), (2) empirically based (based on and/or derived from observations of the natural world), (3) subjective (theory laden), (4) involved with human inference, imagination, and creativity (involves the invention of explanations), (5) involved with a combination of observations and inferences, and (6) socially and culturally embedded (American Association for the Advancement of Science, 1993; Lederman, 1992; National Research Council, 1996).

According to Lederman (1999), “The assumption is that by students understanding the nature of science, they will become ‘more informed consumers of science, which will empower them to make more informed decisions when scientific claims and data are involved’” (p. 916).

In one of Christopher’s lessons, the topic of discussion was nuclear power plants and the proposal to build a new reactor in a plant that was approximately 100 miles away from Eastern High School (Field Notes, 3/31/11). According to Christopher, the purpose of including this issue was to get the students to think about what the impact of building a nuclear reactor would have on their community. Christopher noted before this lesson that “The point is to keep students updated. Additionally they need to be aware of the local occurrences and policy implications” (Pre-Interview 1, lines 9-10). He stated that his goal for the lesson was for “Students to be
educated on the future of nuclear energy and for students to hopefully form their own opinions on what needs to be done with respect to our energy policy” (Pre-Interview 1, lines 22-26). This lesson occurred a little more than two weeks after an earthquake struck Japan, sparking a major tsunami and causing a meltdown of nuclear power plants. Christopher began this lesson by discussing an article that indicated that radioactive isotopes from the Japanese earthquake had been found in milk in a couple of states in the United States. This was the only article that Christopher relied on to introduce the topic of discussion. Although Christopher never mentioned how he determined whether or not the article was scientifically reliable, the fact that he brought in an outside article as a source of information demonstrated his belief that it was important for students to make informed decisions. It also pointed to the characteristic of nature of science that argues that science is empirically-based. As the class discussed the issue, one student commented, “So because all of this radioactivity is going on in Japan, people are making more of a big deal here.” After further discussion of the proposal to build a nuclear reactor, one student concluded by saying, “I wouldn’t have known about it if you didn’t say something about it” (Field Notes, 3/31/11). Christopher closed the discussion by saying, “You need to start thinking about you because even if it doesn’t affect you now, it could affect you” (Field notes, 3/31/11). This statement demonstrated Christopher’s belief that science is tentative and subjective because he encouraged his students to think about issues and how they currently and could potentially have an effect on them. Thus, this example illustrated Christopher’s belief that it was important to present socioscientific issues in his lessons in a way that emphasized the tenets of the nature of science, particularly the tenuous nature, as well as the importance of making informed decisions about both local and global issues. His lessons were presented in ways that outside sources were
introduced into class discussions as a means for students to grapple with and discuss different dimensions and perspectives of societal issues.

Christopher stayed abreast of current events, as was evident through the various classroom observations. As such, the knowledge that he gained from current events was often shared in his class discussions. The current events presented in class helped the students to understand that chemistry and science are tentative and subjective based on the occurrences in nature. It was Christopher’s belief that it was important for students to know what was going on in the world because they would have to make informed decisions about the events that were occurring. He was serious when he explained, “We’ve got all these things going on in the world right now, and there are decisions that have to be made every single day. If you have a kid that’s sitting there that has no clue about anything going on but yet, they are a registered voter and they are helping to make some of these decisions, that’s bad. We need to have people that can, and I’m not even just talking about science, I’m talking about everything in general, you need to be able to make an informed decision about something. Something that interests you, something that may not interest you but it affects you in some way, you need to be able to look at it and realize what’s going on. How does this affect me? What can we do about it, if anything?” (Initial Interview, lines 241-248). Thus, it was evident from Christopher’s statements that his beliefs aligned with the recommendations of the American Association for the Advancement of Science (1993) and the National Research Council (1996) with respect to the importance of preparing students as informed decision makers and scientifically literate citizens. Christopher believed that it was important for students to understand what was going on in society and to think about how to solve “real-world” issues. This led him to incorporate socioscientific issues into his lessons whenever possible.
In summary, three themes emerged with respect to socioscientific issues and Christopher’s underlying beliefs about the nature of science. These themes were: (1) SSI’s were used as a way to get students to think about science and society more deeply, (2) SSI’s were presented by bringing in outside resources as a means for students to grapple with and discuss the different dimensions of societal issues, and (3) SSI’s were incorporated into lessons to help students become more informed decision makers with regards to coming up with possible solutions to the events occurring in society. Approaching the presentation of socioscientific issues in light of incorporating the tenets of the nature of science was a way for Christopher to tackle the dilemma of reaching students whom he termed “gifted underachievers”.

SSI’s and Underlying Beliefs about Chemistry. According to Holbrook (2005), the subject of chemistry involves “the chemists’ demand for naturalistic explanations supported by empirical evidence and involving observation, rational argument, inference, skepticism, creativity, and the importance of being able to replicate work” (p. 2). From Christopher’s perspective, chemistry is a subject consisting of concepts that students don’t find to be very interesting and oftentimes struggle to understand. He explained, “Well, chemistry itself is not the most interesting topic, so as it is, it’s one of those things where it’s the subject and then there’s the apathy with it” (Post Interview 2, lines 28-29). Because this was the case, Christopher believed that it was particularly important to incorporate socioscientific issues into the study of chemistry. Christopher mentioned, “You have to implement those SSIs in order to do that because if you don’t make it real for them, you don’t relate what they’re learning to something in their real-world, they’re not going to get anything out of it. They’re not going to make any connections” (Initial Interview, lines 348-351). For Christopher, incorporating socioscientific issues into the subject of chemistry was a way to help students build connections with concepts,
which could oftentimes be difficult to grasp, drawing on examples of issues going on in the local and global world.

Because Christopher believed that chemistry was such an abstract subject, he felt that incorporating socioscientific issues into the subject matter was beneficial for his students. He noted, “It allows you to figure things out for your own good in a good way” (Initial Interview, line 56). This belief was what made chemistry such a strong subject for Christopher. Christopher’s previous experiences with the subject matter presented him with many opportunities to figure things out on his own, and this is why he believed he excelled in the subject matter in college. Whereas Christopher was successful in chemistry while in college, he did not feel as competent in other subjects like biology where he noticed that “I wasn’t where I needed to be compared to a lot of the other people” (Initial Interview, lines 39-40) in his college classes. Thus, it was Christopher’s belief that socioscientific issues needed to be included in the context of the subject of chemistry in order for his students to make connections and “figure things out”. In essence, it was Christopher’s belief that incorporating socioscientific issues into his lessons provided students with opportunities to use real-world examples in order to provide naturalistic explanations (Holbrook, 2005).

In summary, two themes emerged connecting socioscientific issues to Christopher’s beliefs about chemistry. These themes were: (1) incorporating socioscientific issues into the subject of chemistry provided opportunities for chemical concepts to be presented in a manner that enabled students to make connections and draw relationships between what was learned and what was occurring in society and (2) incorporating socioscientific issues into the subject of chemistry helped students to make naturalistic explanations. In essence, Christopher believed
that incorporating socioscientific issues into the context of chemistry was an important means of helping his students understand an abstract and content-driven subject.

SSI’s and Underlying Beliefs about Chemistry Teaching. Like all other subjects taught at Eastern High School, Honors Chemistry must be taught according to the standards set forth by the state department of education. With regards to teaching material based on the state standards, Christopher expressed his opinion that, “It’s one of those things where the standards have you teaching this much material. There is room for interpretation in there on how in depth you need to go. A lot of times, if you have a good class, they can actually get the concepts quicker so there’s not much of a balance. Honestly, I had plenty of time this semester and still got through everything that I needed to get through. [I] probably could have gotten through some more stuff. It was a weird semester, but it’s one of those things where I could throw a concept out there, the kids are going to grasp it really quickly, they work on it. There’s only so much you can practice something before it’s a waste of time. That opens up more room for activities” (Final Interview, lines 58-65). For Christopher, a lot of these activities came in the form of class discussions involving socioscientific issues. For instance, in an interview, he stated, “Previous discussions have led to healthy debate, and I hope to continue that” (Pre-Interview 1, lines 17-18).

Christopher also mentioned that he mainly used discussions with his honors chemistry students because his students became actively involved in the lesson. In Christopher’s opinion, using discussions with his honors students garnered more class participation than any other method of teaching because his students stayed abreast with current events. In fact, in several observations, students would often mention the different news articles they read that were related to chemistry. Christopher noted, “I think with me, it really was just having discussions about it and just opening up their thought processes to making it a real-world thing. Different classes are going to
be different personalities. They might handle more activities better than discussions, but this class in particular handled discussions really well, so you could actually make that an entire class period and not really have to do anything else with it and you know to keep the conversation rolling. But that’s with this individual class. If I were to try to do this with one of my other classes, I would probably have to use a different approach. It’s just going to really require a teacher to evaluate what they have, what their students are capable of, and then kind of go from there” (Final Interview, lines 28-35). Even though Christopher used discussions as a means of incorporating socioscientific issues into his lessons, he did note that it was unrealistic to include these types of discussions all of the time in his lessons. He opined, “I don’t have a problem putting things aside to a certain extent but at the same time, I would like to keep my job. So if I’m not teaching what the state says we have to teach, then I’m not doing my job as defined by them. I probably should be fired if I had a discussion about stuff every single day and didn’t teach anything that we’re supposed to” (Initial Interview, lines 365-369). It was evident that Christopher believed that socioscientific issues should be a part of chemistry teaching; however, he emphasized the need for a balance in terms of standards-based and socioscientific issues-based chemistry teaching. He emphasized, “I think if you go through and you’re just teaching what’s on the standards and you don’t teach anything else, you don’t talk about anything else, and you don’t make it relevant, then you are just going to have a bunch of kids that can recite standards and tell you the bare bones of stuff, and they cannot apply anything” (Final Interview, lines 99-102).

One of the challenges that Christopher faced with incorporating socioscientific issues in his lessons was getting the topics to align with the chemistry standards. In discussing this challenge, Christopher explained, “The first thing is that a lot of the socioscientific issues center
around things that are beyond the scope and the level of this class. A lot of times you have to kind of identify the issue and then simplify it and also relate it to what you guys are doing. It could be that something also comes up that doesn’t relate at all to what you’re doing and so sometimes it’s just to kind of keep continuity in there, find a spin in there to make it tie into it. Sometimes, it’s like, we were here, but now we are going in this direction for a couple of days, and all that, so those are some of the challenges there. There’s the age-old challenge of the curriculum and standards. I have to teach this and I’ve got this much time to do it. Sometimes it is challenging to kind of incorporate those kinds of things in there” (Final Interview, lines 40-48). Thus, although Christopher believed that it was important to incorporate socioscientific issues in his teaching of chemistry, he also struggled with legitimately presenting some of these issues because of what he perceived as a lack of continuity with the state standards.

In summary, three themes emerged with regards to socioscientific issues and Christopher’s underlying beliefs about chemistry teaching. These themes were: (1) SSI’s were primarily addressed through discussion rather than through active engagement in investigations, (2) what makes an authentic SSI seemed to be determined primarily by the teacher, and (3) the perception of what is required with respect to standards constrained the extent to which the SSI was built upon in his lessons.

SSI’s and Underlying Beliefs about Chemistry Learning. According to Anderson and Krathwohl (2001) and Bransford, Brown, and Cocking (2000), meaningful learning takes place when students remember, make sense of, and are able to apply what they have learned. Minzes, Wandersee, and Novak (2000) added that meaningful learning occurs when students “seek to relate new concepts and propositions to relevant existing concepts and propositions in their cognitive structure” (p. 3). Thus, meaningful learning is an active, constructive, and cumulative
process where students seek to make sense of their experiences (Shuell, 1990). Jonassen (1999) added that learning is meaningful, better understood, and more likely to transfer to new situations when it occurs by engaging real-life, complex problems.

**Making Connections.** For Christopher, the purpose of using socioscientific issues in his lessons was to help students make connections between chemistry concepts and the issues that occurred both locally and globally. In light of the relationship between socioscientific issues and chemistry learning, Christopher explained his goal as trying to “help them learn the scientific concepts behind it and usually they make the connections on their own. Then we try to get into, okay, now that we’ve got these two connections made, what can we do about it?” (Initial Interview, lines 292-294). He emphasized, “It’s important for them to see both the problems and examine solutions, but they need to be able to do it in a way that doesn’t violate ethical problems” (Initial Interview, lines 314-315).

In an initial interview with Christopher, he mentioned several examples throughout the semester where students made connections between chemistry concepts and the local and global world. One example included a discussion of computer chips in cell phones and the corresponding effects on mining operations in foreign countries. Discussing this example, Christopher explained, “I would say a common thing right now, you know [are] our cell phones. They’ve got computer chips in them that I think have a substance called coltan or something. While it helps us do our work better and you know we communicate better, there are villages that are in constant struggles with people coming in and mining their areas and they’re losing their land. People are dying to get a hold of that land that has that coltan on it. Those kinds of things are you know, while it’s good for us, it’s gotta be a different way that we can go about solving that same problem that doesn’t necessarily cause people to have those kinds of issues” (Initial
Interview, lines 301-307). In the example of nuclear power and alternative energy sources mentioned earlier, Christopher related, “We get into nuclear power and those kinds of things. It’s like, okay, well, yes, nuclear power is great because all of the release into the atmosphere is water vapor instead of carbon dioxide and those kinds of things. But then we deal with, okay, what do you do with the spent fuel rods, you know? You’ve got some companies that are like, alright, well, let’s just go ahead and bury this somewhere and not tell anybody about it. So, yeah, we solved one problem but we created another one” (Initial Interview, lines 307-312). In another example of an SSI-based lesson, Christopher discussed his use of the 2010 Deep Water Horizon Oil Spill as a context for helping students understand the concept of polarity of oil with respect to water. In yet another example, students performed a lab entitled “Identification of Anions and Cations in Solutions.” After completing this lab, students discussed the significance of performing tests for ions in water in terms of water quality, noting that pollution could be identified from these tests. Students were then challenged to think of ways to reduce water contamination (Field Notes, 5/4/11). In all of these examples, Christopher encouraged students to come up with solutions that would have positive effects on the environment instead of creating additional problems. He stressed the role of ethics in chemistry learning, emphasizing that “ethics really comes into play there in that you want to solve problems that you have, but you want to do so in a way that it doesn’t cause other problems later” (Initial Interview, lines 312-314). The four examples mentioned above are related to chemistry learning because they demonstrated instances when Christopher helped students to make sense of and apply the concepts that they were learning to local and global issues. These examples demonstrated how Christopher used real-life, local and global socioscientific issues as a means for helping students to make sense of their experiences with chemistry concepts.
Student Engagement. Christopher also incorporated socioscientific issues into his chemistry lessons because he believed that it fostered student engagement, primarily through discussions. He mentioned, “If you can get something that ties into something they’re seeing, then they’ll talk about it. They want to talk about it” (Initial Interview, lines 387-388). In addition he stated, “Even the person that kind of sits there with their head phones on the whole time and tries to sleep and all of that, they’ll have something to say in those kinds of conversations” (Initial Interview, lines 392-394).

For Christopher, student engagement through discourse was extremely important. He had found from previous experiences that his honors students did work primarily for grades rather than interacting with and truly trying to understand the content. He stated, “My kind of strategy to things is that I’m not going to grade every single thing I give the kids. I’m going to look and see how they’re progressing. I’ll give them feedback on those kinds of things. I’m not going to grade every single thing. What I’ve learned is that a lot of them will not do something if there’s not a grade attached to it. It’s like, they’re not learning for the sake of learning. They are learning to get the grade and kind of move on. So, that sort of happens now with it. Do I give more grades and maybe they’ll do more work? Yeah, but then it kind of has a busy work feel to it. The way I set things up is this is what we need to do to get you to where you need to be in terms of what you’re supposed to know and what I think you should know and those kinds of things” (Initial Interview, 205-213). Thus, as Christopher approached concepts from the perspective of socioscientific issues, he believed that he garnered more participation from students through their thoughts about the issues presented. This led him to believe that students were genuinely learning the material without putting so much focus on grades. For Christopher, this was important because he felt that a lot of parents were pushing their children to take Honors
Chemistry, which could at times, lead to lower grades for students who were not prepared to be in this class. He opined, “I try to tell them that it’s admirable that you want your kid to be challenged but at the same time, it was always my opinion with the school I went to, you’re not taking an honors class unless you plan on getting an A and then really at least a high B. We’re not serving these kids well by putting them into an honors class if they are getting C’s in them. In actuality, we’re hurting their chances of getting into a decent school later on. Maybe they pick up a little bit more in an honors class than they did before but if we are over-challenging them, then we could be burning them out at the same time and turning them off from something that maybe they wanted to do to begin with. So there’s a fine line that you have to dance in there and I feel like we haven’t been doing a good job with getting the kids in the right class, the right spot” (Initial Interview, lines 175-184). Thus, for Christopher, including socioscientific issues in his lessons was a way to help students engage in the chemistry concepts. More specifically, Christopher emphasized that having class discussions that included socioscientific issues provided a break from the technical nature of chemistry and allowed students to understand how these concepts applied to what was going on in the local and global world around them.

Elaborating on this, Christopher explained that whereas students may have felt overwhelmed with learning about the technical concepts in chemistry, socioscientific issues discussions enabled the students to take part in and contribute in ways where they felt confident that their opinions mattered. After all, Christopher stated, “These students like discussions, especially those involving environmental concepts” (Pre-Interview 2, line 16).

In summary, three themes emerged with regards to socioscientific issues and Christopher’s underlying beliefs about chemistry learning. These themes were: (1) SSI’s were used as a means for students to make connections between the chemistry concepts taught and the
issues that occurred both locally and globally, (2) SSI’s were used as a means of fostering student engagement through discussion, and (3) SSI’s were used to alleviate the focus on learning for grades.

**Planning For and Enacting Socioscientific Reasoning.** This section focuses on the way that Christopher planned and enacted lessons involving socioscientific issues in his honors chemistry class. Although the researcher observed many lessons that included socioscientific issues, two example lessons will be discussed and highlighted in this analysis. The two lessons chosen featured the use of socioscientific issues in addressing the concepts of reaction rates and nuclear energy. These two lessons were chosen because the researcher felt that they best exemplified the practices of socioscientific reasoning that are fundamental in the negotiation of SSI, according to Sadler, Barab, and Scott (2007). These practices include: (1) recognizing the inherent complexity of SSI’s, (2) examining issues from multiple perspectives, (3) appreciating that SSI’s are subject to ongoing inquiry, and (4) exhibiting skepticism when presented with potentially biased information. The researcher also took into consideration the inclusion of morals and ethics in selecting the example lessons, as Zeidler and Nichols (2009) emphasized the importance of this characteristic being present for an issue to be labeled a socioscientific issue. Even though the researcher observed more than two lessons involving socioscientific issues, she felt that analyzing two representative lessons would allow for a more close-up understanding of how Christopher organized his lessons around particular issues. Table 4.1 is a summary of all of the lessons where Christopher devoted a major portion of the period to socioscientific issues in teaching specific chemistry concepts.
Table 4.1: Summary of Christopher’s SSI Lessons

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date(s)</th>
<th>Summary of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction Rates</td>
<td>3/15/11</td>
<td>1. Class discussion on surface area and the Dixie Sugar Plant Explosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Lab on reaction rates</td>
</tr>
<tr>
<td>Nuclear Energy</td>
<td>3/30/11 – 3/31/11</td>
<td>1. Lab on percent yield and theoretical yield calculations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Class discussion on nuclear reactors and the earthquake in Japan</td>
</tr>
<tr>
<td>Thermodynamics</td>
<td>4/12/11</td>
<td>1. $Q = mc\Delta T$ calculations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Discussion of alternative energy sources for cars</td>
</tr>
<tr>
<td>Ionic Compounds</td>
<td>5/4/11</td>
<td>1. Lab on how to perform tests for ions in water</td>
</tr>
<tr>
<td>(review in preparation for final exam)</td>
<td></td>
<td>2. Discussion on water quality and qualitative testing for pollution</td>
</tr>
</tbody>
</table>

Planned Curriculum. Christopher felt that a lot of forethought and preparation was needed in planning for the inclusion of socioscientific issues in his lessons. He generally liked to organize his lessons around big topics and include a 10-15 minute discussion about a particular topic at the end of a lesson. At times, his lessons were instinctive and on-the-fly, demonstrating flexibility in adapting his plans. In fact, at times, Christopher would email the researcher at the last minute to alert her as to when he was planning his next lesson that included socioscientific issues, since they were not incorporated in all of his lessons. In light of incorporating socioscientific issues, Christopher stated, “A lot of times, I try to plan lessons that are sometimes centered around it and that will be the big topic and this is what we’re going to do and this is what you’re going to see out of this kind of thing. A lot of them just have been kind of on-the-fly or instinct. I’ll throw something up on the board. Maybe a question gets asked, I’ll think about something, and we’ll just start a discussion. I don’t have any problems with days like that. Some people say we’re getting off on a tangent, we’re getting away from the performance standards in the days and those kinds of things but if it’s something that creates [and] provokes meaningful
thought and we have discussion about it, I have no problem throwing away some of the things that maybe we were supposed to do that day because you can always bring them up another time” (Initial Interview, lines 351-360).

Christopher mentioned that in planning for some lessons, he found it difficult to find resources to supplement class discussions. He said, “There are certain topics that you are kind of limited on as to what you should do. I do want to implement as much stuff where they can see where everything connects. The main thing is that you have to make it real for them. It’s just one of those things where there’s not a ton of material out there for it. You have to kind of go with what you can” (Post Interview 2, lines 62-65). Even in these instances, Christopher still continued to incorporate socioscientific issues in his lessons.

The lesson on reaction rates took place on March 15, 2011. Before the start of class, Christopher mentioned to the researcher that “The plan is for the students to be introduced to the concept of reaction rates through a PowerPoint presentation. Since this is new material, the students will be taking notes from the PowerPoint slides. There will more than likely be some type of discussion during the PowerPoint. Then the students will complete a lab activity that is divided into two parts. This will probably take up the rest of the class period” (Email Correspondence, 3/14/11). For this topic, Christopher included an essential question, or main point, which he posted on the white board at the front of the classroom. The essential question that he hoped students would be able to answer by the end of the lesson was: “What are the factors that affect reaction rate and how do we experimentally determine them?” Thus, in planning for this particular lesson, although Christopher did not organize the lesson so that it centered around a socioscientific issue, he planned to include it through some type of discussion. The planning process for this particular lesson illustrated Christopher’s way of oftentimes putting
together lessons where socioscientific issues were thought about “on the fly”. In other words, Christopher intended to have a discussion in class on this particular day on reaction rates, but since no particular socioscientific issue was mentioned to the researcher before the start of class, the researcher inferred from his initial interview and his email correspondence that this was one of those lessons where Christopher would lead a discussion based on his instinct. Indeed, this was the case, as will be discussed in the next section on enacted curriculum. Also, the lack of outside resources incorporated into this lesson showed Christopher’s attempt to “go with what he had” in order to make the lesson relevant for the students.

The lesson on nuclear energy actually took place over the span of two days (March 30, 2011 – March 31, 2011) due to a lab taking longer than expected. Christopher mentioned, “The plan is for them to do a lab, answer some questions, turn that in, and then we are going to continue discussing the situation in Japan. I found a presentation given by the U of Texas [University of Texas] showing a timeline of events and what is happening. Additionally we will discuss the plans to build an additional reactor at a nuclear plant in [location] and what the implications are” (Email Correspondence, 3/30/11). The essential question on the white board was: “What is a mole and how do we perform calculations with Avogadro’s number?” (Field Notes, 3/30/11-3/31/11). In preparing for this lesson, Christopher spent a lot of time browsing the internet and the different news stations in order to stay abreast with what was occurring in society. For instance, in preparation for this lesson, Christopher found a PowerPoint presentation entitled, “Used Nuclear Fuel: From Liability to Benefit” (Orbach, 2011) to initiate a discussion with students about nuclear power plants. This PowerPoint included details about the events of the earthquake that occurred in Japan during March 2011 and how these events affected the nuclear power plants in this country. In addition to using this PowerPoint, Christopher also

Christopher’s goal for bringing in all of these resources was to enable students to see the many sides that have to be considered when weighing in on solutions to the nuclear energy issue. In this particular lesson, even though a lab was included as a part of the instruction to address the essential question of performing calculations using Avogadro’s number, Christopher planned to make nuclear energy the centerpiece of discussion.

In summary, three themes emerged as to how Christopher planned for socioscientific reasoning in his chemistry class. They included: (1) lessons were sometimes planned to center around a specific socioscientific issue, (2) normally short discussions that occurred at the end of class were how topics surrounding a socioscientific issue were addressed, and (3) how a lesson was planned was related to what outside resources were available for use in instruction.

**Enacted Curriculum.** Even though Christopher spent a lot of time preparing lessons that incorporated socioscientific issues, on some occasions there were differences in what was planned and what was enacted. In these lessons, Christopher assumed the role of a moderator or facilitator who guided the class discussions. He commented, “It’s just more of guiding discussion, throwing a topic out there, and kind of being more like a moderator, just kind of getting them to obviously keep the debate clean, make sure it’s relevant, those kinds of things. You know kind of facilitating a lot of discussions about it” (Final Interview, lines 21-23). As a facilitator, Christopher saw his role as mainly presenting the theme and steering this theme towards chemistry as much as possible. In these cases, what he found was that student
discussions could go in a myriad of directions. He opined, “The beauty of this is whatever the students get fired up about and whatever they want to talk about, that's where they steer the conversation. If you make it more about them, you know, if you go in with I want to do this, I want to do this, I want to do this, then these things aren’t going to happen. If you go in with it as this is the theme and let them kind of run with it, then you're just there as more of a scientific expert or adviser or just to give them the information that relates to [the issue]. I try to steer it as much towards chemistry as much as possible so we’re not, you know, just not perceived as a waste of time” (Post Interview 1, lines 73-79).

In the lesson on reaction rates, the enacted curriculum consisted of the students being introduced to the concept through the use of PowerPoint slides. The students took notes on the slides as Christopher explained the material. Some of the topics discussed in the slides included concentration of reactants, surface area, temperature, pressure, catalysts, inhibitors, and activation energy. All of these topics were listed in the state standards that chemistry teachers were expected to cover in their lessons. During this PowerPoint presentation, Christopher served as a facilitator who introduced an example and allowed the students to discuss a topic. As such, Christopher led a discussion on the effect that surface area had on rates of reactions by bringing up a real-world example of a grain elevator explosion. The slide that sparked this discussion was entitled “Surface Area.” After Christopher explained what the “Surface Area” slide was all about, he then described the incident that occurred as a dust explosion at a Dixie Sugar Plant that killed 13 people and injured 42 people. Christopher presented this example by explaining the occurrence based upon what he had previously read in a news article. No other outside resources were brought into the discussion of this explosion. However, students used this example as a means of making a connection between surface area and the dust explosion as they began to ask
Christopher about the occurrence in more detail. After expanding on this issue, Christopher then asked students to come up with solutions that could be implemented to prevent any further occurrences of this type of event. One student mentioned the fact that the building was old, and that this could have played a part in the explosion. This student then suggested that further occurrences could be prevented by making sure that the building was inspected and properly “up to code”. This led to a brief discussion of the ethics of working in facilities that were not “up to code”. This discussion lasted for approximately ten minutes before Christopher had to end it in order to provide the students with the notes from the other PowerPoint slides. (Field Notes, 3/15/11). Because this discussion took part in the middle of a PowerPoint presentation about reaction rates and Christopher wanted to give the students enough time to finish up the notes and to complete the lab that was planned for this lesson, he did not allow this discussion to linger. In this example, Christopher served as a facilitator who began the dialogue about this topic by presenting the facts about the explosion that occurred. Then he opened up the discussion for the students to participate by asking them to express their opinions about how to prevent this type of explosion from happening again. Once the students were provided with the opportunity to express their opinions, Christopher’s role then consisted of helping to keep the conversation on track so that the other parts of the agenda for the lesson were carried out. Thus, this example illustrated a discussion that occurred that gave students the opportunity to briefly open up their thought processes and address an ethical issue.

The lesson concluded with the students performing a lab on reaction rates. The lab consisted of two sections. In the first part of the lab, students used generic Alka Seltzer tablets in order to determine how the reaction rates of the tablets were affected when placed in four different trial settings. The four trial settings were hot, cold, crushing, and room temperature. In
the second part of the lab, students added copper (II) chloride to three different pieces of aluminum foil and observed the reaction rates in this experiment at different temperatures. Students were asked to record the temperature and time of each experiment and to answer some follow-up questions on the lab handout that they were to turn in at the end of class (Field Notes, 3/15/11). Although the lab performed after the discussion did include a section on surface area (when it came to crushing the Alka Seltzer tablets), students did not have the opportunity to discuss the outcomes of the lab as a whole group due to time constraints. Instead, the students only had enough time to fill out temperature and time data components of the data table and answer a few follow-up questions on the lab worksheet that was distributed at the start of the lab. Thus, in this instance an inquiry piece was present in the lab but it did not provide students with the opportunity to think deeply about how the surface area of Alka Seltzer was being affected or how this related to the Dixie Sugar Plant explosion.

The nuclear energy lesson was enacted over the course of two days. The first day of the lesson consisted of the students spending the entire class period completing a lab in which they calculated the actual and theoretical yield of a reaction between vinegar and baking soda. The lab lasted longer than Christopher had anticipated because of the length of time it took for the contents of the students’ flasks to evaporate. Thus, Christopher’s plan to complete the lab and have a 10-15 minute discussion about nuclear energy and the crisis in Japan was altered. Instead, this discussion occurred during the next class period.

Since the nuclear energy lesson spanned the total of two days, the students were able to spend a considerable amount of the second day participating in a class discussion that allowed them to brainstorm possible ways to reduce the United States’ dependence on foreign oil. In fact, the lesson consisted of an hour-long discussion where Christopher first introduced the nuclear
energy issue through the PowerPoint presentation from the University of Texas entitled, “Used Nuclear Fuel: From Liability to Benefit” (Orbach, 2011). The PowerPoint presentation served as a guide to help Christopher facilitate the discussion. The parts of the PowerPoint that he used included the chronology of events of the meltdown of the nuclear power plants in Japan due to the earthquake, radiation levels, and a model of a design that was being proposed to be used in the construction of a nuclear reactor located approximately 100 miles away from Eastern High School. Other sources that Christopher used to help facilitate the discussion included excerpts from President Obama’s speech on America’s Energy Security (The White House, 2011) and excerpts from an article entitled, “Southern’s Nuclear Expansion Wins Enviro Review” (Doggett, 2011). Thus, even though Christopher planned to use a lot of outside resources in this lesson, some of the materials ended up not being used. In reflecting on this, Christopher mentioned, “I think that you know, you would like to get through everything that you would exactly wanted to say. I wanted to get to the President’s speech a little bit more and kind of make them aware of some of the things he’s thinking” (Post Interview, 3/31/11). Within this discussion, one solution that the students considered was increasing production and sales of hybrid vehicles (Field Notes, 3/31/11). In reflecting on this lesson, Christopher stated, ““I think the real thing [is] that they just understand some of the thought process behind all of this new technology that is coming out. You know they, hybrid cars, are such a good thing but they don’t see maybe the downside of them. They see that electric cars are awesome, but you know you make them think okay, well, you’re plugging them into the electric grid. Hopefully, they will think about things in a different manner” (Post Interview 1, lines 61-65). In one instance, the discussion was about alternative energy sources and President Obama’s desire to reduce the United States’ dependence on foreign oil. This discussion became very intense as one student
who normally did not talk very much, passionately expressed her opinions. Even after Christopher ended the dialogue to give students an opportunity to work on their study guides in preparation for the next day’s test, students could still be heard discussing the issue (Field Notes, 3/31/11). In considering this student’s actions in class, Christopher mentioned, “She’s usually reserved. She’ll kind of sit there and she’ll ask questions about stuff but she’ll never be that intense about things. So I mean that was kind of actually surprising to me to see her get that fired up about stuff” (Post Interview 1, lines 31-38).

This lesson was an example of how Christopher served as a facilitator and helped to steer the discussion towards chemistry concepts by using the PowerPoint presentation as a guide. Although the topic garnered much discussion as Christopher had hoped, there was a disconnect between the lab and the socioscientific issue discussed. The lab helped to cover the state-mandated curriculum of performing calculations involving mass, moles, percent yield, and theoretical yield while the socioscientific issue planned for the lesson aimed to serve as a discussion that completed the unit on chemical reactions. However, there was a lack of connection between the two parts of the lesson.

In summary, three themes emerged as to how Christopher enacted socioscientific reasoning in his teaching of chemistry. These themes included: (1) in lessons involving SSI’s, the teacher served as a facilitator/moderator who guided class discussions in order to ensure that the topics were relevant and controlled, (2) time constraints determined what and how lessons were enacted, and (3) it could be difficult to build coherent connections between those concepts emphasized in state standards and socioscientific issues.

**Fostering Socioscientific Reasoning.** In the honor’s chemistry class, lessons involving socioscientific issues usually consisted of discussions because Christopher believed that his
students loved to engage in dialogue. Most of these discussions usually occurred towards the end of class. However, there were some instances where these short discussions occurred during other times of the class period due to other activities that Christopher had planned for the lesson.

He stated, “We usually end up with maybe one 10 to 15 minute discussion a week or so. We have probably one class where almost the entire class. That just doesn’t happen very often (Initial Interview, lines 364-365). Furthermore, he said, “I think with me, it really was just having discussions about it and just opening up their thought processes to making it a real-world thing” (Final Interview, lines 28-29).

In one particular instance, Christopher recalled how the socioscientific issue discussed in class lasted the entire class period. He saw this lesson as covering a myriad of topics. He said, “Everything. Literally, it started off as polarity and that lead to how different things will dissolve in each other, like dissolves like as the common expression. So I started them off with polarity of water versus polarity of oil. So that got into the oil spill discussion from this past year with the oil spill in the gulf. That got into different advertising schemes from BP in terms of, you got, one of these sources is saying that people are still going after BP for money because they haven’t been paid their compensation. Then you have these BP- like commercials that are saying well, actually, you know, I had a vacation rental home and I showed BP the cancellation and they paid me the money and so I showed them the difference between BP’s advertising versus everybody else’s version of it. So we got into that and then that led into alternative energy sources. That led into the politics of alternative energy sources. So it literally jumped from polarity all the way down the line. So it doesn’t take much to get it” (Initial Interview, lines 376-386).
One of the things Christopher mentioned that he struggled with was keeping the conversations controlled and focused on the socioscientific issues at hand. He said, “One of the things is that you have to contain them, too. It’s like if they start getting really mad, getting loud, or start arguing. So you have to kind of control them” (Post Interview 1, lines 43-45). In one particular instance, Christopher recalled how during a class period, many students contributed to the lesson, but sometimes the students would get off topic. He stated, “Now controlling it and making it a meaningful discussion is where the challenge lies because if they are side barring on something that happened on Jerry Springer, then obviously you’re getting away from where it should be. Did I do anything to control the conversation? No. If they have a question, I provide answers. I was a moderator and kept it orderly in there because everybody had something to say on this kind of day” (Initial Interview, lines 388-392).

Reflecting on the experiences of incorporating socioscientific issues in his lessons, Christopher expressed the belief that students do make connections between the chemistry content and the issues discussed. He said, “They understand the basic chemistry process behind it. They understand how it relates to the outside world to a certain extent. We did well with it” (Post Interview 2, lines 19-21). Yet, Christopher continued to think of ways to improve his lessons so that students could think differently about the local and global world. He mentioned, “I think it could be a lot more interesting if we are able to go more in depth with it and see their reactions behind it” (Post Interview 2, lines 29-30). This comment reflected Christopher’s desire to “give them a little more knowledge from the outside world” (Post Interview 2, line 33).

Sadler’s Assessment of Socioscientific Reasoning. After analyzing how Christopher planned and enacted particular SSI lesson experiences, the researcher examined each of his lessons in terms of opportunities for socioscientific reasoning. Specifically, each lesson was
analyzed with respect to complexity, perspectives, inquiry, skepticism, and ethics and morals.

The categorizations for each lesson are listed in tables 4.2 – 4.5 below. Christopher’s categorizations for each section are indicated by the description being typed in bold font. These categorizations were indicative of what the researcher believed best described Christopher’s incorporation of socioscientific reasoning. An explanation for each categorization is given underneath the table.

Table 4.2: Categorization of Reaction Rates Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</strong></td>
<td><strong>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</strong></td>
<td><strong>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</strong></td>
<td><strong>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</strong></td>
</tr>
<tr>
<td>Perspectives</td>
<td><strong>Teacher does not provide opportunities for students to carefully examine the issue.</strong></td>
<td><strong>Teacher provides opportunities for students to assess the issue from a single perspective.</strong></td>
<td><strong>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</strong></td>
<td><strong>Teacher provides opportunities for students to assess the issue from multiple perspectives.</strong></td>
</tr>
<tr>
<td>Inquiry</td>
<td><strong>Teacher does not provide opportunities for students to recognize the need for inquiry.</strong></td>
<td><strong>Teacher provides opportunities for students to present vague suggestions for inquiry.</strong></td>
<td><strong>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</strong></td>
<td><strong>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</strong></td>
</tr>
<tr>
<td>Skepticism</td>
<td><strong>Teacher does not provide opportunities for students to be able to declare differences among stakeholders.</strong></td>
<td><strong>Teacher provides opportunities for students to suggest that differences likely exist among stakeholders.</strong></td>
<td><strong>Teacher provides opportunities for students to describe differences among stakeholders.</strong></td>
<td><strong>Teacher provides opportunities for students to describe differences among stakeholders and discuss the</strong></td>
</tr>
</tbody>
</table>
### Ethics and Morals

<table>
<thead>
<tr>
<th></th>
<th>Stakeholders.</th>
<th>Significance of Conflicting Interests.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher provides no opportunity for students to raise ethical and/or moral issues.</strong></td>
<td>Teacher provides little opportunity for students to consider ethical and/or moral issues.</td>
<td><strong>Teacher provides ways for students to consider ethical and/or moral issues.</strong></td>
</tr>
<tr>
<td><strong>Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a way for students to discuss the significance of a moral or ethical stance.</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this lesson, students were given the opportunity to discuss the concept of reaction rates and the factors that influence them. More specifically, students were able to make connections between surface area and the explosion at the Dixie Plant and were provided with an opportunity to generate ideas about ways to prevent such a dangerous event from occurring again.

**Complexity.** The researcher categorized Christopher as a 1 for complexity because he gave students the opportunity to come up with solutions but did not encourage them to consider the pros and cons of the solutions they generated. For example, when the students only looked at the Dixie Sugar Plant explosion from the angle that the building was old and not “up-to-code”, Christopher did little to prompt them to consider other explanations and possibilities.

**Perspectives.** The researcher categorized Christopher as a 2 with regards to perspectives because the student’s explanation of how the age of the building could be related to the cause of the explosion was only generated based upon the synopsis of the one news article that Christopher used to summarize the account of the incident. No other outside sources were used in presenting this material to the students.

**Inquiry.** The researcher categorized Christopher as a 2 with respect to inquiry because the students were given an opportunity to collect scientific data with regards to surface area when they completed the lab after the class discussion. However, not much time was allowed for
students to reflect deeply on how the lab related to the Dixie Plant Explosion, as the students were asked to answer a few questions on the lab handout that focused on temperature and its effect on reaction rates. Students were not asked to answer any questions about surface area and its effect on reaction rates.

*Skepticism.* The researcher categorized Christopher as a 2 in relation to skepticism because the students were able to discuss why stakeholders may have held out on upgrading the Dixie Sugar Plant. In his role as a moderator, Christopher left the discussion up to the students in order to generate ideas as to why stakeholders could have possibly held these opinions, but these discussions did not lead to thoughts of the significance of conflicting interests. Instead, as the students steered the conversation, the class discussions led toward their opinions and their proposed solutions to the issue at hand.

*Ethics and Morals.* The researcher categorized Christopher as a 3 in ethics and morals because students were given the opportunity to discuss the ethics behind working in buildings that were not considered “up to code”. Students were given the opportunity to consider what future effects working in substandard buildings would have on employees as well as those who live in the community.

Table 4.3: *Categorization of Nuclear Energy Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning*

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</strong></td>
<td><strong>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</strong></td>
<td><strong>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be</strong></td>
<td><strong>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be</strong></td>
<td></td>
</tr>
<tr>
<td>Perspectives</td>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
<td>Teacher provides opportunities for students to assess the issue from a single perspective.</td>
<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
<td>Teacher provides opportunities for students to assess the issue from multiple perspectives.</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>Inquiry</td>
<td>Teacher does not provide opportunities for students to recognize the need for inquiry.</td>
<td>Teacher provides opportunities for students to present vague suggestions for inquiry.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</td>
</tr>
<tr>
<td>Skepticism</td>
<td>Teacher does not provide opportunities for students to be able to declare differences among stakeholders.</td>
<td>Teacher provides opportunities for students to suggest that differences likely exist among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders and discuss the significance of conflicting interests.</td>
</tr>
<tr>
<td>Ethics and Morals</td>
<td>Teacher provides no opportunity for students to raise ethical and/or moral issues.</td>
<td>Teacher provides little opportunity for students to consider ethical and/or moral issues.</td>
<td>Teacher provides ways for students to consider ethical and/or moral issues.</td>
<td>Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a way for students to discuss the significance of a moral or ethical stance.</td>
</tr>
</tbody>
</table>

The nuclear energy lesson occurred over a two-day period. Whereas the students were engaged in a laboratory activity on the first day, on the second day, students were provided with an opportunity to participate in a discussion about the possible construction of a nuclear reactor in a community approximately 100 miles away from their school. Thus, the researcher chose to categorize Christopher’s fostering of socioscientific reasoning based upon this aspect of his lesson.
Complexity. The researcher categorized Christopher as a 3 for complexity because he provided students with the opportunity to see that the potential solutions were tentative based on the outside resources that were used to present the socioscientific issue at hand. Students began to understand that the building of a nuclear reactor in a neighborhood in relatively close proximity to their school required a lot of thought and was indeed a complex issue to consider. Because of the various resources that Christopher included in this lesson, students were able to understand that there were many views that needed to be considered before they could think about proposing solutions to these dilemmas.

Perspectives. The researcher categorized Christopher as a 3 in relation to perspectives because of the multiple perspectives that he included in his lessons. These perspectives came from scientists who did research, policymakers, popular news stations, and articles of citizens who had vested interests in how the issues were playing a role in their own lives. The researcher believed that students were able to understand that there were many different views that existed because of the variety of resources used.

Inquiry. The researcher categorized Christopher as a 1 with respect to inquiry because no opportunity was presented for the students to recognize the need for inquiry. The only means of communicating this socioscientific issue was through a discussion that was based upon outside resources that Christopher included in the lesson. No additional inquiries which would lead to the collection of scientific or social data were included in this lesson.

Skepticism. The researcher categorized Christopher as a 2 with regards to skepticism because when he did present the theme to be discussed, he described the differences among stakeholders. However, in his role as a moderator, Christopher left the discussion up to the students, which did not lead to a consideration of the significance of conflicting interests. As the
students took active roles in the conversation, the class discussion generated many thoughts and opinions with regards to their proposed solutions.

*Ethics and Morals.* The researcher categorized Christopher as a 3 in ethics and morals because students were provided with opportunities to discuss the ethics of building a nuclear reactor in a nearby community. The ethics were considered particularly in relation to the effects of the earthquakes in Japan on the nuclear reactors in the country. Because of the events that occurred in Japan, students were able to carefully consider the ethics of building a nuclear reactor in a nearby community.

Table 4.4: *Categorization of Thermodynamics Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning*

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
<td></td>
</tr>
<tr>
<td>Perspectives</td>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
<td>Teacher provides opportunities for students to assess the issue from a single perspective.</td>
<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
<td>Teacher provides opportunities for students to assess the issue from multiple perspectives.</td>
</tr>
<tr>
<td>Inquiry</td>
<td>Teacher does not provide opportunities for students to recognize the need for inquiry.</td>
<td>Teacher provides opportunities for students to present vague suggestions for inquiry.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</td>
</tr>
<tr>
<td>Skepticism</td>
<td>Teacher does not provide</td>
<td>Teacher provides opportunities for</td>
<td>Teacher provides opportunities for</td>
<td>Teacher provides opportunities for</td>
</tr>
</tbody>
</table>


In this lesson, students were provided with the opportunity to learn about concepts related to thermodynamics and how these principles connected to alternative energy sources for cars. Thus, the researcher chose to categorize Christopher’s lessons based on how these components were presented.

**Complexity.** The researcher categorized Christopher as a 1 for complexity because the discussion of alternative fuel sources provided students with the opportunity to give simplistic solutions. Christopher did not encourage students to consider the pros or cons associated with the solutions they provided.

**Perspectives.** The researcher categorized Christopher as a 2 for perspectives because the students were given the opportunity to assess alternative fuel sources from a single perspective. Most of the students looked to hybrid cars as their one example of alternative fuel sources. Thus, the students formed their opinions and solutions with regards to alternative fuel sources based on their experiences with either driving a hybrid vehicle or knowing someone who drove a hybrid vehicle.
Inquiry. The researcher categorized Christopher as a 1 in relation to inquiry because he did not provide any opportunities for students to recognize the need for inquiry. In this class discussion, Christopher served as a moderator, and made sure that the topic stayed focused on alternative energy sources. The students focused primarily on their personal experiences and drew on these to shape their opinions in order to formulate solutions to the issue presented.

Skepticism. The researcher categorized Christopher as a 1 for skepticism because although he presented the theme to be discussed, he did not provide students with opportunities to consider differences among stakeholders. The opinions of the students reflected their personal experiences without an examination of different stakeholder views.

Ethics and Morals. The researcher categorized Christopher as a 2 in ethics and morals because although the topic of alternative fuel sources lent itself to the consideration of ethical issues, students were given little opportunity to provide input with regards to ethics. In fact, in reflecting on how much emphasis was placed on including morals and ethics in this lesson, Christopher mentioned, “It just isn’t that kind of lesson” (Post Interview 2, line 47).

Table 4.5: Categorization of Ionic Compounds Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
<td></td>
</tr>
<tr>
<td>Perspectives</td>
<td>Teacher does not provide opportunities for</td>
<td>Teacher provides opportunities for students to assess</td>
<td>Teacher provides opportunities for students to examine</td>
<td>Teacher provides opportunities for students to assess the</td>
</tr>
</tbody>
</table>
The ionic compounds lesson occurred during the week of final exams. Students were given the opportunity to participate in a lab entitled “Identification of Anions and Cations in Solution.” The purpose of the lab was to identify ions in an unknown solution through the application of chemical tests. Christopher used this lab in order to help students understand how to perform tests for ions in water and to make connections as to how this relates to water quality and why water quality is important. This enabled students to engage in discussions about water quality, testing for pollution, and ways to reduce pollution.

**Complexity.** The researcher categorized Christopher as a 2 for complexity because the students were encouraged to identify and discuss the pros and cons of testing for pollution.
However, because the students completed a lab before their discussion on this topic, students saw the issue as being relatively simplistic and based on a single solution. As the students generated and proposed a solution for testing water pollution based on their laboratory observations, they did not consider any other testing methods.

_Perspectives._ The researcher categorized Christopher as a 2 in perspectives because students were given the opportunity to assess the testing of pollution primarily in light of a single perspective. Students were asked to consider other ways of testing for water pollution, but the only solution generated was based on techniques used in the laboratory exercise they completed.

_Inquiry._ The researcher categorized Christopher as a 3 in relation to inquiry because the students were given the opportunity to suggest a plan for inquiry that involved the collection of scientific data. Students proposed a plan for testing water pollution by describing a data collection method that mirrored the procedures that were used in the lab they conducted on this day. Thus, the students’ plan for inquiry was based off of the laboratory exercise as no other solutions were generated.

_Skepticism._ The researcher rated Christopher with a score of 1 in skepticism because when he presented the theme to be discussed, he provided a way for students to have opportunities to analyze differences among stakeholders. In this lesson, Christopher served as a moderator and left the discussion up to the students, which did not lead to a discussion of the significance of conflicting interests.

_Ethics and Morals._ The researcher categorized Christopher as a 2 in ethics and morals because there was little opportunity provided for students to consider the ethical dimensions of pollution. This discussion served as a summary to the lab, as the lesson was focused on reviewing for the students’ final exam.
This analysis shed light on the extent to which Christopher fostered socioscientific reasoning in his planned and enacted curriculum. His lessons were characterized by interrelationships between the chemistry concept taught and the socioscientific issues that related to them. However, a lot of the interrelationships were presented in light of single perspectives. Thus, in general, Christopher’s SSI-based lessons promoted a low level of socioscientific reasoning. Even though his lessons captured the array of practices fundamental to the negotiation of socioscientific issues (Sadler, et al., 2007), the researcher hopes Christopher will continue to grow in these areas as he continues to teach more lessons that include SSI’s.

In summary, three themes emerged with regards to how Christopher fostered socioscientific reasoning in his honors chemistry lessons. These themes were: (1) classroom discourse was encouraged in all socioscientific issues-based lessons, (2) there was a disconnect between conceptual understanding of an SSI and practical application in the laboratory context, and (3) students’ opportunities to engage in higher order thinking skills were limited due to time constraints, lack of outside resources, and a focus on covering all content standards.

Closing Narrative: Christopher’s Future Plans. Christopher is always looking for new ways to engage his students and get them to think about the issues that are occurring in society. When asked what was next for him with teaching his chemistry classes, he said, “Well, the program I’m doing this semester, I’ll be working with a materials scientist at [name of university]. He actually deals with carbon nanotubes which are used to make solar panels, and they’re also used for other different power applications. They also use them to make different composites out of, like for sports equipment and aircrafts. That experience alone will actually give me more content knowledge and kind of the backbone of how are solar panels made and how does that relate to alternative energy. Why are these better than this? With that, we are
actually going to be doing a videoconferencing project with him. I actually did one a couple of
days ago for the first time. It’s been done here before, but we’ll actually be able to talk directly
with him, see his lab from our classroom on a 50-inch TV that we have in here. He will have a
camera where he can control and see us and we can control his camera on his end and zoom in
and different things. I’ll be integrating that a lot more into probably on an experimental basis
right now. I think I’ll be comparing two different classes, you know one being the
videoconferencing class and the other class doing different kinds of projects and just kind of see
if there is a difference in the results from that. It could be interesting research. We’ll see. That’s
kind of where we are going to go with it. Obviously his lab will go into the process of how
alternative energy can be used, and then that lends to a natural discussion of well, we know how
to do this, why don’t we do this all the time now? You get into the manufacturing standpoint,
cost, how long it takes and those kinds of things. That’s kind of where we will be going with it”
(Final Interview, lines 111-128).

Christopher also plans to incorporate socioscientific issues in other science classes as
well as he has been assigned to teach physical science and physics during the next school year.
He stated, “In the fall, I’ll be teaching physical science level chemistry and then physics. But
that’s going to be a unique opportunity because I’ve never taught freshmen before and that’s
where you can get them really interested in science if you can get them earlier on and then just
kind of get them to think about it. Then when you get them in a couple of years, hopefully you can
build on it” (Final Interview, lines 137-141). When asked about incorporating socioscientific
issues in these classes, he said, “Yeah, any science class I teach, you know, you have to. If you
don’t, then you’re wasting your time pretty much. What’s the purpose of teaching science? Are
you trying to make a bunch of kids that are going to work in labs? No. If every single kid majors
in science, then science would no longer need kids majoring in science, you know what I mean. So, maybe it would solve one of our problems short-term but the goal in my opinion is to educate as many kids as you can about the consequences of their actions, and then if you have a couple of them that want to go on and pursue it more, then that’s awesome and you enrich them even more” (Final Interview, lines 145-151).

Summary Discussion and Preliminary Interpretation of Themes. Table 4.6 below provides a summary of the emerging themes gleaned from the three research questions.

Table 4.6: Summary of Themes Emerging from Christopher’s Case

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Emerging Themes</th>
</tr>
</thead>
</table>
| 1. Why do chemistry teachers use socioscientific issues in their teaching?        | 1. SSI’s were used as a result of personal experiences as a student where effective learning strategies were understood through the witnessing of good and bad teaching styles.  
2. SSI’s were used as a means of developing a philosophy/goal of teaching that gave students the opportunity to learn concepts more in depth. |
| 2a. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about nature of science? | 1. SSI’s were used as a way to get students to think about science and society more deeply.  
2. SSI’s were presented by bringing in outside resources as a means for students to grapple with and discuss the different dimensions of societal issues.  
3. SSI’s were incorporated into lessons to help students become more informed decision makers with regards to coming up with possible solutions to the events occurring in society. |
<p>| 2b. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry? | 1. Incorporating socioscientific issues into the subject of chemistry provided opportunities for chemical concepts to be presented in a manner that enabled students to make connections and draw relationships between what was learned and what was occurring in society. |</p>
<table>
<thead>
<tr>
<th>Question</th>
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<tbody>
<tr>
<td>2c. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry teaching?</td>
<td>SSI’s were primarily addressed through discussion rather than active engagement in investigations.</td>
<td>What makes an authentic SSI seemed to be determined primarily by the teacher.</td>
<td>The perception of what was required with respect to standards constrained the extent to which the SSI is built upon in his lessons.</td>
</tr>
<tr>
<td>2d. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry learning?</td>
<td>SSI’s were used as a means for students to make connections between the concepts taught and the issues that occurred both locally and globally.</td>
<td>SSI’s were used as a means of fostering student engagement through discussion.</td>
<td>SSI’s were used to alleviate the focus on learning for grades.</td>
</tr>
<tr>
<td>3. How do chemistry teachers plan for and enact socioscientific reasoning in a secondary chemistry class?</td>
<td>Lessons were sometimes planned to center around a specific socioscientific issue.</td>
<td>SSI’s were oftentimes addressed as short discussions that occurred at the end of class.</td>
<td>How a lesson was planned was reflected upon what outside resources were available for use in the lesson.</td>
</tr>
<tr>
<td>3a. To what extent do chemistry teachers foster socioscientific reasoning in these lessons?</td>
<td>Classroom discourse was encouraged in all socioscientific issues-based lessons.</td>
<td>There was a disconnect between</td>
<td></td>
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</table>
In the preceding development of emerging themes, it was apparent that Christopher stressed the importance of incorporating socioscientific issues in his chemistry lessons. His beliefs stemmed from his personal experiences and his philosophy/goals about teaching. According to Lumpe, Haney, and Czerniak (2000), preservice and inservice teachers develop their beliefs about teaching from years spent in the classroom as both students and teachers and these beliefs are not necessarily consistent with the literature about best practices in teaching. Christopher’s mainly positive experiences with his high school science teachers helped to shape his beliefs about how he best learned science. This helped him to form his philosophy/goals with regards to teaching. Blake (2002) contended:

What teachers believe in, as it relates to their philosophy of teaching, their role within that process, the role and expectations of the students for learning, and the role of the school, science curricula, and context for instruction, will be an essential foundation for what occurs in the classroom (p. 36).

It was obvious from the observations, interviews, and documents that Christopher’s main philosophy/goal with respect to teaching was to help students to think about the local and global world differently. Christopher did this through discussions and bringing in various types of resources for students to examine.
Christopher wanted to enable his students to think about the local and global world differently; his desire was to help his students to become informed decision-makers. Christopher emphasized this importance in class discussions as he continuously mentioned to his students the need to start thinking about these issues in terms of the personal impact they could potentially have on their lives. This belief aligned with one of the tenets of the nature of science that involves the process of decision-making.

Christopher emphasized the importance of socioscientific issues in terms of helping his students to make connections. On a few occasions, Christopher noted how the academic level of his current students was weaker than those students in honors chemistry classes he had taught previously. Thus, in order for students to grasp concepts, he would incorporate socioscientific issues as a means of getting his students to discuss and form opinions about possible solutions to the dilemmas at hand. This, in turn, led to more student engagement as the students participated in these discussions. Oftentimes, the discussions would go longer than expected and sometimes become heated. However, in Christopher’s mind, students were able to understand how the issues related to the chemistry concepts because of the depth of their discussions. Because of this positive outcome, Christopher continued to incorporate socioscientific issues into his lessons, despite challenges such as aligning the issues with the state standards, building conceptual understanding and practical application in the laboratory, and finding enough resources to even have discussions about the dilemmas at hand. Christopher’s efforts demonstrated his dedication to making sure that students had the opportunity to see the local and global world differently.

For Christopher, planning for and enacting socioscientific issues was a different experience for each lesson. Similarly, what students experienced with each lesson varied as to the types of outside resources included in discussions, the level of discussions that were allowed,
and the supplemental activities that enabled the students to make further connections with the chemistry content. For this particular honors chemistry class, Christopher incorporated socioscientific issues mainly through the use of discussions because he believed this garnered the most class participation. This aligned with Zeidler and Nichols’ (2009) argument that socioscientific issues center around the use of scientific topics that require students to engage in dialogue, discussion, and debate. Although Christopher planned for these discussions to last from 10-15 minutes and occur at the end of class, sometimes these discussions would last a lot longer. On rare occasions, these discussions could span the entire class period. In all of these instances, Christopher served as a moderator/facilitator. In this role, he presented the themes to be discussed and helped to keep the discussions focused on the issues at hand. As he reflected on this way of incorporating socioscientific issues into his lessons, he felt that his students did indeed make connections and benefit from the discussions that occurred in class. This, in turn, served as a means to help Christopher approach his dilemma of how to “motivate these kids that seem to be, there’s the common study concept of gifted underachievers” (Initial Interview, lines 194-195).

In summary, this section provided a within-case analysis of Christopher’s incorporation of socioscientific issues in his honors chemistry class. In chapter 5, Christopher’s experiences will be included in a cross-case analysis.

**Narrative 2, Shelly Thomas: A New Course for a Novice Teacher**

**Context of Conceptual Chemistry Class.** At the time that this study occurred, conceptual chemistry was in its first year at Clearview High School. According to Shelly, the structure of the conceptual chemistry class was different from typical science classes because “there were really no guidelines and no standards to use. There were no guidelines and really
just this [conceptual chemistry] book. When I opened up this book, I thought, “Gosh. I mean I’ll be honest. I wouldn’t even give this to a college student.” It’s so hard. I had a hard time following it. I was terrified. I thought, “Oh my God, I’m supposed to teach chemistry and I can’t even teach conceptual because this book makes no sense to me.” It was a horrible book and I didn’t know what I was going to do. When Linda and I sat down to plan, I just came out and said, “Look, you don’t know me really well, but this book is crap!” And she said, “Oh thank God. I feel the same way!” (Final Interview, lines 270-277). She mentioned her concerns as she stated, “I’ve just come from teaching college. How am I going to do this? (Final Interview, lines 218-219). She noted that others schools in the district used the conceptual chemistry textbook, but had taught conceptual chemistry as “mostly a trial and error class because most people teach it as just the chemistry portion of physical science” (Initial Interview, lines 75-76).

However, this was not how Shelly wanted to teach the course. Instead, she was “trying to tweak it and actually teach it as just a maybe lower level general chemistry class, which is what we really hope to eventually be the standard for next year” ( Initial Interview, lines 76-78).

Since Shelly was in her first year as a high school teacher, she came in to this experience with some concerns. She opined, “The first week of class, in the very, very beginning, I was terrified of teaching these kids because I thought, ‘Oh my Lord, a conceptual chemistry class. They have behavior problems, they’re slow. I’ve just come from teaching college. How am I going to do this?’ And that was not the case at all. I had some behavior problems. I had some behavior problems in my general class, in my advanced class. I had some slow kids. I had some special needs students. But what I found was that all conceptual meant was they maybe were not as ready for more of the advanced. But as I’m finding out, really there’s no true difference. It’s all in the timing to get them and how you explain it. (Final Interview, lines 216-223).
In fact, Shelly had a lot of positive things to say about her students. She described them by saying, “They’re very good. Most of my kids are pretty open to try anything. If I’m in the middle of class and I’m like, they’re not getting it, if I crawl on top of the desk and sing it to them in opera, they’ll look at me weird, but they’re okay with it. I’m very laid back with them. We do a lot of group work. I originally started out with 32 kids in my conceptual class. I’m now down to 27, 26, well, 26, 25. I’ve lost quite a few who have dropped out, a few that have transferred, a few [that have had] schedule changes. I won’t say that they are lower level in terms of comparing them to my general class. They just maybe don’t have the math that my general class does, but I have many in my conceptual class that would do very well within the general class. I had one kid today who was like, “Ms. Thomas, that was so easy.” It’s the same stuff that I gave my general class. We just go at a bit slower pace and we just go over everything a little bit more” (Initial Interview, lines 83-96).

Shelly also described the make-up of students in her conceptual chemistry class as having varying academic and ability levels as she mentioned, “My conceptual class, the kids who are in the class, range anywhere from ‘I just have to have this class so that I can at least get out of the minimum wage’ to the kids that have aspirations to be in endocrinology. So it’s very different from my general chemistry class which, you know, general chemistry you do tend to have your lower performing but for the most part those are the kids you know are college bound. My conceptual class, not so much” (Final Interview, lines 157-162). “It’s pretty much a junior class because we do biology freshman year, conceptual physics first and then conceptual chemistry” (Final Interview, lines 164-165). “I had in my conceptual class, I had one student who this semester who hasn’t passed her graduation test. Well she’ll be a senior next year. She hasn’t passed the graduation test the last two times she’s taken it. In the same class, I have someone
who is number three in her entire class in my conceptual class. So, it’s not necessarily that they’re put in there because of their academic ability. A lot of times it’s because of scheduling” (Final Interview, lines 304-309).

In discussing how the conceptual chemistry class was structured, Shelly noted, “I have one that’s a senior and I think he’s really taking it because he just needed another science class. I have a few of those surprise sophomores who really are supposed to be juniors but they’re on that cusp in terms of credit wise. But most of them are juniors, so really that class is a graduation prep class. That is what we do. Really the first four or five weeks we focus on preparation for the graduation test. We even took a week off in between what we were learning because I always try to build in an extra week of you never know what’s going to happen and you might need a week somewhere, which was great because we took that week off and did nothing but review for the graduation test. We took a day and reviewed social studies, we took a day and we reviewed science, they reviewed English, they reviewed math. I went around to all of the departments and got practice and study guides [and] PowerPoints because a lot of them haven’t had US History since the beginning of their sophomore year or they haven’t had biology since their freshman year. They’re juniors and they needed a refresh. A lot of the kids came back and said, “I’m really glad we did that” (Initial Interview, lines 110-122).

Shelly had several goals she wanted to accomplish with her conceptual chemistry students. She mentioned, “So my number one goal is to get them ready for the graduation test because without that it really doesn’t matter what their aspirations are. The second one is to give them the foundational information so that regardless of what they decide to do, (a) they’re ready for the graduation test and (b) whether they want to go to a technical school or they want to go to a college, whether they just are interested, let’s get some foundation, especially if they want to
go on to human anatomy or environmental science, just so they have some basic knowledge. (Final Interview, lines 165-171). “Then my bottom totem pole, it sounds bad that I say it’s on the bottom, but it doesn’t mean it’s not as important. It just means it’s not as foundational as the others. Then we do give them the higher level education foundation” (Final Interview, lines 175-177).

During the time that Shelly participated in the study, it was close to the end of the semester and school year. Thus, she mentioned that teaching the students was getting to be a struggle. She expressed the need to incorporate “something different because by this point they’re tired, they have been through a lot of work, especially my junior class because it’s been graduation test. They are worn out and they are getting rowdy. Everybody wants to be seniors” (Final Interview, lines 327-329). “It’s not just the end of the semester, it’s the end of the year. So I know that really those last two weeks I have to entertain them” (Initial Interview, lines 328-330).

Narrative Description. The following sections present narrative descriptions in light of the research questions in the study.

Why SSI is used in Chemistry Teaching. Shelly incorporated socioscientific issues in the teaching of her conceptual chemistry lessons for a variety of reasons. These included: (1) as a way to explain her past work experiences and provide students with opportunities to solve workplace dilemmas (2) as a way to give continuity to the lessons that were organized in thematic units, and (3) as a way to embrace teachable moments.

Past Work Experiences. Shelly has held various jobs throughout her life. In fact, she mentioned a conversation that she and one of her students had about her past work experiences. In this conversation, the student asked, “‘Are you sure you’re not in your 60s because I swear
you probably remember where JFK was because you cannot be so young to have done everything’. I was like, ‘I’m going to take that as a compliment’. He was like, ‘How could you have done everything and be so young?’” (Final Interview, lines 206-208). With regard to her work experiences, Shelly noted, “I guess because it pretty much sums up, too I’ve been everywhere and I’ve done everything. I like to say I’m a jack of all trades. And, too, because I’ve been on the broad end of the spectrum, I’ve been the historian, I’ve been the scientist, you know the hard humanities versus the hard science and everything in between. I like to show my students that it doesn’t matter what your initial thing you do is. A lot of times you end up off tide where you end up completely in the opposite direction. Too, they need to see that I was in their shoes twelve years ago. I was exactly where they were sitting. You know, look what I’ve done” (Final Interview, lines 199-205). Shelly used those work experiences to illustrate dilemmas she had to face and to provide students with opportunities to think about how to approach those issues. Because this was the case, she believed her students learned conceptual chemistry best through “real-world applications because I know I use myself a lot and I’m not ashamed to tell them, you know, mistakes that I have made in the lab and consequences from it” (Final Interview, lines 128-129). Furthermore, she mentioned “And I wanted to really make it fun. I wanted them to come out thinking okay, science isn’t so bad. It’s not so dry. Even if I hate it, you know, my current teacher is a little nuts, and that’s okay. It’s okay to be a little crazy and you know I graduated from this school in 1999, and I tell them, I’m like ya’ll. I came back. They’re like ‘Why’? ‘For ya’ll.’ Just for them to see too, look what I’ve done. I came back. I’m using what I’ve learned” (Initial Interview, lines 217-221).

In one lesson on forensics, Shelly showed her students a slideshow of her experiences as a researcher in London. In this capacity, Shelly’s role was to dig up the skeletons of bodies in a
15th century cemetery in order to study the DNA of individuals who died of the black plague. This presentation garnered a lot of interest from the students as many asked questions about how she conducted her research. Some of these questions included: (1) Where would you extract the DNA? (2) How do you determine whether the skeleton is male or female? (3) What happens if the individual changed genders? These questions also led to discussions about the morals of an individual changing genders and the morals of digging up dead bodies in order to do research.

In another lesson on acid rain, Shelly showed her students pictures that she had taken of statues while she was working in Paris. Shelly initiated the discussion on acid rain by asking the students, “What is acid rain? Is it good rain or bad rain? What does it do?” (Field Notes, 5/2/11). This garnered student responses and led to a discussion on the effects of pollution on global systems. Shelly then showed her students pictures as a way to illustrate how acid rain played a role in the appearances of the statues. Students noted many discolorations, indentions, and chippings on the statues, and this led Shelly to ask students to consider ways to reduce pollution.

**Continuity to Lessons.** As a novice high school teacher, Shelly noted that she thrived off of structure and continuity. Thus, in planning for this course, she and Linda, the other conceptual chemistry teacher, used themes to organize the different concepts taught. These themes were important to Shelly because they provided her with focus and direction as she navigated through teaching this newly designed course. The use of thematic organizers allowed Shelly to bring in ethical and moral dilemmas because she saw them as applications of the concepts taught. She stated, “I would say pretty much what my goal was, is for every unit I would introduce them into what the theme of the unit was and then what we were going to cover within that theme and then to tie it together we would kind of, I would mention the theme as we were going along, but we
stuck to our applications. Then at the end we would try to do kind of something where either using an activity or lab or video or something hands-on, visual that says okay, this is what you learned, apply it. How does this connect?” (Final Interview, lines 21-26).

During the “Petroleum Breaking and Making Bonds Unit”, students were presented with concepts of electron shells, covalent bonds, ions and ionic bonds, chemical reactions, energy efficiency, and fossil fuels. Although all of these concepts were covered, the theme for the unit was petroleum and how it was used in society. In order to close out this unit, Shelly presented the students with a project that they were required to complete in which they were to work in groups in order to design a vehicle that could use an alternative energy source. This activity gave students the opportunity to take the information that they had learned about energy efficiency and fossil fuels and apply it to a solution that would reduce the use of petroleum. Shelly believed that students could relate to this project because many of the students drove cars and the rising price of gasoline really had an effect on them at a personal level. Thus, this example showed an instance where Shelly used an activity as a means of having the students connect and apply what they had learned to an authentic situation.

Teachable Moments. Socioscientific issues were also included because they allowed for teachable moments during the lessons. Although these teachable lessons led to last minute changes in lesson plans and teaching “on the fly”, Shelly believed that these lessons were beneficial for the students and garnered a lot of student participation. She said, “I hate to say it but it was really fortuitous that there was the tsunami in Japan because that literally had been the water theme, it tied in the petroleum theme, it tied in the nuclear chemistry theme. I mean it was great for us to learn from it. It was terrible that it happened” (Final Interview, lines 28-31).
One example of a teachable moment was in a lesson mentioned earlier in the nuclear chemistry thematic unit. Shelly stated, “We had talked about Chernobyl and we actually did a lot of cross curriculum, especially with that unit because we looked at not only the scientific applications of how does an atomic weapon get created, what is nuclear energy? How is it used? But we also looked at the historical application. So we looked at the effects of the atomic bombing on Japan. We looked at the effects of the nuclear meltdown at 3-Mile Island and at Chernobyl. It just happened to come the same week as the 25th anniversary, so that just worked out really well this semester” (Final Interview, lines 36-42).

Another example of a teachable moment that occurred was the death of Osama bin Laden. Shelly mentioned how her principal sent out an email that said, “You [should] feel free to use it as a teachable moment” (Post Interview 1, line 37). Although she had not originally planned to bring this event up in her class, Shelly used it in order to initiate a discussion about the ramifications of his death. This led to a lot of student participation as they grappled with how his death would affect the use of petroleum, the economy in general, the safety of the United States, military personnel and their families, and Al Qaeda. Students raised a lot of questions concerning the ethical dilemmas of not showing bin Laden’s dead body in the news, the United States’ approach to his burial, and the fact that many military personnel had lost their lives and limbs in the past while searching for him.

In summary, three themes emerged as to why Shelly used socioscientific issues in her conceptual chemistry class. These themes were: (1) SSI’s were used as a way to explain her past work experience and provide students with opportunities to solve work-place dilemmas, (2) SSI’s were used as a way to bring continuity to lessons that were organized into thematic units,
and (3) SSI’s were used as teachable moments that allowed students to apply the concepts learned with the current societal events.

**SSI and Underlying Beliefs about Nature of Science.** Within the context of her conceptual chemistry class, Shelly relied heavily on discussions, labs, and videos in incorporating socioscientific issues. This was due to the fact that she believed that her students learned best through “hands on experiences [because] most of them are visual students” (Initial Interview, line 229). Shelly believed that having these types of learning experiences opened up more opportunities for discussions in her lessons. She mentioned, “So it opens up in a way that I’ve noticed, it definitely opens up more discussion between the students and the teacher because they’re not just notes, notes, notes, notes, notes” (Initial Interview, lines 242-244).

The lab activities were designed to help students understand that science was not exact and can change at any moment. Shelly noted, “Depending on what happens today in the lab, it can totally change. And that’s what I tell my kids every day is that science is not exact. That is an oxymoron because one small mistake or change and it totally changes theories and laws. And that’s what I try to tell them is that just because this is what we thought for so long does not mean that it’s written in stone. Even if it’s written in stone doesn’t mean it can’t be x’d out” (Final Interview, lines 106-110). This statement speaks to one of the tenets of the nature of science that describes science as tentative (American Association for the Advancement of Science, 1993; Lederman, 1992; National Research Council, 1996).

In one particular lesson involving forensics, Shelly initiated a discussion about her previous work experience of fingerprinting individuals in order to look for patterns. Students talked about how DNA evidence is not always exact and how sometimes individuals are placed in jail for crimes they did not commit. Students then began to mention how in some cases,
individuals were eventually released from prison because the DNA samples that were retested ended up exonerating the accused persons. This led Shelly to explain that there are indeed times when DNA testing can lead to a wrongful conviction of an individual and that several factors should be examined when looking at evidence. As a way to talk about different pieces of evidence that can be used, Shelly allowed her students to take samples of their fingerprints and showed them different identifying factors that they should look for in examining their own fingerprints. This laboratory activity provided the students with the opportunity to examine characteristics about themselves that they had never noticed before. For instance, one student noticed how he had a double loop and he explained how it “goes this way and back around.” In response to this student, Shelly said, “It’s what is called an island. This is an identifying factor. Sometimes they nickname it an island in a stream.” This student then said to another student, “My junk is off the map, bruh. I got an island.” Shelly then said, “It could also be classified as a pocket loop. I’ve never seen this before” (Field Notes, 5/12/11). This laboratory activity served to show students that although each individual does have identifying factors, sometimes science is not exact and can lead to errors that can cause negative repercussions.

Lessons involving socioscientific issues also helped students to think outside of the box. Shelly noted, “Things like that help, just so that they start to think and not always memorize, which is what they’re so used to doing, because that’s not necessarily the case and they have to start thinking outside the box or realizing that there’s other ways to look at something” (Final Interview, lines 114-116). It was through these discussions of socioscientific issues that students were able to think of solutions that they normally would not have considered.

For example, Shelly had students participate in a project in which they had to design cars that could run off of alternative fuel sources. This project served as a conclusion to the petroleum
unit. Because students were so used to operating vehicles that ran on petroleum, this forced them to consider alternative ways of fueling their vehicles. After conducting research for this group project, students presented their solutions. Some of the solutions included the creation of a “Veggie Wagon” that ran off of vegetables, creating a car that runs off of dirt and water, and creating a car that ran off of half electric energy and half gasoline. The examples mentioned above, as well as all other project presentations garnered many discussions about the effectiveness of the solutions. This project allowed students to think outside of the box when it came to proposing solutions to designing vehicles that would reduce dependency on petroleum.

Shelly’s belief that students should “think outside of the box” illustrated the nature of science tenet that describes the involvement of human inference, imagination, and creativity (American Association for the Advancement of Science, 1993; Lederman, 1992; National Research Council, 1996).

Socioscientific issues were also used as a context for helping students learn how to interpret evidence. Shelly believed laboratory activities were important because they provided students with opportunities to have better skill sets. In performing labs, Shelly mentioned, “It’s really more interpretive things: how to read a periodic table, how to write in a lab notebook, how to be organized, how to interpret data because that in itself for labs, it goes beyond just proving hypotheses. It’s showing them how to create a graph, how to read a graph, how to do something and connect what they did with what it means” (Final Interview, lines 171-175).

According to Shelly, it was these connections involving socioscientific issues that enabled students to understand how the labs they were engaged in related to societal dilemmas. The fact that these labs were empirically based and involved a combination of observations and inferences (American Association for the Advancement of Science, 1993; Lederman, 1992;
National Research Council, 1996) demonstrated Shelly’s belief in the importance of incorporating tenets of the nature of science into her lessons.

In one lab observed, the students were engaged in an activity where they tested the pH of different sodas in order to determine their level of acidity. The premise of this lab was based upon Shelly mentioning to students how Appalachian children were experiencing rotting teeth at a young age due to drinking too much soda. Thus, students were asked to test the pH of different soda brands in order to determine which ones were the most acidic and to come up with recommendations as to which sodas Appalachian children should avoid. This laboratory exercise demonstrated Shelly’s belief in the importance of addressing socially and culturally embedded issues, which is one of the tenets of the nature of science (American Association for the Advancement of Science, 1993; Lederman, 1992; National Research Council, 1996).

As students were engaged in laboratory activities, Shelly mentioned how oftentimes, students would get different results. She noted, “And I had several labs where the kids were like ‘Oh, it’s so and so and so and so because of this, this, and this’, but then kids across the table were like, ‘Well no, ours did this, this, and this.’ And they would say, ‘Well who’s right?’ And I would say, ‘Well both of you are right because you both followed the procedures but you got different results and that’s the main point’” (Final Interview, lines 118-122). Thus, Shelly always emphasized, “It’s all in your interpretation of the data” (Final Interview, line 118). This difference in data collected turned out to be the case in the acid/base lab mentioned in a previous example. Students obtained different data results, and this allowed for a discussion of interpreting the data that was collected and providing recommendations based on individual group results.
In summary, four themes emerged as to socioscientific issues and Shelly’s underlying beliefs about the nature of science. These themes were: (1) SSI’s were used to help students understand that science is not exact and can change at any moment, (2) SSI’s were used to help students think “outside of the box”, (3) SSI’s were used as a way to help students learn how to interpret evidence, and (4) SSI’s were used as a way to include cultural contexts in lessons presented.

**SSI and Underlying Beliefs about Chemistry.** Since Shelly had not taken a chemistry course since her undergraduate schooling, she had mixed emotions about the subject. She noted, “I know how scary it can be and how boring it can be” (Initial Interview, line 88). Her belief about chemistry helped to shape her perspective as to how her students viewed the subject. In reference to her students, she mentioned, “Most of them could care less about chemistry. They see no value in it ever. Most of them just want to blow something up” (Initial Interview, lines 281-282). She added, “I do have some in there that are just taking it because they have to have another science. They could care less” (Final Interview, lines 142-143). Shelly felt that this was because “so many of the kids came in with this attitude of I hate science” (Final Interview, lines 86-87). Shelly’s perceptions of her students’ attitudes towards chemistry helped to shape how she approached the course. It was her desire to “make it fun” (Initial Interview, line 217) for the students. Thus, Shelly incorporated socioscientific issues into her lessons as a way to help students see the value in chemistry. It was her belief that by seeing the value in chemistry, her students would become more engaged during the lessons and connect those issues to the events occurring in society. It was Shelly’s desire for her students to understand the value in chemistry because they “use it every day”, and it allowed her students to “think logically in all forms of life” (Initial Interview, lines 177-178).
In approaching the subject matter, Shelly tried to incorporate as many relevant socioscientific issues as possible. She mentioned, “I try to pick relevant topics. It may not necessarily be of interest to them, but they do affect them” (Final Interview, lines 141-142).

Some of the topics that were chosen and presented in her conceptual chemistry class during this semester included nuclear energy, petroleum, genetic engineering, and water-based issues. Thus, Shelly believed in using socioscientific issues in relevant chemistry topics in order to help students see how they were being affected by events that were occurring in society.

In summary, two themes emerged in relation to socioscientific issues and Shelly’s underlying beliefs about chemistry. Those themes were: (1) SSI’s were used as a way to help students see the value in chemistry and (2) SSI’s were incorporated in relevant chemistry topics to show students how they were being affected by societal events.

SSI and Underlying Beliefs about Chemistry Teaching. Since Shelly believed that chemistry was a difficult subject for many students to grasp, she would present socioscientific issues-based lessons in ways that connected with the overarching themes of each unit. She mentioned, “I like the themes” (Final Interview, line 130) and that “for every unit I would introduce them to what the theme of the unit was” (Final Interview, lines 21-22). Shelly believed that it was important to structure her lessons in this manner because “it’s tough teaching them to multi-task” (Initial Interview, lines 254-255). Thus, it was important for Shelly to teach chemistry in a way that allowed for the students to “stick to our applications” (Final Interview, lines 23-24). Therefore, socioscientific issues were incorporated in thematic units in order to provide students with opportunities to apply the issues presented to the themes being taught. It was Shelly’s belief that this approach was successful because students could make connections, and they oftentimes mentioned to her how they shared this information with others outside of the
school setting. For instance, Shelly mentioned, “I definitely, that’s why I like the themes which I like with the nuclear chemistry showing them Chernobyl because I want them to see that it’s not something written in a book. It’s the real-life application that really happened. If nothing else, at least it kind of, it puts a bug in their brain in a way that translates to them. When the 25th Anniversary came in, one of my students came in and she said, ‘Oh Ms. Thomas, I saw Chernobyl on the news and I told my mama all about it.’ So that’s something that really their generation would have never even heard about had we not been talking about nuclear chemistry” (Final Interview, lines 129-136).

Shelly also liked to incorporate socioscientific issues through the use of technology. She stated, “So much of what we do is technologically based” (Initial Interview, lines 267-268). “I also like to use technology in my classroom. We use the PowerPoints. I do videos through this. We’ll do review games through this. I do have a smartboard, it’s a mimeo board, interactive that I’ve yet to put up because I have yet to figure out how to put it up. I’m hoping to use that next semester” (Initial Interview, lines 255-258). She believed that using technology was important because of the growing use of technology in society. She felt that students would become more engaged in lessons when technology was used. Thus, Shelly incorporated socioscientific issues through the use of technology because she felt that it encouraged students to relate to the issues as they interacted with the technology. For instance, when Shelly initiated a discussion on the death of Osama bin Laden, she used technology in order to play a YouTube (2011) video of President Obama’s speech about this event. This allowed students to think about and discuss all of the ramifications they believed would be a result of this event. In another example, Shelly used PowerPoint slides and photographs as she talked about acid rain and the effects that it had on society. By examining the photographs, students were able to understand the effects of acid
rain and were encouraged to think of ways to reduce pollution so that these effects would be diminished.

In summary, two socioscientific issues themes emerged about Shelly’s beliefs about chemistry teaching. Those themes were: (1) SSI’s were incorporated in thematic units in order to provide students with opportunities to relate the issues presented to the larger themes being taught and (2) SSI’s were incorporated through the use of technology because it encouraged students to relate to the issues as they interacted with technology.

**SSI and Underlying Beliefs about Chemistry Learning.** After interacting with her students for the past four months, Shelly felt that her students learned chemistry best through hands-on activities. She noted, “Hands on. Most of them are visual students” (Initial Interview, line 229). Thus, oftentimes, Shelly would introduce socioscientific issues into her lessons in hands-on settings as a means for students to make connections. She mentioned, “We do a lot of demonstrations. We do a lot of labs. I give them more labs than I do my general chemistry class right now” (Initial Interview, lines 233-234). She added, “So they do a lot of group work” (Initial Interview, lines 247-248). These group interactions involving hands-on activities often led to collaborative discussions as the students sought solutions to the issues presented. For instance, in a DNA lab, students were able to perform a fingerprint analysis of themselves and engage in discussion about how DNA testing can sometimes lead to false incriminations. Students were then challenged to think of solutions and identifying factors that would reduce the chances of wrongful convictions. In the acid/base lab example mentioned previously, students tested the pH of different sodas and worked collaboratively in order to make recommendations as to which brands could cause the most harm in rotting the teeth of children living in Appalachian communities. Shelly liked to design her lessons so that, “Then at the end we would try to do kind
of something where either using an activity or lab or video or something hands-on and visual that says okay, this is what you learned, apply it” (Final Interview, lines 24-26).

Shelly also liked to incorporate real-world applications into her lessons as much as possible. She commented, “I knew that if I was just very close-minded and very straight-laced and it’s only this way instead of being more open-minded and broad-field and broad-viewed in how I taught it, the kids would have completely written it off” (Initial Interview, lines 87-90). Thus, “real-world applications because I know I use myself a lot and I’m not ashamed to tell them, you know, mistakes that I have made in the lab and consequences from it” (Initial Interview, lines 128-129). Therefore, socioscientific issues were presented in Shelly’s lessons in the context of real-world applications as a way to foster learning. For instance, during a forensics lesson when Shelly presented her research of digging up skeletons in a 15th century cemetery in order to extract DNA, students were very engaged in learning about the process and grappled with the ethics of conducting this type of research. When Shelly discussed the project that her students conducted on designing cars that ran on alternative fuel sources, she mentioned, “It was a set of activities that came with the book and we just tweaked it so that we did it at the end and they looked at the applications that we used” (Final Interview, lines 54-56). Shelly believed that this project allowed for the use of real-world applications as she noted, “I think the alternative energy unit where they had to create their own cars and the thoughts that came about exactly at the time where gas prices were starting to come to $4. Suddenly for kids, that generated so much conversation because they were like ‘Oh it costs me an arm and a leg to fill up my car’” (Final Interview, lines 43-46). Thus, Shelly believed that it was important to incorporate socioscientific issues into the context of real-world applications as a means of fostering learning.
In summary, two themes emerged in relation to socioscientific issues and Shelly’s beliefs about chemistry learning. Those themes were: (1) socioscientific issues were incorporated in hands-on settings as a means for students to make connections and (2) socioscientific issues were presented in the context of real-world applications as a way to foster learning.

Planning For and Enacting Socioscientific Reasoning. This section focuses on the way Shelly planned and enacted lessons involving socioscientific issues in her conceptual chemistry class. Shelly’s use of socioscientific issues was centered around thematic units. Throughout the entire conceptual chemistry course, six thematic units were presented in the curriculum. A curriculum map describing all six thematic units is included in Appendix D. The researcher observed Shelly during her thematic unit, which was entitled “Air Chemistry and Atmosphere”. The researcher also observed Shelly outside of her thematic unit due to the fact that all components of the conceptual chemistry course were taught and it was final exam week. Although the researcher observed many lessons in this unit that included socioscientific issues, two examples will be discussed and highlighted in this analysis. The two lessons chosen featured the use of socioscientific issues in addressing the concepts of acid rain and genetics/eugenics. These two lessons were chosen because the researcher felt that they best exemplified the practices of socioscientific reasoning as described by Sadler, Barab, and Scott (2007) and Zeidler and Nichols (2009). Even though the researcher observed more than two lessons involving socioscientific issues, she felt that analyzing two representative lessons would allow for a more close-up understanding of how Shelly organized her lessons around particular issues. Table 4.7 is a summary of all of the lessons inside of the “Air Chemistry and Atmosphere” unit where Shelly devoted a major portion of the period to socioscientific issues in teaching specific chemistry concepts.
Table 4.7: *Summary of Shelly’s SSI Lessons in the Air Chemistry and Atmosphere Unit*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
<th>Summary of Events</th>
</tr>
</thead>
</table>
| Kinetic Molecular Theory     | 4/25/11| 1) Petroleum Project Presentations  
|                              |        | 2) PowerPoint Notes on Thermal Energy  
|                              |        | 3) Kinetic Molecular Theory Cartoon Activity                                      |
| Acids and Bases; Global Warming | 4/29/11| 1) Acid/Base Worksheet  
|                              |        | 2) Movie: The History Channel- A Global Warning?  
|                              |        | 3) High School Crash Reenactment (for prom)                                      |
| Acids and Bases (Acid Rain)  | 5/2/11 | 1) Gas Laws Quiz  
|                              |        | 2) Discussion on death of Osama bin Laden  
|                              |        | 3) Acid Rain Discussion                                                          |
| Acids and Bases (Labs)       | 5/3/11 | 1) Bellringer  
|                              |        | 2) Lab- Acid/Base  
|                              |        | 3) Lab- Charles’s Law                                                             |

Since this was the last unit that would be taught for the course, Shelly had to plan lessons that would engage students for the remaining two weeks of the school year. Table 4.8 is a summary of all of the lessons for the remaining two weeks when Shelly devoted a major portion of the period to socioscientific issues in teaching specific chemistry concepts.

Table 4.8: *Summary of Shelly’s SSI Lessons Outside of a Thematic Unit*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
<th>Summary of Events</th>
</tr>
</thead>
</table>
| Genetics/Eugenics | 5/11/11 | 1) Bellringer  
|                 |          | 2) Genetics and Eugenics Discussion  
|                 |          | 3) DNA Riddle Activity (The Ultimate Pedigree Challenge)  
|                 |          | 4) Audiovisual Stimuli                                                            |
| Forensics      | 5/12/11 | 1) Forensic Fingerprints PowerPoint  
|                 |          | 2) Fingerprinting Activity  
|                 |          | 3) Slideshow of Teacher’s Previous Research with Skeletons  
|                 |          | 4) Audiovisual Stimuli                                                            |

*Planned Curriculum.* Shelly devoted a significant amount of time to planning lessons that included socioscientific issues. In fact, she mentioned during one class period that oftentimes,
she stayed after school until at least 6:00 pm in order to be prepare for her lessons (Field Notes, 5/2/11). This was because Shelly liked to center her socioscientific-issues based lessons around the central topic of the thematic unit, and this required a lot of forethought and preparation. Shelly was also very organized and liked to have everything in order when it came time to present her lessons. This was evident as she always had her objectives, essential questions, lesson agendas, and any other instructions listed on the board before the students entered her classroom.

The lesson on acid rain took place on May 2, 2011. Shelly posted two essential questions on the white board that she hoped the students would be able to answer by the end of the class period. These two questions were: (1) How are heat and temperature different? and (2) How is a gas affected when temperature, volume, and pressure change? Shelly also posted the state standard that she intended to cover. It read:

“SPS5: Phases of matter as related to atomic/molecular motion

(a) Molecular motion of states of matter

(b) Behavior of gases

(c) Acids and bases

Also listed on the white board was the agenda for class which included the following: (1) Charles’s and Boyle’s Law Quiz, (2) Review Acid/Base, (3) EQ, and (4) Lab- Acid/Base and Charles’s Law. This agenda corresponded with the plans that she mentioned to the students the previous week in class when she said, “On Monday, we will be doing labs and talking about the acid rain spill” (Field Notes, 4/29/11). Even on a side board in the classroom, Shelly listed out the lab instructions as follows:
1st Block Labs
1) Write down the hypothesis for BOTH labs on 2 separate sheets of paper in your lab book.
2) Make sure you read each lab carefully.
3) Don’t forget your questions for Lab #1 and #2.
4) You may “cut out” the procedures from each handout to put into your procedures section of your notebook.
5) Don’t forget to write down All your observations and Data Table under your results section.

The genetics/eugenics lesson occurred on May 11, 2011 during an extended class period due to standardized testing. In planning for this lesson, Shelly mentioned, “What we’re going to actually get to that week of EOCTs, they’re going to be doing forensics work. What we are going to do is a little forensics work, a little genetics” (Initial Interview, lines 309-310). “We get into epigenetics then and human genome tampering and genomic cloning and genetic engineering and we start talking about those topics. Then that leads to forensics and they do genetic crime scene and things like that. That’s when we really get to talk about ethics and then I tell them stories that I’ve dealt with in my research” (Initial Interview, lines 313-317).

On the whiteboard in her class, Shelly posted the agenda for the day’s lesson. The following topics were listed:

1) Genetics
2) Forensics
3) Audio Visual Stimuli

For Shelly, the genetics portion consisted of a discussion on cloning and manipulating genes, an activity where students would use Sponge Bob and Patrick in order to solve Punnett Squares, and the solving of “The Ultimate Pedigree Challenge” (Latham & Jaffe, 1997) riddle. Since this was an extended class period, Shelly’s plans also included the students watching a movie that was not related to science. She called this “audio visual stimuli.”
In summary, three themes emerged as to how Shelly planned lessons involving socioscientific issues. Those themes were: (1) socioscientific issues-based lessons were often planned around the central topic in a thematic unit, (2) socioscientific issues-based lessons were structured and organized in advance, and (3) socioscientific issues-based lessons were teacher-centered, with little input from students in terms of contributing to the planning process.

*Enacted Curriculum.* Socioscientific-issues based lessons in Shelly’s conceptual chemistry class were mainly enacted through discussions, laboratory activities, demonstrations, and the use of technology. A lot of times, the enacted lessons occurred as planned. However, there were a few occasions where this was not the case due to outside events having an effect on the way the plans were enacted. In a lot of cases, time constraints also determined what and how an SSI-based lesson was enacted. For Shelly, this was never a concern because she was “laid-back in my approach” (Initial Interview, line 87) to teaching the course. In those instances where all of the agenda was not covered, Shelly would rearrange her lesson plans for the next day in order to incorporate what was not covered in the previous day’s lesson.

For the acid rain lesson, although Shelly had planned to have students engage in lab activities and discuss the implications of acid rain, her plans changed dramatically. This was due to the major news event of the death of Osama bin Laden. Shelly noted, “They were going to do labs and show acids and gas laws. [Then], you know take the quiz. I actually had no intention of talking about it in first block until I got an email from my principal saying that this is a teachable moment. You feel free to use it as a teachable moment. Even though it is a chemistry class, it is a conceptual chemistry which means it is a real-world application class. Even though Osama bin Laden’s death really maybe doesn’t have a huge impact on chemistry, it is still a world-wide impact and that’s really the theme of this entire class curriculum is the impact on the world for
application. So it was kind of a fly-by-the-seat-of-my-pants lesson. Let them see it. Let them discuss it. I’m sure they have questions. Let’s let it be an open spring board for them” (Post Interview 1, lines 35-43).

As the students arrived to class, the television was turned on to CNN News where headline reports indicated that Osama bin Laden was killed the previous night. After the tardy bell rang, Shelly went over the agenda for this day and for the remainder of the week. She then announced, “Osama bin Laden was killed last night by US Special Forces. Apparently around 10:30 or 11:00 our time the announcement was made. After the quiz, I will replay the CNN video of the announcement. This is an event that will probably change our entire global policy. So after the quiz, we will set aside some time to talk about it because you guys are raising some good questions” (Field Notes, 5/2/11). As students studied for their quiz on Boyle’s Law and Charles’s Law, Shelly continued to let the news play in the background. She then placed the television on mute as the students took their quiz. Upon completion of the quiz, Shelly gave a summary of the events that occurred the previous night and then played a YouTube (2011) clip of President Obama’s speech. After students viewed the clip, Shelly led a discussion about the events of the previous night. This allowed for students to ask a lot of questions about the event and to voice their opinions about the ramifications of the event. Students were given opportunities to discuss all of these questions and some students even talked about knowing individuals serving in the military and how this could affect them and their families. In fact, one of the students mentioned that a teacher at Clearview High School had a picture outside of her classroom door of an individual who died while serving in Iraq and how an event such as the one that occurred the previous night was a good thing for his family because they would probably feel that the fallen soldier’s death was not in vain. The discussion about Osama bin Laden’s
death spanned approximately 30 minutes, and Shelly had to end it prematurely because students had to take their daily restroom break. However, discussions about the event continued after the class was dismissed to go to the restroom. When students returned from the restroom, Shelly only had 15 minutes to talk about acid rain. The discussion started with the causes of acid rain and students were asked to think about ways to reduce pollution. Then, Shelly showed students pictures that she had taken while she was in Paris and pointed out where acid rain affected the appearances of statues through discolorations and through chipping and erosion.

For the most part, the genetics/eugenics lesson was enacted the way Shelly had originally planned for it to occur. Students were introduced to the topic of eugenics by Shelly providing a definition. She defined eugenics as “when you take the genes and change them to what you want them to be. It’s called genetic engineering” (Field Notes, 5/11/11). Then she led students into a discussion by asking the following question: “Do you see any problems?” (Field Notes, 5/11/11). Students immediately began to provide responses such as killing, deformation, and mutations. This led to a discussion on cloning and what happens if you clone someone who is not perfect. Students suggested that those who were not perfect would be ostracized, and this comment allowed some students to link this scenario with what Hitler was trying to accomplish when he was trying to create the perfect Arian race of blond hair, blue-eyed individuals. Shelly then mentioned that this went along with her master’s research and how genetic research started out with trying to keep out trisomy 23 in order to “keep out Down’s Syndrome” (Field Notes, 5/11/11). This led to the question of “Where do you stop?” Students began to discuss the ethics of where you should stop and one student even mentioned, “I think it should be curing and for nothing else.” Other questions that surfaced included: (1) Who’s to say we are going too far? (2) Who has the right to tell me to change my child to be smarter, have a certain hair color, or from
being fat? (3) If you have something wrong with you, would you want to fix it? (4) What happens if we end up doing more damage than good? Students were given the opportunity to address these questions and to look at the pros and cons of cloning and manipulating genes. This garnered a 45 minute discussion on the topic.

As a way to continue on with the topic of genetics, Shelly had students complete a worksheet on Punnett Squares that involved the cartoon characters Sponge Bob and Patrick. The purpose of the worksheet was for students to understand how Punnett Squares worked so that they could eventually complete “The Ultimate Pedigree Challenge” (Latham & Jaffe, 1997) riddle. With this riddle, students were asked to figure out through drawing a diagram how the man described could be married to his grandmother and yet be his own grandfather. This riddle garnered a lot of discussion as students began to discuss inbreeding and the ethics behind it. Because the riddle took longer to finish than anticipated, Shelly decided to save the forensics part of the lesson for the next day and allow the students to conclude the rest of the class period by watching the movie Madagascar.

In summary, two themes emerged as to how Shelly enacted socioscientific issues-based lessons. These themes were: (1) Shelly was flexible in using teachable moments to make changes to her planned lessons (2) time constraints determined what and how an SSI-based lesson was enacted.

**Fostering Socioscientific Reasoning.** In reflecting on the discussion on the death of Osama bin Laden, Shelly mentioned, “So it definitely hit home for some kids. Some kids really see this as being a huge, huge current event. Others could care less. For them, it’s just news. It’s not affecting them. It’s not an immediate change in their lifestyles. So if nothing else, it exposed them to a different way of thinking. If it’s nothing but exposure by osmosis, it is still exposure.
I’m sure some of them were like, ‘Yes it gets us out of work in a way’, but they don’t realize it is still work” (Post Interview 1, lines 24-29).

The discussion on the death of Osama bin Laden also fostered a connection with what the students had learned previously in the petroleum unit. Shelly noted, “It does make me feel good when you see them tie in things that we cover with what is going on. Sometimes though, I’m not necessarily sure they remember the fact that we did that or if it’s just because I drill that into them and it’s second nature. They all are concerned. You know most of them drive. Most of them have to pay their own gas. I remember being in high school at their age and gas was 98 cents a gallon. I could fill up my car on 10 dollars. So I cannot imagine being their age again with the job I had then and trying to fill up my gas tank. Oh my Lord, I’d be walking everywhere. So that is one of those things, the reason I think it came up, because that is one of those immediate effects on them. Are they going to be able to afford gas to put in their car? So I like the fact that at least the themes that we cover in this class do have real-world applications as they unfold in history” (Post Interview 1, lines 52-62).

Sadler’s (in press) Assessment of Socioscientific Reasoning. In this section, the researcher examined each of Shelly’s lessons in terms of opportunities for socioscientific reasoning. More specifically, each lesson was analyzed with respect to complexity, perspectives, inquiry, skepticism, and ethics and morals. The categorizations of each lesson are listed in tables 4.9 – 4.14. Shelly’s categorizations for each heading are indicated by the description being typed in bold font. These categorizations were indicative of what the researcher believed best described Shelly’s fostering of socioscientific reasoning. An explanation for each categorization is given underneath each table.
Table 4.9: Categorization of Kinetic Molecular Theory Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning

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<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
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<td>Teacher provides opportunities for students to describe differences among stakeholders and discuss the significance of conflicting interests.</td>
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<th>Ethics and Morals</th>
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<td></td>
<td>Teacher provides no opportunity for students to raise ethical and/or moral issues.</td>
<td>Teacher provides little opportunity for students to consider ethical and/or moral issues.</td>
<td>Teacher provides ways for students to consider ethical and/or moral issues.</td>
<td>Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a way for students to discuss the significance of a moral or ethical stance.</td>
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For this lesson, the incorporation of socioscientific issues was most evident in the group project presentations that involved students designing an automobile that used alternative fuel sources as a way to reduce dependence on petroleum. Thus, the researcher chose to categorize Shelly’s fostering of socioscientific reasoning based upon this aspect of her lesson.

**Complexity.** The researcher categorized Shelly as a 4 for complexity because she provided opportunities for students to come up with solutions for designing cars that used alternative fuel sources. Students were able to examine the issue from multiple perspectives based on the views and opinions of different stakeholders, as Shelly gave them the opportunity to do research in the computer lab and to view advertisements. In fact, during one of the presentations, a student asked, “Do you think, miraculously, if the economy gets better, that they will continue to need these cars?” Shelly responded, “Yes, I do believe in order to sell these cars and so that production will get bigger because we are moving from a conservative to a liberal shift in global factors. We are trying to repair global factors. For instance, oil is a non-renewable source that will eventually dry up” (Field Observations, 4/25/11). In reflecting on how she introduced the project to the students, Shelly mentioned, “We actually pulled up a lot of Super Bowl advertisements. So I passed that to them, and said, ‘You know, a lot of it was on the new fusion cars and hybrid cars. What would you think would be a good idea?’ What the kids did when we went to the library to do research in the computer lab, so many of them said, ‘Does it have to be one of our inventions or can we look at something that is already out there?’ I said, ‘Most definitely look at what’s out there because that’s the next wave of the future.’ So that’s what some of them did, and they were pretty shocked about not only were there so many cars out there with either alternative fuel sources or better mileage, but they were getting to be very
affordable. So if nothing else, it’s helping them to become better consumers as well” (Final Interview, lines 64-72). All group project presentations on this day showcased different designs and students were able to understand the complexities of designing an automobile that met the requirements of the project guidelines and also contained some of the luxuries that teenagers wanted to have in their vehicles.

*Perspectives.* The researcher categorized Shelly as a 4 as related to perspectives because she gave students the opportunity to view the alternative fuels issue from multiple perspectives as they researched the topic. Some of the resources used included commercial advertisements, models in the conceptual chemistry textbook, and Internet sites. This allowed for student groups to create various designs that met the project requirements.

*Inquiry.* The researcher categorized Shelly as a 1 for inquiry because the alternative fuels project was not designed in such a way that students were given an opportunity to consider a plan for inquiry. The students were only required to research the topic, come up with a design, and present their product. They were not given the opportunity to reflect deeply about the designs presented in class. Thus, the researcher did not feel that students recognized the need for understanding the importance of collecting scientific or social data with regards to their creations.

*Skepticism.* The researcher categorized Shelly as a 2 with respect to skepticism because of the different advertisements she provided the students with as an introduction to the project guidelines. Students were able to see that differences existed among stakeholders as they examined advertisements for hybrid cars, regular cars, and gasoline companies. Although these advertisements were used to help students think about ideas for creating their group designs, they
did not allow for students to describe differences among the stakeholders. Instead, they served as a launching pad for generating ideas for designs.

*Ethics and Morals.* The researcher categorized Shelly as a 3 in ethics and morals because students were given the opportunity to consider the ethics of designing vehicles that used alternative energy sources. As Shelly reflected on how she presented the project guidelines to the students, she said, “*And then we tied it back to the petroleum unit and how gas prices were so expensive. One of the main chemical reactions we use every day is driving to and from, you know the powering of the car, the use of that oil to make your car run*” (Final Interview, lines 58-60). Students were also given the opportunity to consider the future effects of the continued use of petroleum for powering vehicles and how that would affect natural resources. For instance, during one presentation, Shelly facilitated a discussion on this issue. She stated, “*I saw last night that gas went up again. It is $3.77 here today and $3.85 in [name of city]. Here’s one thing that [name of college] is doing for employees not living in [name of county]. They are offering them a four-day work week by increasing their work day. Why would this affect employees?*” One student responded, “*It cuts down on gas consumption.*” Shelly continued, “*Friday is the largest day for gas consumption. We cut our budget in [name of school system] last year by cutting 20 days off of school because of gas issues. Next year, it will still be a 160 day school year. By 2014, they are even thinking about cutting the school year more. One of the options would be (a) limiting school buses. How would this affect students? Remember, it’s a constitutional problem because every child has the right to this transportation. The second option would be (b) having four-day school weeks*” (Field Notes, 4/25/11).
Table 4.10: Categorization of Acids and Bases/Global Warming Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning

<table>
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In this lesson, the class period was cut short due to an assembly for juniors and seniors who would be attending the prom. The assembly consisted of a crash scene reenactment that emphasized the importance of students not drinking and driving during the prom festivities. Thus, Shelly’s lesson plan for this day consisted of the students completing a worksheet and watching a video that discussed the socioscientific issue of global warming. Therefore, the researcher’s categorizations are based upon the topic of global warming and how this was presented in Shelly’s lesson.

**Complexity.** The researcher categorized Shelly as a 1 for complexity because students were only given the opportunity to consider simplistic solutions to the issue. In fact, at the beginning of the class discussion, Shelly asked the students, “What would happen if there was a global disaster?” (Field Notes, 4/29/11). Students responded with answers and did not go into any details about their responses. Instead, Shelly allowed students to voice their opinions as a way to encourage students to think about the issue before presenting the video. Thus, students did not consider multiple factors. They instead expressed their opinions based on what they had heard about this topic from discussions in previous science classes.

**Perspectives.** The researcher categorized Shelly as a 2 in perspectives because the students were only provided one source for examining the issue of global warming. That source was the video that was shown during class. Although the video provided computer animations, as well as a look at fourteen extreme locations impacted by global warming, no other sources were provided for students to assess the issue presented.

**Inquiry.** The researcher categorized Shelly as a 1 in relation to inquiry because the students were not given an opportunity to recognize a need or suggest a plan for inquiry. Instead, this topic was presented as a filler because the class period was cut short due to the assembly. In
fact, as Shelly introduced the video to her students, she indicated that they would have
“anywhere between 15 and 25 minutes to watch the movie”. She then instructed the students that
they did not have to take notes and that there would be no writing prompts “as long as they
stayed quiet” (Field Notes, 4/29/11).

Skepticism. The researcher categorized Shelly as a 2 for skepticism because at the start of
the discussion, as a group of students briefly described the reasons they believed that global
warming was occurring, there were a few students who mentioned that they heard other sources
declare that global warming did not exist. Thus, this led to Shelly indicating that indeed different
people hold varying views about this controversial topic. This allowed for her to segue into
giving a synopsis about the video the students were getting ready to view and to prepare them for
the types of data sources that would be presented that support the notion that global warming
does exist.

Ethics and Morals. The researcher categorized Shelly as a 2 in ethics and morals because
students were given the opportunity to discuss the ethics behind global warming. In fact, when
Shelly raised the question about what would happen if a global disaster occurred, this allowed
students to voice their opinions about the ramifications of a global disaster and to discuss reasons
they believed a global disaster would occur and the ethics behind these reasons.

Table 4.11: Categorization of Acids and Bases/Acid Rain Lesson Using a Modified Version of
Sadler’s (in press) Assessment of Socioscientific Reasoning

<table>
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In this lesson, students were given the opportunity to briefly discuss acid rain. The majority of the class period was spent discussing the death of Osama bin Laden, which had just occurred the night before. Thus, the researcher categorized Shelly’s lesson with a focus on the topic of Osama bin Laden’s death.

**Complexity.** The researcher categorized Shelly as a 3 for complexity because she only allowed for students to come up with solutions and did not get into the pros and cons of the
solutions that the students discussed. In reflecting on this issue, Shelly mentioned, “I think there are some that really got a lot out of it and when we were coming back from the bathroom, you unfortunately missed this. I had several of the kids asking really good questions. They were like ‘what do we do now? What is this going to mean for us? Do you think it’s over? Are we moving on?’ I said, ‘You know those are great questions about what everybody in the world is asking right now, and nobody knows. It’s definitely a turning point.’ So it definitely hit home for some kids” (Post Interview, lines 20-25). Students were able to understand that potential solutions would be tentative as the repercussions of this event continued to unfold. In fact, Shelly gave the analogy of the United States being on the offensive and Al Qaeda being on the defensive as a result of this event. She mentioned, “Because we have gone in and done what we wanted to do, it is going to take some time if they decide to regroup. That means we now have them on the defense. We are on the offensive. They have to scramble after us. We are the ones who are trying to control the game play. We make the decisions. They have to react to our decisions. So in war, if you can ever be on the offense, you always have the upper hand. So this is a major, major turning point for us” (Field Notes, 5/2/11).

Perspectives. The researcher categorized Shelly as a 4 in perspectives because multiple viewpoints were assessed from this issue. With the aid of live CNN news coverage and a YouTube clip of President Obama’s speech concerning the death of Osama bin Laden, students were able to think about how this event had a major impact on the United States. Some of the viewpoints the students looked at as they discussed this topic included those who have stock (as the stock market increased significantly on this day according to CNN News), those individuals traveling by air (as Shelly mentioned that a friend of hers from another country who worked in the US Embassy was told that they were on high alert), Al Qaeda followers who had just lost
their leader, and military personnel and their family members who had participated in war at some point since the September 11, 2011 attacks.

Inquiry. The researcher categorized Shelly as a 1 for inquiry because the students were not given the opportunity to recognize the need for inquiry. Instead, the information was presented to the students through the use of CNN News and through a YouTube (2011) video of President Obama’s speech. Because this was the case, students did not see the need to collect scientific or social data related to the event. Instead, they accepted the topic as an event that would bring about major consequences in the United States and other countries for years to come.

Skepticism. The researcher categorized Shelly as a 3 in skepticism because the students were able to understand that differences did exist among stakeholders. Some of the stakeholders mentioned throughout the discussion included: (1) the aftermath of the United States economy and those involved with stocks, (2) the effects on military personnel and their families who had been fighting in the war, (3) the reconfiguration of Al Qaeda, (4) Pakistan’s response to the United States’ involvement, and (5) the way of life for the people in Pakistan. Shelly provided the students with opportunities to describe the different views that each stakeholder held, but this did not lead to thoughts of the significance of conflicting interests.

Ethics and Morals. The researcher categorized Shelly as a 3 in ethics and morals because students were given the opportunity to consider multiple ethical and moral issues concerning the death of Osama bin Laden. Some of these issues included: (1) the ethics of bringing military personnel home early, (2) the ethics of not showing Osama bin Laden’s dead body on the news, (3) the morals of adhering to the Muslim tradition of burial within 24 hours after death, and (4) the ethics of going into Pakistan and killing Osama bin Laden without alerting the Pakistani
government with regards to the plans of the United States government. Although these ethical and moral issues were addressed, Shelly did not provide opportunities for students to discuss the significance of these stances.

Table 4.12: Categorization of Acids and Bases (Labs) Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning

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<td>Teacher provides opportunities for students to describe differences among stakeholders and discuss the significance of conflicting interests.</td>
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<tr>
<th>Ethics and Morals</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher provides no opportunity for students to raise ethical and/or moral issues.</td>
<td>Teacher provides little opportunity for students to consider ethical and/or moral issues.</td>
<td>Teacher provides ways for students to consider ethical and/or moral issues.</td>
<td>Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a</td>
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</table>
In this lesson, students completed labs that focused on the concepts of acids and bases and Charles’s Law. The acids and bases lab was a titration lab that provided students with the opportunity to test the pH of different soda brands. This lab was introduced with a discussion of how soda had an effect on teeth. Shelly mentioned, “In Appalachia kids, their teeth are falling out because they drink so much Mountain Dew. Mountain Dew has a pH of around 3” (Field Notes, 5/3/11). Students were then allowed to discuss solutions to this issue and to test different sodas to determine which brands were the most acidic.

**Complexity.** The researcher categorized Shelly as a 1 for complexity because she only allowed students to come up with simplistic solutions and did not get into the pros and cons of the solutions that the students discussed. The main solution that students presented included drinking less soda and more water. Multiple factors were not considered as the students only looked at the issue of rotting teeth as being the result of drinking acidic sodas.

**Perspectives.** The researcher categorized Shelly as a 2 in perspectives because the students’ thoughts of rotting teeth as a result of drinking too much soda were only examined because of news that Shelly presented to them. This news was based on an article that Shelly read in the past. No other outside sources were used in presenting this material to the students.

**Inquiry.** The researcher categorized Shelly as a 2 for inquiry because the students were given an opportunity to collect scientific data to determine the acidity of different types of soda. However, not much time was allowed for students to reflect deeply on how the lab related to the rotting teeth as the students were asked to answer a few questions on the lab handout that
focused on summarizing the results they obtained. No time was allowed for class discussion of the results as students were then asked to complete a shorter lab that related to Charles’s Law.

_Skepticism_. The researcher categorized Shelly as a 1 for skepticism because the students were not given the opportunity to declare differences among stakeholders, such as families, soda companies, and businesses who sale the products. Instead, students were presented with the issue and then allowed to test the acidity of different sodas in a lab setting.

_Ethics and Morals_. The researcher categorized Shelly as a 1 in ethics and morals because Shelly did not provide students with the opportunity to discuss any ethical or moral issues concerning rotting teeth. Instead, this issue was used to introduce the premise for the students to perform the start of the lab. Thus, students saw this as a straightforward issue that could easily be resolved by reducing the intake of soda.

Table 4.13: _Categorization of Genetics/Eugenics Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning_

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
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<thead>
<tr>
<th>Perspectives</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
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</thead>
<tbody>
<tr>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
<td>Teacher provides opportunities for students to assess the issue from a single perspective.</td>
<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
<td>Teacher provides opportunities for students to assess the issue from multiple perspectives.</td>
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<table>
<thead>
<tr>
<th>Inquiry</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher does not provide opportunities for students to present</td>
<td>Teacher provides opportunities for students to suggest</td>
<td>Teacher provides opportunities for students to suggest</td>
<td>Teacher provides opportunities for students to suggest</td>
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<tr>
<td>Issue</td>
<td>Description</td>
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<td></td>
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<tr>
<td>Skepticism</td>
<td>Teacher does not provide opportunities for students to be able to declare differences among stakeholders.</td>
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<tr>
<td>Teacher provides opportunities for students to suggest that differences likely exist among stakeholders.</td>
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<td>Teacher provides opportunities for students to describe differences among stakeholders.</td>
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<tr>
<td>Teacher provides opportunities for students to describe differences among stakeholders and discuss the significance of conflicting interests.</td>
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<tr>
<td>Ethics and Morals</td>
<td>Teacher provides no opportunity for students to raise ethical and/or moral issues.</td>
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<tr>
<td>Teacher provides little opportunity for students to consider ethical and/or moral issues.</td>
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<td>Teacher provides ways for students to consider ethical and/or moral issues.</td>
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<tr>
<td>Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a way for students to discuss the significance of a moral or ethical stance.</td>
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Although this lesson was not a part of a thematic unit, it involved a discussion of genetics and eugenics. Students were given the opportunity to voice their opinions concerning cloning and manipulating genes. Students were also provided with the opportunity to complete “The Ultimate Pedigree Challenge” (Latham & Jaffe, 1997) riddle in which they were asked to draw a pedigree of a man’s family based on the clues given in a poem.

**Complexity.** The researcher categorized Shelly as a 3 for complexity because she provided students with opportunities to understand that there are many questions that have to be taken into consideration when deciding whether to be for or against this issue. Some of these questions included: (1) Where do you stop? (2) If something is broken should research fix it? (3) Is this playing God? Students were able to see that these questions did not have single, simplistic solutions as they wrestled with how this type of research has huge effects on individuals and society.
**Perspectives.** The researcher categorized Shelly as a 4 in perspectives as students were given opportunities to examine this issue from multiple viewpoints. Some of the perspectives used to discuss this issue included parents of children who have a disorder, researchers who were for and against cloning, Jewish individuals who were ostracized because of Hitler, and lawyers who have participated in court cases dealing with manipulating genes.

**Inquiry.** The researcher categorized Shelly as a 1 for inquiry because the students were not given an opportunity to present suggestions for inquiry or to collect scientific data with regards to genetics or eugenics. Instead, this lesson served more as a discussion of, and ramifications of, cloning and manipulating genes.

**Skepticism.** The researcher categorized Shelly as a 2 in skepticism because the students were able to discuss that stakeholders have varying opinions with regards to cloning and manipulating genes. Several examples of different stakeholders were mentioned in this discussion. However, Shelly did not provide opportunities for students to describe the differences among stakeholders. Instead, the examples mentioned served as instances in history that contributed to the topics being discussed.

**Ethics and Morals.** The researcher categorized Shelly as a 3 in ethics and morals because students were given the opportunity to discuss the ethics behind cloning, manipulating genes, and inbreeding. These topics garnered a lot of discussions as students commented on the ethics of “fixing” individuals and how to determine when individuals have gone too far with cloning and manipulating genes.
Table 4.14: *Categorization of Forensics Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning*

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
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<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
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<table>
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<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher does not provide opportunities for students to recognize the need for inquiry.</td>
<td>Teacher provides opportunities for students to present vague suggestions for inquiry.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</td>
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<th>Skepticism</th>
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<td>Teacher provides ways for students to consider ethical and/or moral issues.</td>
<td>Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a way for students to discuss the significance of a moral or ethical stance.</td>
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The lesson on forensics also occurred outside of a thematic unit. In this lesson, students were presented with information about fingerprinting and provided with the opportunity to take samples of their own fingerprints in order to determine what identifying patterns they had. Through PowerPoint slides, Shelly then introduced the students to her research abroad where she dug up skeletons in cemeteries in order to extract DNA from individuals living in the 15th century.

*Complexity.* The researcher categorized Shelly as a 2 for complexity because as she presented her research, students were able to discuss the pros and cons of digging up bodies from a grave in order to extract DNA. Students saw Shelly’s research as having a single solution of trying to figure out whether or not the Y chromosome deteriorated faster than the X chromosomes of children in a cemetery. Overall, the students felt that her research could help to provide answers to questions about the black plague that occurred during this time period.

*Perspectives.* The researcher categorized Shelly as a 1 in perspectives because the presentation on her research was more of an informative nature. Thus, students were not given the opportunity to examine the issues involved with this research as they saw it as an opportunity to learn about forensics and how to extract DNA from dead bodies. No other outside sources were used in presenting this material to the students.

*Inquiry.* The researcher categorized Shelly as a 2 for inquiry because the students were given an opportunity to think about inquiry when it comes to extracting DNA. In one instance, Shelly discussed how in a process called individualization, she was able to go through a series of steps in order to determine whether a skeleton was a male or female. This led to a student asking how to determine the sex of an individual who changes his/her gender. Based on Shelly’s descriptions of the differences between male and female skeletons, students began to think of
suggestions to test transsexual skeletons. This discussion ended with Shelly describing an experience where she did have to examine a skeleton of a transsexual individual.

*Skepticism.* The researcher categorized Shelly as a 1 in skepticism because the students were not given the opportunity to declare differences among stakeholders. Instead, students saw Shelly’s research as a job that was being performed. Since it was seen as a job, students felt this was an honest way to make a living and that no other stakeholders would have any concerns with what Shelly and other researchers were doing.

*Ethics and Morals.* The researcher categorized Shelly as a 2 in ethics and morals because students were briefly given the opportunity to discuss the ethics behind digging up skeletons from graves in order to do research. They were also given an opportunity to discuss the ethics of changing gender when it came to the point of the discussion about identifying a transsexual skeleton.

In summary, four themes emerged in relation to Shelly’s fostering of socioscientific reasoning in her conceptual chemistry lessons. These themes were: (1) incorporating socioscientific issues within thematic units allowed for the transfer of knowledge across units, (2) laboratory activities and class discussions fostered opportunities for decision-making, (3) projects were used as a means to foster higher order thinking skills, and (4) in some instances, there was a disconnect between the socioscientific issue presented and the standards addressed.

**Closing Narrative: Shelly’s Future Plans.** When asked what was next for her in teaching her conceptual chemistry class, Shelly mentioned, “We’re going to take what we did this semester and this year, learn from the mistakes and build on them, which pretty much is I think we came into this class because we were following [name of one high school in the county] and because we were following [name of another high school in the county] and the way they
taught it, we weren’t sure how to teach this class. And we really said okay, this is how [name of one high school in the county] is doing it. This is how [name of another high school in the county] is doing it. This is how we are going to do it. It worked. It definitely worked obviously because our kids did really well on the graduation test. We were really proud of them. In this semester’s class, I had all but two to not only pass everything, but they all passed with high efficiency on the science portion and I had all of mine but two last semester to do the same thing. So the way we were teaching it obviously worked. What we discovered was that maybe our expectations for the students’ output wasn’t as high as it should be. So next fall, we’re going to sort of make them into guinea pigs and we’re definitely going to up the stakes a little bit more. I started doing that this semester with my students and I told them, ‘I’m giving you everything I gave my general class.’ They were like, ‘Oh Lord.’ There were some parts that they didn’t do as well on, but again, I think it’s all about how you teach it. Perhaps I taught it too quickly. But if I do only have conceptual chemistry [classes] next fall, and that’s my only prep, that’s great because that means that I can try something with the first class and if it doesn’t work, I can tweak it for the second class so that by the end of the day, I know what really works and can just try and not worry about losing time. So we’re going to up the stakes in the fall and we’re going to teach it as a general chemistry class but maybe not really a slower class, but just in a more slower pace to give them time to cover everything. A lot of the things that are on the general pacing guide, we don’t even teach to general. So there are going to be several things that I toss out and we’re going to have a new pacing guide. But we’re keeping the themes. We’re incorporating more of the higher level taxonomy information, more of the labs and increase our expectations. I think that’s some of the problem. I think that’s where some of the behavior problems came from is that their expectations for what we had to learn or not learn about. Now
do I think it’s gonna work for everybody? No. I think we’re going to have some that are not
going to get it. What am I going to do? I haven’t quite figured it out. What I think I’m going to do
is in that circumstance where they just can’t get it, it’s kind of good that I already have
everything that I have been doing as well as the advanced class. What we’re really doing is
taking those two and we’re merging them. So if I have some students that are just not getting it,
then I will probably bump it down a little or bump it up a little depending on the students. So
we’re going to see how this fall goes. If I see half way through that it’s too hard, it’s not
working, it’s not going to take me the whole semester to switch the class. My fall semester will be
guinea pig classes” (Final Interview, lines 266-315).

With respect to the impromptu lesson that involved the discussion of Osama bin Laden’s
death, Shelly mentioned that she would incorporate this into her plans for the fall. She stated, “I
will definitely put this in with my petroleum unit next year if we still teach it the way we are
going to teach it because by then, especially by next semester, something will have happened.
Somewhere, somehow there will be an effect of what happened today. This was kind of like
watching the Challenger exploding in the middle of talking about the space race in the Cold War
and not really knowing how it’s going to affect within being able to teach a year later and seeing
the consequences and the repercussions. So I definitely would use this in my petroleum unit at
the end when I talk about the consequences of using petroleum and blah, blah, blah. At least by
that point I will be able to tell my students next fall, you know, look, this is what happened on
this day. You lived through it. What were the repercussions of this in terms of our output or input
in that region?” (Post Interview 1, lines 86-95).

Summary Discussion and Preliminary Interpretation of Themes. Table 4.15 provides
a summary of the emerging themes gleaned from the three research questions.
<table>
<thead>
<tr>
<th>Research Question</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why do chemistry teachers use socioscientific issues in their teaching?</td>
<td>1. SSI’s were used as a way to explain past work experiences and provide students with opportunities to solve work-place dilemmas.</td>
</tr>
<tr>
<td></td>
<td>2. SSI’s were used as a way to bring continuity to lessons that were organized into thematic units.</td>
</tr>
<tr>
<td></td>
<td>3. SSI’s were used as teachable moments that allowed students to apply the concepts learned with current societal events.</td>
</tr>
<tr>
<td>2a. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about nature of science?</td>
<td>1. SSI’s were used to help students understand that science is not exact and can change at any moment.</td>
</tr>
<tr>
<td></td>
<td>2. SSI’s were used to help students to think “outside of the box.”</td>
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<td></td>
<td>3. SSI’s were used as a way to help students learn how to interpret evidence.</td>
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<tr>
<td></td>
<td>4. SSI’s were used as a way to include cultural contexts in lessons presented.</td>
</tr>
<tr>
<td>2b. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry?</td>
<td>1. SSI’s were used as a way to help students see the value in chemistry.</td>
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<tr>
<td></td>
<td>2. SSI’s were incorporated in relevant chemistry topics in order to show students how they were being affected by societal events.</td>
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<tr>
<td>2c. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry teaching?</td>
<td>1. SSI’s were incorporated in thematic units in order to provide students with opportunities to relate the issues presented to the larger themes being taught.</td>
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<td>2. SSI’s were incorporated through the use of technology because it encouraged students to relate to the issues as they interacted with technology.</td>
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<tr>
<td>2d. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry learning?</td>
<td>1. SSI’s were incorporated in hands-on settings as a means for students to make connections.</td>
</tr>
<tr>
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<td>2. SSI’s were presented in the context of real-world applications as a way to foster learning.</td>
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</table>
3. How do chemistry teachers plan for and enact socioscientific issues-based lessons in a secondary chemistry classroom?

**Plan**
1. SSI-based lessons were often planned around the central topic in a thematic unit.
2. SSI-based lessons were structured and organized in advance.
3. SSI-based lessons were teacher-centered, with little input from students in terms of contributing to the planning process.

**Enact**
1. Shelly was flexible in using teachable moments to make changes to her planned lessons.
2. Time constraints determined what and how an SSI-based lesson was enacted.

3a. To what extent do chemistry teachers foster socioscientific reasoning in their lessons?

**Plan**
1. Incorporating SSI’s within thematic units allowed for the transfer of knowledge across units.
2. Laboratory activities and class discussions fostered opportunities for decision-making.
3. Projects were used as a means to foster higher order thinking skills.
4. In some instances, there was a disconnect between the SSI presented and the standards addressed.

The preceding discussion of emerging themes suggested that Shelly attempted to incorporate socioscientific issues into her conceptual chemistry lessons as much as possible given the constraints that thematic units enabled this to occur. Shelly believed that it was important to incorporate socioscientific issues into her lessons because they provided her with the opportunity to bring in her previous work experiences in order to give students the opportunities to solve work-place dilemmas, allowed for continuity between the lessons that were organized into thematic units, and allowed for teachable moments. Shelly’s approach to the inclusion of socioscientific issues in her lessons aligned with Schwab’s (1973) argument that the curriculum should be “open to a great variety of values and visions, including those that rub
against the grain of society” (p. 514). It was Shelly’s belief that she should approach conceptual chemistry in an open approach of bringing in authentic experiences rather than a closed approach of only teaching the content matter. Shelly believed that in this manner, her students would benefit more from the lessons.

Within her lessons, Shelly incorporated many of the tenets of the nature of science. Her belief aligned with McComas, Clough, and Almozroa (1998) as they defined nature of science as:

A fertile hybrid arena which blends aspects of various social studies of science including the history, sociology, and philosophy of science combined with research from the cognitive sciences such as psychology into a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors (p. 4).

Because Shelly’s background consisted of various experiences in the field of science and history, she seemed to find it easy to include many of the tenets of the nature of science into her socioscientific issues-based lessons through the use of discussions and various lab activities. This led to, in many instances, opportunities for her conceptual chemistry students to interpret evidence and think outside of the box as they grappled with the dilemmas that they were presented.

Shelly believed that it was important to incorporate socioscientific issues into her lessons because students came into her classroom with negative attitudes about chemistry. This aligned with Carlone’s (2004) argument that chemistry traditionally follows a pattern of prototypical science in which there is a focus on procedure and decontextualized problem-solving and an exclusion of socioscientific issues. Therefore, in order to engage her students, Shelly introduced
socioscientific issues into her lessons with the hope that students would see the value in the subject and understand how chemistry affected their everyday lives.

As a novice teacher, it was important for Shelly to have structure in her lessons. Thus, incorporating socioscientific issues into her lessons provided her with structure because it allowed for her to tie the issues into the themes of the units covered. Although this required a lot of planning and forethought on her part, Shelly believed that the students benefited because they were able to make connections with the themes by becoming engaged in the socioscientific issues presented.

Shelly’s success with her conceptual chemistry course during her first year of teaching encouraged her to continue with similar plans for the upcoming years. As she continues to design the course based on real-world applications, she is aligning with the beliefs of researchers (Kolstø, 2001; Zeidler and Keefer, 2003; Zeidler et al, 2002) who have argued that socioscientific issues (SSI) should be an important component in preparing a scientifically literate citizenry because SSI more accurately portrays science in the real world.

In summary, this section provided a within-case analysis of Shelly’s incorporation of socioscientific issues in her conceptual chemistry class. In chapter 5, Shelly’s experiences will be included in a cross-case analysis.

**Narrative 3, Linda Greene: Making the Best Out of a Difficult Situation**

**Context of Conceptual Chemistry Class.** At the time of data collection, conceptual chemistry was entering its second year as a course at Clearview High School. This was Linda’s second time teaching it as she only taught sections of the course during the Fall 2010 semester. At the time Linda agreed to participate in the study, she and Shelly were in the process of making changes to the curriculum so that it reflected more of the chemistry state standards.
Linda wanted to infuse more chemistry into the curriculum and challenge her students based off of the success that she had with teaching conceptual chemistry during the previous school year. Also at the time Linda agreed to do the study, she was pregnant and anticipated going on maternity leave later on in the semester. However, those plans changed as doctors suggested that she go on maternity leave earlier than expected.

When asked to describe the make-up of her conceptual chemistry class, Linda noted, “Well, we started out and we still have days where it was social hour and the class was huge. Now, it’s 27, and I can’t even complain because there are some teachers that have like 40-some students in their classes. We have some really huge classes this year. We started out going, ‘I don’t think we’re going to be able to do labs.’ That was our first thing. How do you put 35 students in a class into a lab that’s not even equipped for a class of 28? And I don’t have a collaborative teacher because I don’t have a special ed population. So, you know, they’re like, just take half of the students and do a lab with half of them. And I’m like, I’m in a lab with half of these students and then the other half are doing what? Running around the classroom? Because that was my class. If you looked at a student, if another student was like, ‘What you looking at me for?’ That was being nice about it. I mean it, we had to go through and say okay, ‘Here are the words we can say in class and then these are the inappropriate words we need not to say.’ Then you have to go through, ‘This is when you should talk and this is when you shouldn’t talk.’ You know, it’s just like, do I really have to go through this? So now, it’s starting to get to the point where they’re starting to pay attention, but I still have to, even today, you know, it’s like ring the bell. Get their attention. Go through the whole process again of, ‘Okay people, when I’m talking please don’t talk.’ It gets a little tiring but that’s who you’re with” (Initial Interview, lines 199-214). She added, “We have a couple of sophomores but it’s mostly juniors. One girl,
she said, ‘If you don’t have patience to work with little kids, then you don’t need to teach’”

(Initial Interview, lines 218-219). Another student said, ‘We’re not little kids. We should know better.’ And I was like, ‘Thank you very much. That is very true.’ You have so many students with so many issues” (Initial Interview, lines 223-225).

Narrative Description. The following sections present narrative descriptions in light of the research questions in the study.

Why SSI is used in Chemistry Teaching. Linda believed it was important to incorporate socioscientific issues into her lessons. Her reasons included: (1) to engage students of all ability levels and (2) to provide students with opportunities to apply the content learned to the issues presented.

Linda has had experience with teaching students of all ability levels as she has taught AP, advanced, general, and conceptual chemistry. In fact, Linda noted how her conceptual chemistry students felt they were treated differently by other teachers because of the lower-level classes they were taking. Linda mentioned, “So these are huge classes and they’re usually the ones that have come in and they’ve been like the first couple of days they were talking about how they didn’t feel like it was right that teachers treat them a certain way. I told them, I said, ‘It’s because you’ve always been together and you’ve always acted this way together. And the teachers may not even know if you can perform well in an upper level class because you’ve always been in these lower level classes and you spend most of your time talking or off task to where they’re not even going to try to find out if you can do better than what you’re showing’”

(Final Interview, lines 107-114). In fact, according to Linda, the conceptual chemistry students also believed they were inferior compared to other levels of chemistry, as was mentioned by students during one class period. While Linda was leading the students in a review of vocabulary
they had been taught in previous units, she mentioned to the students that she had been doing this review with her other chemistry sections, which happened to be advanced chemistry students. Her conceptual chemistry students indicated that the students in her other sections were successful in the review activity because “They’re advanced” (Field Notes, 9/13/11). Therefore, Linda saw incorporating socioscientific issues-based lessons as a way to engage students of all ability levels. She noted, “My ultimate goal is to, I guess, to keep it to where they’re interested throughout and it’s not just those kids that know that they need to understand the concepts because they’re going to college. But, you know, the kids that I have in my conceptual class who probably, you know after high school that’s it for them” (Initial Interview, lines 263-266).

Linda also believed it was important to incorporate socioscientific issues into her lessons because she wanted to provide her students with opportunities to apply the content learned to the issues presented. She believed that socioscientific issues provided a means for keeping the content relevant for the students. As she reflected on how this course first came into existence at her school the previous year, she mentioned that several questions ran through her head. They included, “How do you keep it relevant so that they can see that even when you’re doing Hess’s Law? How do you keep it to where they’re like, ‘Okay, I see how I can apply this’” (Initial Interview, lines 249-250). “How do you keep it relevant for them so that you don’t have the behavior issues?” (Initial Interview, lines 266-267). For Linda, keeping the content relevant in a course that already had a stigma of being labeled as a “dumping ground” (Final Interview, line 105) was important. Thus, she saw the incorporation of socioscientific issues as a way to keep the content relevant for her students.
In summary, two themes emerged as to why Linda incorporated socioscientific issues into her lessons. They included: (1) to engage students of all ability levels and (2) to provide students with opportunities to apply the content learned to the issues presented.

**SSI and Underlying Beliefs about Nature of Science.** Linda believed it was important that students be engaged in activities that incorporated nature of science tenets. For instance, during the semester of this study, Linda required her general chemistry students to complete a project that she hoped to eventually incorporate into her conceptual chemistry classes. She mentioned, “General chemistry this year as part of their final project, they have to do a research project where it’s almost in the same line as a science fair project but they’re not having to create the tri-fold poster. So what they have to do, they had to figure out a dilemma. It didn’t have to be chemistry related. The biggest thing is to have them do something that was interesting to them. But that’s the kind of stuff that they’re doing. They have to go through, they had to, at this point, what they’ve done is they’ve designed their experiment and now they should be getting ready to perform their experiment and they have to do it at least twice. It’s all out of school. And by the 25th of October, they have to give us their data so we can see, oh, okay, this is what you said you were going to do and this is what you found out so far. But that’s the kind of stuff that they can do. And just giving them the prodding to, you know, some of them need a little bit of extra help to figure out what they want to do, they can do that. That was something that we were just like, you know, we can’t try with this group. I mean, eventually we hope to be able to try it with the conceptual class because I think it would work with them” (Final Interview, lines 83-98). Linda felt that having students engaged in this type of project incorporated some of the nature of science tenets including: (1) empirically based (based on and/or derived from observations of the natural world), (2) involved with human inference, imagination, and
creativity (involves the invention of explanations), (3) involved with a combination of observations and inferences, and (4) socially and culturally embedded (American Association for the Advancement of Science, 1993; Lederman, 1992; National Research Council, 1996). Linda believed that it was important for students to be engaged in projects such as this one because it provided students with opportunities to choose topics relevant to their interests in order to examine the issues related to these dilemmas in more detail. From Linda’s perspective, these types of projects led students to analyze and interpret data in such a way that would allow them to make informed decisions. According to Lederman (1999), “The assumption is that by students understanding the nature of science, they will become ‘more informed consumers of science, which will empower them to make more informed decisions when scientific claims and data are involved’” (p. 916).

In another example, Linda described an issue that she introduced into her conceptual chemistry class the previous year. She said, “Like I remember one of them, you know, we have the vending machines at the school and they stay on the entire time. One of the things that I have my students do last fall in conceptual was they had to write a proposal to the principal and they had to either be for or against putting healthy snacks in the vending machine because right now they have the hot fries, and the salt and pepper potato chips and all kinds of weird stuff in there. With childhood obesity and all the people with the food network that go into the schools and they’re talking about how to eat healthy in the cafeteria, how could you take these vending machines and make it to where you actually have some pretty healthy choices? So, I guess that’s something that I think about with a socioscientific problem” (Initial Interview, lines 322-330).

In summary, one theme emerged with regards to socioscientific issues and Linda’s underlying belief about the nature of science. This theme was: incorporating nature of science
tenets into socioscientific-based issues provided a means for students to analyze data, draw conclusions, and make informed decisions based upon conclusions.

SSI and Underlying Beliefs about Chemistry. In Linda’s view, chemistry was a challenging, yet important subject that connected concepts from many different disciplines. She mentioned, “I wanted the challenge of it. Biology is, I’m not trying to be mean, I mean I did major in Biology, but Biology is vocabulary. If they know the vocabulary, then they’re okay. That’s kind of it. You can get them on their task with just vocabulary, but chemistry, the whole, to me at the time, it was a brand new world. I would always go to my mentor and be like, ‘What are you doing? What is that? How do you work this problem? How do you do this? How do you do that? How is this related to that aspect of society? How do you relate this to your students?’ And it was just like, ‘Oh man, I wouldn’t mind teaching this class.’ So that was easy. I just thought that I would always take that next progression, except physics” (Initial Interview, lines 147-154). So even before Linda had the opportunity to teach chemistry, she realized the importance of the subject matter was in its relation to societal issues.

Linda’s belief about the importance of chemistry’s relation to societal issues helped to shape how she approached socioscientific issues within the context of chemistry. Linda noted, “Whenever I start a semester, we go through why take chemistry because when you ask the students, ‘Why are you in this class?’ [They say], ‘Because.’ [I say] ‘Because?’ Or you get a student that says, ‘I want to be a pediatrician and I don’t understand why I’m taking chemistry.’ Like, ‘You want to be a pediatrician. Okay.’ But the great thing is, we found a lot of stuff that would answer that question of why to take chemistry. It talks about how chemistry is the central science. If you go back to biology, and all of the processes that your body goes through, guess what, those are chemical processes. And they can relate to that for a little bit. They can relate to
the issues that occur in the body as a result of chemical processes” (Initial Interview, lines 232-238). For Linda, it was important to tie socioscientific issues into the subject matter because it allowed students to see the relevance for taking the course as it pertained to their future aspirations. Linda believed that incorporating socioscientific issues into lessons gave students opportunities to relate the content to other subject matters, issues, and dilemmas.

In summary, two themes emerged as to socioscientific issues and Linda’s underlying beliefs about chemistry. They were: (1) socioscientific issues were incorporated into chemistry content in order to enable students to see the importance of the subject matter in relation to societal issues and (2) socioscientific issues were incorporated into chemistry content to help students see the relevance of the course as it pertained to their future aspirations.

SSI and Underlying Beliefs about Chemistry Teaching. Although Linda believed that societal issues should be included in the teaching of chemistry, she did not include ethical and moral components in her lessons. She mentioned, “Well, the way we teach it, it doesn’t really play a role because I think we’re so cut and dry. You know, it’s like teach them how to write a binary compound, you know the name for a binary compound. It’s like to me, there doesn’t seem to be any ethical issue with that. I think if you take it though and you’re looking at how can they take what they’re doing in here and take it outside of the classroom into the community, then I think you run into some issues. I think we just kind of kept it so much where it’s separated and it’s not until they go off somewhere else that they figure out that, ‘Oh my gosh, I can use this chemistry and I can work for the Environmental Protection Agency’” (Initial Interview, lines 334-341). Linda’s belief about how to approach socioscientific issues in the context of chemistry was more consistent with Ziedler et al’s (2005) description of issues-based science. Zeidler et al (2005) defined issues-based science as a subset of the Science-Technology-Society (STS)
movement that emphasized the impact of scientific and technological development on society but did not focus on the moral and ethical issues embedded in decision-making. For Linda, the societal issues presented in her lessons allowed for students to see that dilemmas do exist in society, but she did not present these issues in a way that would give her students the opportunity to wrestle with ethical and moral components associated with these dilemmas.

In summary one theme emerged as related to socioscientific issues and Linda’s underlying belief about chemistry teaching. This theme was that chemistry teaching was approached through issues-based science rather than socioscientific issues-based science as ethical and moral components of dilemmas were not addressed in chemistry lessons.

SSI and Underlying Beliefs about Chemistry Learning. Based upon the time Linda spent with her students during the semester of the study, she believed her students were most productive when taking notes and when placed in collaborative group settings. She mentioned, “I have some that they have to just write everything down, and I’m trying to get them to not do that” (Initial Interview, lines 272-273). “I don’t even do complete PowerPoint presentations anymore. I just go through, and I’m like, ‘I need to put this up so that they can see this concept.’ And I put it up so that I can talk about it and go through something just to get them into what I’m trying to do, and it’s not so that they can copy it word for word, and that’s what they want to do. They want to copy it word for word when you’re standing there going, ‘I’m done talking about this. I’m ready to move on.’ They want to copy it. I’m not going to make a set of guided notes for it because it wasn’t intended to be notes. They even want to draw the pictures, and I’m like, ‘No, you don’t have to do this. You don’t have to copy this.’ You have some of those. There are others that when you put them in the collaborative groups, they’re able to talk it out with each other, work through a problem” (Initial Interview, lines 280-289). Linda believed that students
gravitated towards focusing on taking notes because it was something they were used to doing in their other classes. She mentioned, “I think it’s other classes in general because that’s what they bring in. Whatever they did, you know, if they had a teacher that had a PowerPoint up, they would take notes on it” (Initial Interview, lines 279-280). Linda’s purpose for using PowerPoints was to present a concept or an issue, whereas she believed that her students saw it as another opportunity to take notes. In Linda’s view, students’ emphasis on taking notes was an indication that they thought note-taking was more important than being focused on the issue at hand. So, in order for students to continue to have some type of interactions in their learning, she had them work in collaborative groups to come up with solutions to the issues presented. In this setting, she believed that students were able to think about and discuss the issues at hand instead of just writing them down.

In summary, one theme emerged with regards to socioscientific issues and Linda’s underlying belief about chemistry learning: socioscientific issues were addressed through group collaborations as a means of providing students with opportunities to discuss the issues presented in class.

Planning For and Enacting Socioscientific Reasoning. This section focuses on the way that Linda planned and enacted lessons in her conceptual chemistry class. The researcher was only able to observe a total of four lessons due to Linda having to go on early maternity leave. Table 4.21 provides a list of Linda’s lessons during the chemical reactions unit that the researcher had the opportunity to observe. None of Linda’s lessons incorporated the use of socioscientific issues into the chemistry context. Although this was the case, two example lessons will be discussed and highlighted in this analysis in order to provide a more close-up
understanding of how Linda organized her lessons. The two lessons chosen were the ionic
formation lesson and the covalent bonds lesson.

Table 4.16: Summary of Linda’s Lessons During the Chemical Reactions Unit

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
<th>Summary of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionic Formation</td>
<td>9/13/11</td>
<td>1. Symbols Quiz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Unit 3: Nomenclature and Bonding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Activating Reading Guide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. New Unit Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Vocabulary Review</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Ion Foldable</td>
</tr>
<tr>
<td>Formation of Formulas</td>
<td>9/14/11</td>
<td>1. Class Starter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Review of Ion Formation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Handout: Ions and their Chargers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Formation of Formulas Notes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Test corrections</td>
</tr>
<tr>
<td>Covalent Bonds</td>
<td>9/15/11</td>
<td>1. Class Starter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Questions about ion formation and ionic bonds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Covalent Bond Notes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Test corrections</td>
</tr>
<tr>
<td>Ionic and Covalent Nomenclature</td>
<td>9/16/11</td>
<td>1. Class Starter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Notes: Types of Chemical Bonds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Practice with naming and writing formulas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Covalent vs. Ionic Frayer Models</td>
</tr>
</tbody>
</table>

Planned Curriculum. When Linda first agreed to participate in the study, she discussed
how she and Shelly decided to revamp the conceptual chemistry course in order for it to reflect
many of the components of the general chemistry classes. These components included
continuing on with having thematic units and incorporating more real-world applications through
the use of projects (Informal Conversation, 5/23/11). While in the planning process, Linda
mentioned, “I guess it wasn’t really that much of a headache because we already have a
framework down for the chemistry courses, and it’s divided up from general to advanced. All we
had to do was take what we do in the general class and the biggest thing that separates, I would
say general from conceptual is the math level. So we’re doing a trial-and-error math thing right
“now” (Initial Interview, lines 365-369). “So that’s kind of how we took it and because we already had the framework for general down, it didn’t take that much to do it for conceptual” (Initial Interview, lines 375-376).

However, on the first day of observations, Linda’s plans changed as she mentioned, “This unit will be taught more as a traditional unit because I’m leaving half-way through it for maternity leave” (Pre-Interview 1, lines 17-18). When asked about the change of approaching the unit in light of the petroleum theme that had been used in the past, Linda mentioned “It really just boiled down to the fact that when I had to leave a week early and having the sub come in, it just made it easier to keep it in a more traditional way versus you know, going in a more thematic way that she’s not familiar with. It’s one thing if she could plan out what kind of, you know, projects or themes we would do, but being that she would just have to come in and figure out what was going on, it was just easier. She can do nomenclature versus, you know, oh, we’re doing something that ties in some type of something different with it. So, that’s how it came about” (Final Interview, lines 21-27).

Linda also explained how her conceptual chemistry class make-up also affected the way she planned for this unit. She opined, “With this class, um, there are some that caught on really well. You know, it’s really hard because of the personalities that I have in this classroom. I hate to say it like this but it’s almost like I already know that it’s not going to work and I usually am not like that. You know, I’m like, oh, okay, I can still work with them. But, it’s almost like just do stuff. Just do stuff. Keep going. Keep going. And when you’re going in and you’re having them work on a problem that would tie in chemistry to something that’s going on in society, it requires them to work together, to work independently, to do research, and um, if I go ‘Work these three problems by yourself,’ then I have to hear about you know, ‘I’m going to the club. Somebody’s
fighting. Somebody’s being this. Don’t look at this. You know, don’t touch me. He hit me.’ I mean it’s just like, ‘Really?’ And they are the older students that I have. The general chemistry class is mostly sophomores. The conceptual chemistry is mostly juniors. So it’s really hard and it’s not always been that way. Last semester, last year, because you were here, you know it was easier to plan these types of things with them because they were more receptive. They were more open” (Final Interview, lines 54-66).

The ionic formation lesson occurred on September 13, 2011, and it was the first lesson of the unit. Linda had the key understanding, performance standards, unit essential question, daily essential question, concepts, and agenda posted on the white board. Table 4.22 provides a summary of the information Linda placed on the white board as related to her plans for the lesson.

Table 4.17: Summary of Linda’s Plans for the Ionic Formation Lesson

<table>
<thead>
<tr>
<th>Component</th>
<th>Description of Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Understanding</td>
<td>Atoms in ionic compounds are held together by chemical bonds formed by the attraction of oppositely charged ions while covalent bonds are formed when atoms share electrons.</td>
</tr>
<tr>
<td>Performance Standards</td>
<td>SC3d, SC3e, SC1c, SC1d</td>
</tr>
<tr>
<td>Unit Essential Question</td>
<td>What characteristics affect the bonding of elements and how compounds are made?</td>
</tr>
<tr>
<td>Daily Essential Question</td>
<td>How can an ionic compound, made of charged particles, be electrically neutral?</td>
</tr>
</tbody>
</table>
| Concepts             | 1. Ionic and Covalent Bonding  
                        | 2. Nomenclature                                                                         |
| Agenda               | 1. Symbols Quiz  
                        | 2. Unit 3 Nomenclature and Bonding Activating Reading Guide  
                        | 3. New Unit Information  
                        | 4. Vocabulary Review  
                        | 5. Ion Foldable  
                        | 6. Ion Formation Handout |
The covalent bonds lesson occurred on September 15, 2011, and this was the third lesson of the unit. Table 4.23 provides a summary of Linda’s plans that were posted on the white board in her classroom.

Table 4.18: Summary of Linda’s Plans for the Covalent Bonds Lesson

<table>
<thead>
<tr>
<th>Component</th>
<th>Description of Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Understanding</td>
<td>Atoms in ionic compounds are held together by chemical bonds formed by the attraction of oppositely charged ions while covalent bonds are formed when atoms share electrons.</td>
</tr>
<tr>
<td>Performance Standards</td>
<td>SC3d, SC3e, SC1c, SC1d</td>
</tr>
<tr>
<td>Unit Essential Question</td>
<td>What characteristics affect the bonding of elements and how compounds are made?</td>
</tr>
<tr>
<td>Daily Essential Question</td>
<td>How can an ionic compound, made of charged particles, be electrically neutral?</td>
</tr>
</tbody>
</table>
| Concepts                   | 1. Ionic and Covalent Bonding  
2. Nomenclature                             |
| Agenda                     | 1. Class starter on side board  
2. Questions about ion formation and ionic bond  
3. Covalent Bonds Notes  
4. Polar Bears and Penguins |

*Enacted Curriculum.* The ionic formation lesson was enacted similarly to the way it was planned. The class began with Linda giving her students approximately five minutes to study for the symbols quiz. Students were then asked to complete a quiz in which they had to provide the symbols of elements that were listed on a handout given to them. Students were then instructed to pick up a handout to begin working on once they completed and turned in their quizzes. The handout that students picked up consisted of questions that students had to provide answers for in the blank spaces underneath. Linda instructed the students that they could find answers to the questions by opening up their conceptual chemistry books to chapter 7. As students worked on the handout, Linda began writing information on the SmartBoard. This information included: “Unit 3: Chemical Bonding and Nomenclature (Chapters 7 & 8).” Then she began to write the following terms on the SmartBoard: chemical bond, anion, cation, ion, and ionic bond. Linda
indicated that the students were going to participate in an activity called “$1.00 Words.” In this activity, students were asked to come up with a description of each of the five words listed on the SmartBoard. Each word used to describe the vocabulary words cost 50 cents and they only had $1.00 to spend on each word. Linda mentioned that the goal of this activity was for students to define each vocabulary word with no more than two words. Linda also mentioned that this activity served as a review of some of the vocabulary words that the students had encountered throughout this semester. Linda called on students to provide definitions for the vocabulary words. Some of the examples given included: “holds together” for the term chemical bond, “negative charge” for the term anion, and “positive charge” for the term cation. Once this activity was completed, Linda asked her students to get out their periodic tables as she reviewed certain components of the table with them. These components included: how to number the columns on the periodic table and what the Roman numerals represented. After this review, Linda handed out blank sheets of paper and instructed students that they would be making a foldable. She then walked the students step-by-step through the process of making the foldable. Once the paper was folded into eight different squares, Linda instructed the students to copy down all of the information on the white board located on the side wall. The information on this white board consisted of the following components: (1) column number, (2) number of valence electrons, (3) an example element in that column, (4) the Lewis dot diagram of the example element, (5) how many valence electrons the elements in the column would lose, (6) what type of cation the elements in the column would form, and (7) the valence electron configuration. There were a total of eight different lists, and each list was written in its own square on the foldable. After giving students the opportunity to copy all of the information onto their foldables, Linda
then explained to the students how they would use their foldable. She then gave the students a handout that reinforced how to use the foldable to answer questions.

The covalent bonds lesson began with Linda instructing the students to complete a warm-up exercise written on the side board. She indicated that this was a review of what the students had been doing over the past few days. The warm-up had the following question on the board: “What ion does each element form?” There was a list of seven elements written underneath the question, and students had to write the ion formed on their own papers. Linda reminded the students that they could use their periodic table or their foldable in order to help them figure out the ions formed by each element. After giving the students time to complete the warm-up, Linda went over it by having individual students call out answers as she wrote them on the board. Once the warm-up was completed, Linda reviewed the topics of ions and ionic bonds with the students. She wrote the following on the SmartBoard:

- **Ions** - charged particles
- **Gain or lose electrons**
- **Metals lose electrons:** positive ions
- **Nonmetals gain electrons:** negative ions

Students were given the opportunity to ask questions about the above concepts before moving into covalent bonds. Linda wrote the definition of covalent bonds on the SmartBoard and indicated that these were elements that had at least half of their outer shells filled. In order to demonstrate the two types of covalent bonds, Linda grabbed some M&M’s from the back of the classroom. She gave one student a total of 12 M&M’s and asked the student to give half of her M&M’s to another student. Linda indicated that this represented nonpolar covalent bonds. She then wrote “equal sharing of electrons” on the SmartBoard for the definition of nonpolar
covalent bond. Linda then gave this same student 14 M&M’s and instructed the student to only give away 4 to another classmate. Linda then explained that this represented polar covalent bonds. She then wrote “unequal sharing of electrons” on the board as the definition of polar covalent bonds. After this demonstration, Linda handed out a laminated periodic table to her students. It was entitled “electronegativity chart”. The chart had a list of electronegativity values for each element. Linda demonstrated how to subtract the electronegativity values of elements in order to determine whether the bonds were nonpolar covalent, polar covalent, or ionic. On the front white board, she listed the value range for each type of bond so that once the students had subtracted the electronegativity values and obtained an answer, they could use this answer to determine which bonding range the difference in values fell in. After demonstrating how this process worked, Linda provided her students with practice examples for them to complete. After giving them time to work, she then went over the examples with the students. After going over the answers to these examples, Linda then handed back an old test to her students for them to do test corrections for the remainder of the class period.

In summary, one theme emerged with regards to planning and enacting: planning for and enacting chemistry lessons involving socioscientific reasoning was mitigated by personal and professional conflicts.

**Fostering Socioscientific Reasoning.** This section categorizes all of Linda’s lessons observed in the unit. Tables 4.19-4.22 indicate how Linda’s lessons were categorized as related to a modified version of Sadler’s (in press) assessment of socioscientific reasoning.
Table 4.19: *Categorization of Ionic Formation Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning*

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
<td></td>
</tr>
<tr>
<td>Perspectives</td>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
<td>Teacher provides opportunities for students to assess the issue from a single perspective.</td>
<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
<td>Teacher provides opportunities for students to assess the issue from multiple perspectives.</td>
</tr>
<tr>
<td>Inquiry</td>
<td>Teacher does not provide opportunities for students to recognize the need for inquiry.</td>
<td>Teacher provides opportunities for students to present vague suggestions for inquiry.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</td>
</tr>
<tr>
<td>Skepticism</td>
<td>Teacher does not provide opportunities for students to be able to declare differences among stakeholders.</td>
<td>Teacher provides opportunities for students to suggest that differences likely exist among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders and discuss the significance of conflicting interests.</td>
</tr>
<tr>
<td>Ethics and Morals</td>
<td>Teacher provides no opportunity for students to raise ethical and/or moral issues.</td>
<td>Teacher provides little opportunity for students to consider ethical and/or moral issues.</td>
<td>Teacher provides ways for students to consider ethical and/or moral issues.</td>
<td>Teacher clearly provides ways for students to consider ethical OR moral issues and provides a way for students to discuss the significance of a moral and/or ethical stance.</td>
</tr>
</tbody>
</table>
In this lesson, students were provided with the opportunity to learn about concepts related to ionic formation by creating and using a foldable.

*Complexity.* The researcher categorized Linda as a 1 for complexity because no socioscientific issue was presented in order for students to consider any solutions.

*Perspectives.* The researcher categorized Linda as a 1 for perspectives because no opportunity was presented for students to carefully examine a socioscientific issue.

*Inquiry.* The researcher categorized Linda as a 1 for inquiry because she did not provide any opportunities for students to recognize the need for inquiry as no socioscientific issue was introduced into the lesson.

*Skepticism.* The researcher categorized Linda as a 1 for skepticism because no socioscientific issue was incorporated into the lesson, and thus students were not given the opportunity to declare any differences among stakeholders.

*Ethics and Morals.* The researcher categorized Linda as a 1 in ethics and morals because no moral or ethical issues were raised in the lesson.

Table 4.20: *Categorization of Formation of Formulas Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning*

<table>
<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complexity</strong></td>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
</tr>
<tr>
<td><strong>Perspectives</strong></td>
<td>Teacher does not provide opportunities for</td>
<td>Teacher provides opportunities for students to examine</td>
<td>Teacher provides opportunities for students to examine</td>
<td>Teacher provides opportunities for students to examine</td>
</tr>
</tbody>
</table>
In this lesson, students were provided with the opportunity to learn about how ionic compounds were formed and how to write formulas for ionic compounds.

**Complexity.** The researcher categorized Linda as a 1 for complexity because no socio-scientific issue was presented, and thus students were not provided with an opportunity to consider solutions to any issues.

**Perspectives.** The researcher categorized Linda as a 1 for perspectives because Linda did not provide any opportunities for students to examine an issue.
Inquiry. The researcher categorized Linda as a 1 for inquiry because she did not provide any opportunities for students to recognize the need for inquiry as no socioscientific issues were presented in class.

Skepticism. The researcher categorized Linda as a 1 for skepticism because no socioscientific issues were presented, and thus students were not given any opportunities to declare any differences among stakeholders.

Ethics and Morals. The researcher categorized Linda as a 1 with in ethics and morals because no moral or ethical issues were discussed in the lesson.

Table 4.21: Categorization of Covalent Bonds Lesson Using a Modified Version of Sadler’s (in press) Assessment of Socioscientific Reasoning

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
</tr>
<tr>
<td>Perspectives</td>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
<td>Teacher provides opportunities for students to assess the issue from a single perspective.</td>
<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
<td>Teacher provides opportunities for students to assess the issue from multiple perspectives.</td>
</tr>
<tr>
<td>Inquiry</td>
<td>Teacher does not provide opportunities for students to recognize the need for inquiry.</td>
<td>Teacher provides opportunities for students to present vague suggestions for inquiry.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</td>
</tr>
<tr>
<td>Skepticism</td>
<td>Teacher does not provide</td>
<td>Teacher provides opportunities for</td>
<td>Teacher provides opportunities for</td>
<td>Teacher provides opportunities for</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
In this lesson, students learned about how covalent bonds formed and how to classify the different types of covalent bonds.

*Complexity.* The researcher categorized Linda as a 1 for complexity as no socioscientific issue was presented and students were not given the opportunity to consider solutions to an issue.

*Perspectives.* The researcher categorized Linda as a 1 with in perspectives because no opportunities were given for students to examine an issue.

*Inquiry.* The researcher categorized Linda as a 1 for inquiry because she did not provide any opportunities for students to recognize the need for inquiry as no socioscientific issues were presented in the lesson.

*Skepticism.* The researcher categorized Linda as a 1 for skepticism because no socioscientific issues were presented, and therefore, students were not given the opportunity to declare any differences among stakeholders.

*Ethics and Morals.* The researcher categorized Linda as a 1 in ethics and morals because no moral or ethical issues were presented in the lesson.
<table>
<thead>
<tr>
<th>Complexity</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher provides opportunities for students to consider very simplistic or illogical solutions without considering multiple factors.</td>
<td>Teacher provides opportunities for students to consider pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Teacher provides opportunities for students to construe the issue as relatively complex primarily because of a lack of information, which allows for potential solutions to tend to be tentative or inquiry-based.</td>
<td>Teacher provides opportunities for students to perceive the general complexity of the issue based on different stakeholder interests and opinions which allows for potential solutions to be tentative or inquiry-based.</td>
<td></td>
</tr>
<tr>
<td>Perspectives</td>
<td>Teacher does not provide opportunities for students to carefully examine the issue.</td>
<td>Teacher provides opportunities for students to assess the issue from a single perspective.</td>
<td>Teacher provides opportunities for students to examine a unique perspective when asked to do so.</td>
<td>Teacher provides opportunities for students to assess the issue from multiple perspectives.</td>
</tr>
<tr>
<td>Inquiry</td>
<td>Teacher does not provide opportunities for students to recognize the need for inquiry.</td>
<td>Teacher provides opportunities for students to present vague suggestions for inquiry.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Teacher provides opportunities for students to suggest a plan for inquiry focused on the collection of scientific AND social data.</td>
</tr>
<tr>
<td>Skepticism</td>
<td>Teacher does not provide opportunities for students to be able to declare differences among stakeholders.</td>
<td>Teacher provides opportunities for students to suggest that differences likely exist among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders.</td>
<td>Teacher provides opportunities for students to describe differences among stakeholders and discuss the significance of conflicting interests.</td>
</tr>
<tr>
<td>Ethics and Morals</td>
<td>Teacher provides no opportunity for students to raise ethical and/or moral issues.</td>
<td>Teacher provides little opportunity for students to consider ethical and/or moral issues.</td>
<td>Teacher provides ways for students to consider ethical and/or moral issues.</td>
<td>Teacher clearly provides ways for students to consider ethical and/or moral issues and provides a way for students to discuss the significance of a moral or ethical stance.</td>
</tr>
</tbody>
</table>
In this lesson, students were provided with the opportunity to learn to name and write formulas for ionic bonds (including polyatomic ions) and covalent bonds.

**Complexity.** The researcher categorized Linda as a 1 for complexity because no socioscientific issue was presented, and thus students were not given an opportunity to consider any solutions.

**Perspectives.** The researcher categorized Linda as a 1 in perspectives because Linda did not provide her students with any opportunities to examine a socioscientific issue.

**Inquiry.** The researcher categorized Linda as a 1 for inquiry because she did not provide any opportunities for students to recognize the need for inquiry as no socioscientific issues were presented.

**Skepticism.** The researcher categorized Linda as a 1 for skepticism because no socioscientific issue was presented, and therefore students were not given any opportunities to declare any differences among stakeholders.

**Ethics and Morals.** The researcher categorized Linda as a 1 in ethics and morals because no moral or ethical issues were addressed in this lesson.

**Closing Narrative: Linda’s Future Plans.** When asked about her future plans as related to teaching her conceptual chemistry class, Linda mentioned, “I have 2 sections of conceptual in the spring. So, hopefully all of the kinks will be worked out in the spring. You never know because you get another set of students and you might have another set of issues” (Initial Interview, lines 380-382). Linda mentioned that she would like to try to include the semester-long project that her general chemistry students were currently doing into the conceptual chemistry curriculum at some point. However, she added, “But, with the planning it really
depends on the make-up which I don’t know. I don’t know. How many more of them do we have at this school?” (Final Interview, lines 132-135).

Summary/Discussion/Interpretation of Themes. Table 4.23 below provides a summary of the emerging themes gleaned from the three research questions.

Table 4.23: Summary of Themes Emerging from Linda’s Case

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Themes</th>
</tr>
</thead>
</table>
| 2. Why do chemistry teachers use socioscientific issues in their teaching?       | 1. SSIs were included in lessons as a way to engage students of all ability levels.  
                                | 2. SSIs were included in lessons as a way to provide students with opportunities to apply the content learned to the issues presented. |
| 2a. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about nature of science? | 1. Incorporating nature of science tenets into socioscientific-based issues provided a means for students to analyze data, draw conclusions, and make informed decisions based upon conclusions. |
| 2b. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry? | 1. SSI’s were incorporated into chemistry content in order to enable students to see the importance of the subject matter in relation to societal issues.  
                                | 2. SSI’s were incorporated into chemistry content to help students see the relevance of the course as it pertained to their future aspirations. |
| 2c. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry teaching? | 1. Chemistry teaching was approached through issues-based science rather than socioscientific issues-based science as ethical and moral components of dilemmas were not addressed in chemistry lessons. |
| 2d. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry learning? | 1. SSIs were addressed through group collaborations as a means for providing students with opportunities to discuss the issues presented in class. |
| 3. How do chemistry teachers plan for and enact socioscientific reasoning in a secondary chemistry class? | 1. Planning for and enacting chemistry lessons involving socioscientific reasoning were affected by personal and professional conflicts. |
| 3a. To what extent do chemistry teachers                                                                 | 1. Personal health, transitional |
|
Although Linda believed it was important to incorporate societal issues into her lessons, she did not include any in the unit that was observed. This was due to personal as well as professional constraints. Linda’s case is similar to a description of participants in a study by Sadler, Amirshokoohi, Kazempour, and Allspaw (2006), in which they examined teacher perspectives on the use of socioscientific issues and dealing with ethics in the context of science instruction. Based upon this study, Linda would be described as having the same characteristics of Profile B participants who supported infusing socioscientific issues into science curricula in theory but reported significant constraints which prohibited them from actualizing these goals.

Even in past instances where Linda described her uses of societal issues, it appeared that she avoided tying in the ethical and moral components to the dilemmas presented. Thus, Linda incorporated issues-based lessons rather than socioscientific issues-based lessons.

Linda’s case serves as an outlier as this study aimed to explore why and how chemistry teachers incorporated socioscientific issues into their curriculum in an era where much emphasis is placed on the technical nature of the content of chemistry. Although Linda believed it was important to incorporate what she deemed as socioscientific issues-based lessons, the lessons observed showed how she placed an emphasis on teaching the content and not incorporating any types of applications or dilemmas for students to engage in. Thus, Linda’s case will not be included in the cross-case analysis in chapter 5.
Summary of the Chapter

This chapter presented three case narratives that were constructed from data collected in the study. The cases highlighted themes emerging from the storied narratives. The uniqueness of each case was evident based upon the way each secondary chemistry teacher talked about his/her beliefs, insights, and perspectives as related to the incorporation of socioscientific issues into his/her lessons. The cases also revealed the differences in approaches that each secondary chemistry teacher employed when given the opportunity to teach socioscientific issues-based. Each case was written with the following parts: (1) a description of the context, (2) a narrative account, (3) a closing narrative, and (4) a summary discussion and preliminary interpretation of themes. This case structure provided continuity for discussing the storied narratives embedded in the data. In chapter 5, the researcher will provide a cross-case analysis of two of the cases, a discussion and interpretation of significant findings, and conclude with implications for this study.
CHAPTER 5
CROSS-CASE ANALYSIS AND IMPLICATIONS

Introduction

The three narratives presented in the previous chapter described the individual cases of Christopher, Shelly, and Linda in relation to their beliefs and practices in relation to incorporating socioscientific issues-based lessons in their chemistry classes. As shown in the previous chapter, the narratives were developed around emerging themes that illustrated the uniqueness of each case. This chapter intends to build upon the discussion of the individual cases and provide an analysis across two of the cases.

This chapter is composed of three sections: (1) cross-case analysis, (2) discussion and interpretation, and (3) implications of the study. The first section, the cross-case analysis, provides a detailed discussion of the themes emerging across Christopher’s and Shelly’s individual cases, as well as an elaboration on the commonalities and relationships. Linda’s case was considered an outlier in terms of the purposes and goals of this dissertation because she did not foster socioscientific reasoning in her lessons. Therefore, she was not included in the cross-case analysis. The first section follows a format similar to the previous chapter in that each of the three research questions is addressed in the following order:

1) Why do chemistry teachers use socioscientific issues in their teaching?

2) How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about:
   a. Nature of science?
   b. Chemistry?
c. Chemistry teaching?
d. Chemistry learning?

3) How do chemistry teachers plan for and enact socioscientific reasoning in a secondary chemistry classroom?
   a. To what extent do chemistry teachers foster socioscientific reasoning in these lessons?

Miles and Huberman (1994) suggested that a cross-case analysis allows the researcher to enhance the description of a phenomenon through "examination of similarities and differences across cases" (p. 173). As such, data from each of the research questions was compared across the two participants in order to highlight the similarities and differences between the secondary chemistry teachers. These findings were tied to existing literature.

The second section of the chapter provides further interpretation of the data through a discussion of the research questions. In this section, findings from all three cases were discussed and interpreted in further detail. Existing literature was also tied to the findings.

The final section of this chapter concludes this dissertation by providing a discussion of the implications of the study for the science teacher education and research communities. More specifically, analysis of themes that emerged from the participants' data, both individually and as a group, provide insight that impacts the field of science education with regards to secondary chemistry teachers.

**Cross-Case Analysis**

According to Creswell (2007), a cross-case analysis is “an analysis step that typically follows within-case analysis when the researcher studies multiple cases” (p. 245). Miles and Huberman (1994) suggested that one goal of the cross-case analysis is to deepen and enhance
"understanding and explanation" (p.173). Merriam (1998) argued that a cross-case analysis is necessary because it builds abstractions across cases, provides a unified description across cases, and can lead to the identification of emerging themes, categories, or typologies that synthesize the data from all the cases. Stake (2006) added that a researcher should provide a cross-case analysis in order to arrive at a binding concept, whether a theme, issue, phenomenon, or functional relationship.

Stake (2006) contended that themes preserve the main research questions. Based on this principle, the researcher organized the emerging themes from the cross-case analysis according to the research questions. Table 5.1 provides a summary of themes emerging from the cross-case analysis.

Table 5.1: Summary of Research Questions and Related Themes

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Theme 1</th>
<th>Theme 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why do chemistry teachers use socioscientific issues in their teaching?</td>
<td>Secondary chemistry teachers’ uses of SSI were mediated by people, places, and events.</td>
<td>Secondary chemistry teachers’ uses of SSI were mediated by their beliefs of the importance of inference as students examined issues from different perspectives.</td>
</tr>
<tr>
<td>2a. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about nature of science?</td>
<td>Secondary chemistry teachers’ uses of SSI were mediated by their beliefs that students should become informed decisions-makers.</td>
<td></td>
</tr>
<tr>
<td>2b. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry?</td>
<td>Secondary chemistry teachers’ uses of SSI were mediated by their beliefs with regards to their students’ perceptions of the subject matter.</td>
<td></td>
</tr>
<tr>
<td>2c. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry teaching?</td>
<td>Secondary chemistry teachers’ uses of SSI were mediated by their beliefs that providing teacher-chosen topics allowed for better control over the curriculum.</td>
<td></td>
</tr>
</tbody>
</table>
2d. How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about chemistry learning?

Secondary chemistry teachers’ uses of SSI were mediated by their beliefs that the incorporation of real-world examples provided opportunities for student engagement.

Secondary chemistry teachers’ uses of SSI were mediated by their beliefs that using hands-on activities provided opportunities for students to make connections between dilemmas presented and the chemistry content associated with the dilemmas.

3. How do chemistry teachers plan for and enact socioscientific reasoning in a secondary chemistry class?

Secondary chemistry teachers plan lessons centered around big topics.

The mediating factor for the enacting of socioscientific reasoning in a secondary chemistry class was locus of control.

3a. To what extent do chemistry teachers foster socioscientific reasoning in these lessons?

Socioscientific reasoning was mainly fostered through classroom discourse as a way to encourage student engagement.

Fostering socioscientific reasoning could be challenging to the secondary chemistry teachers due to instances of disconnections between content and context.

The following sections explain the different themes that emerged from the cross-case analysis as they related to existing literature. In this way, the issues or assertions made in each theme were strengthened and clearly explained.

Why SSI is used in Chemistry Teaching

People, Places, and Events. According to researchers (Ashton & Webb, 1986; Hoy, 1969; Rosenhotz, 1989; Smylie, 1989), teachers continue to solve instructional problems largely by relying on their own beliefs and experiences, even after entering service. As Vygotsky (1978) argued, this is because beliefs support and reveal a person’s world. After a closer examination of the past personal experiences of Christopher and Shelly, it was evident that their beliefs with respect to the incorporation of socioscientific issues into their teaching of chemistry were
mediated by three important factors: people, places, and events. Both Christopher and Shelly noted how people such as parents and teachers played a role in how they learned science. This, in turn, influenced how they taught chemistry. For example, Christopher’s chemistry teachers influenced the way he now teaches chemistry. Shelly’s interactions with her father and the hands-on experiences that he provided paved the way for the research that she participated in while living abroad. Place was another mediating factor in the past personal experiences of both participants. For example, Christopher’s experiences in both high school and college helped him understand how he learned chemistry best. This, in turn, influenced the way in which he currently teaches chemistry. Shelly’s work in laboratory settings provided her with many opportunities to solve work-place dilemmas using her past educational experiences. The final mediating factor was events. For Christopher, the event of having a negative experience with learning in his honors biology class convinced him that he could not effectively learn through rote memorization. Shelly’s hands-on experiences in some instances, such as excavating corpses, provided her with opportunities to share these events with her students as a way to help them solve work-place dilemmas.

Both Christopher and Shelly emphasized that past personal experiences played a role in why they included socioscientific issues in the teaching of chemistry. This aligned with the work of Lacey (1977) and Pajares (1992) as these researchers suggested that lifetime experiences contribute to teachers’ development of strongly held beliefs about teaching and learning. This finding also related to Schwab’s notion of curriculum. Schwab believed that theories of curriculum and of teaching and learning could not by themselves effectively communicate answers to the questions of what and how to teach. This was because, according to Schwab (1971b), these questions arose in concrete situations that were influenced by time, place, person,
and circumstance. For Christopher and Shelly, people, places, and events influenced their beliefs about what and how to teach chemistry.

SSI and Underlying Beliefs about Nature of Science

**Informed Decision Makers.** According to Dawson and Venville (2010), school science education should give students the opportunity to use their understanding of science in order to make informed and balanced decisions about socioscientific issues that have an impact on their lives. These authors emphasized this was because “young people need to be able to weigh up the risks and benefits of alternative solutions, pose questions, evaluate the integrity of evidence and counter evidence and make well informed decisions” (p. 134). A closer examination of Christopher’s and Shelly’s socioscientific issues-based lessons and their relationship to nature of science showed that their beliefs about NOS were mediated by their desire for students to think deeply in order to become informed decision-makers. Both Christopher and Shelly introduced topics that encouraged their students to examine the issues in far greater detail than any previous instances. For Christopher, this was important because of the potential effects he believed that these issues could have on individuals and society. He emphasized, “The main thing that I want to do with the chemistry class, and I do this for my advanced class and my honors, is to make them think about their world in a different way (Initial Interview, lines 347-348). This was important for Shelly because it enabled her students to rely on imagination and creativity. For instance, the alternative fuels project that Shelly assigned provided her students with opportunities to create a car that ran off of other sources of energy besides petroleum. She mentioned that many of the students had never thought about having cars use alternative fuel sources before being presented with this project; thus students had the opportunity to use their
imagination and creativity, along with research, in order to design a final product. Freiré et al (2009) emphasized:

It is not enough to know a lot of scientific facts, or isolated scientific concepts that one cannot use or does not know how to use. Any citizen should appropriate a series of competencies that can support him/her in decision making concerning social and ethical issues related to science and technological development and in solving daily problems (p. 45).

This was the aim for both Christopher and Shelly as they explicitly included nature of science tenets in their socioscientific issues-based lessons. Both Christopher and Shelly believed that by explicitly including nature of science tenets in their socioscientific issues-based lessons, students would understand processes related to chemistry as they evolved naturally through their classroom experiences with SSIs. In other words, both Christopher and Shelly did not want their students to experience processes that were forced upon them through rote learning because they believed that this would cause students to reject the nature of chemistry. Instead, they believed that explicitly including nature of science tenets helped their students to better appreciate the value of chemistry in the context of its place in societal issues. For example, Christopher used empirically-based evidence in his presentation on the topic of nuclear reactors because his goal was for “students to be educated on the future of nuclear energy and for students to hopefully form their own opinions on what needs to be done with respect to our energy policy” (Pre-Interview 1, lines 22-26). Shelly mentioned how during laboratory exercises, students would often get different results. She used these moments to emphasize that in the midst of following procedures, it was possible to obtain different results and thus she stressed the importance of interpreting data.
**Inference.** Osborne and Dillon (2008) argued that science is an important tool to understand social and ethical issues that emerge from science and technological developments. Using outside sources in socioscientific issues-based lessons related to Christopher’s and Shelly’s underlying belief about the nature of science in that these sources provided opportunities for students to be engaged in human inference in order to examine issues from different perspectives. This was important to Christopher because he believed these outside sources provided empirically-based evidence that gave students opportunities to grapple with and discuss different dimensions and perspectives. As such, he often brought in news articles from various sources as a means for presenting the socioscientific issues discussed in class. For Shelly, outside sources gave her a context to present to her students so that they could see the relevance in the activities as they used inference to come up with solutions to dilemmas presented to them.

**SSI and Underlying Beliefs about Chemistry**

**Students’ Perceptions of the Subject Matter.** As mentioned by researchers (Black & Atkin, 1996; Gräber, 2002; Kracjik, Mamlok, & Hug, 2001; Osborne, 2003; Osborne & Collins, 2001; Pak, 1997), chemistry classes at the secondary level are unpopular among students. Tomas, Ritchie, and Tones (2011) argued that it is important to establish favorable classroom conditions in order to elicit situational interest for students who are not motivated by individual interest for a particular topic. A closer examination of Christopher’s and Shelly’s beliefs in light of the incorporation of socioscientific issues in chemistry are seen that their beliefs were mediated by student perceptions of the subject matter. What they perceived as the negative attitudes and dispositions on the part of their students caused both participants to try new approaches to making the subject matter relevant. These new approaches involved the incorporation of socioscientific issues-based lessons. Christopher noted, “Chemistry itself is not
the most interesting topic, so as it is, it’s one of those things where it’s the subject and then there’s the apathy with it” (Post Interview 2, lines 28-29). Thus, it was Christopher’s belief that, “You have to implement those SSIs in order to do that because if you don’t make it real for them, you don’t relate what they’re learning to something in their real-world, they’re not going to get anything out of it. They’re not going to make any connections” (Initial Interview, lines 348-351).

Shelly described the negative attitudes that her students had as they entered her conceptual chemistry class at the beginning of the semester. She opined, “Most of them could care less about chemistry. They see no value in it ever. Most of them just want to blow something up” (Initial Interview, lines 281-282). Shelly believed these attitudes came from the students’ overall dislike for science as she noted that “so many of the kids came in with this attitude of I hate science” (Final Interview, lines 86-87). Shelly believed it was important to incorporate socioscientific issues into the subject matter so that students could see the value in it as they made connections to societal issues. With regards to chemistry, Shelly believed that her students “use it every day”, and so it was important for her students to “think logically in all forms of life” (Initial Interview, lines 177-178).

Crawford, Kelly, and Brown (2000) contended that many students are failing at science because the processes of sense making for science are made difficult by the grammatical complexities of spoken and written discourse that mark science as intellectually elite, forbidding, and obscure. These authors also argued that a lack of student enthusiasm, interest, or motivation in science contributes to reduced participation in science classes. As such, both Christopher and Shelly saw the incorporation of socioscientific issues as a way to engage their students in a content area that is usually approached through rote learning of factual knowledge (Gabel, 1999).
SSI and Underlying Beliefs about Chemistry Teaching

Topics Chosen by Teacher. Olson (1981) argued that teacher control over classroom talk and the general classroom context enables teachers to make sense of their practice. The mediating factor for both Christopher and Shelly choosing which SSI topics to include was control. Both Christopher and Shelly were novice teachers, and it was important for them to maintain control of their classes. Christopher chose the socioscientific issues to be discussed as a way to maintain control of his class and to make sure that he was teaching according to the state standards. He believed that it was his job to make sure that all state standards were covered in his class, so he tried to choose issues that could relate to the concepts covered. One of the challenges that Christopher found was that “The first thing is that a lot of the socioscientific issues center around things that are beyond the scope and the level of this class. A lot of times you have to kind of identify the issue and then simplify it and also relate it to what you guys are doing” (Final Interview, lines 40-42). So, Christopher spent a lot of time selecting and refining topics so that they could align with the state standards. Shelly chose the socioscientific issues-based topics to be covered in her class as well because she believed that it was important that they have a relationship to the overarching themes for each unit. As a first year teacher, Shelly thrived off of structure and continuity. She stressed, “I like themes” (Final Interview, line 130) and that “for every unit I would introduce them to what the theme of the unit was” (Final Interview, lines 21-22). Selecting the topics also gave her a way to maintain control and structure over her class. She mentioned how in every unit, it was important to teach chemistry in a way that allowed for the students to “stick to our applications” (Final Interview, lines 23-24).
SSI and Underlying Beliefs about Chemistry Learning

Real-World Examples. Real-world examples have been assigned various definitions. Davis and Petish (2005) defined real-world examples as “situations in which scientific principles are applied, usually implicitly, to everyday situations” (p. 264). Bouillion and Gomez (2001) defined the term as problems that are current, unsolved, and of consequence. More specifically, these authors stated that real-world examples have the following characteristics: “(a) they have no clear answer and are interdisciplinary in nature, (b) are relevant and of interest to the curriculum and students’ lives, and (c) are highly visible and accessible to students” (Bouillion and Gomez, 2001, p. 891).

Real-world examples were stressed in both Christopher’s and Shelly’s classes. The mediating factor for this was student engagement. Both believed that their students actively participated in lessons where real-world applications were presented. Christopher liked to use real-world applications in his lessons because they fostered discussion. He mentioned, “If you can get something that ties into something they’re seeing, then they’ll talk about it. They want to talk about it” (Initial Interview, lines 387-388). In addition he stated, “Even the person that kind of sits there with their head phones on the whole time and tries to sleep and all of that, they’ll have something to say in those kinds of conversations” (Initial Interview, lines 392-394). Some of the real-world examples he introduced into his lessons included dilemmas dealing with cell phones, nuclear energy, and the oil spill. Shelly loved to incorporate real-world examples for several reasons. First, because she had experienced so many things in her life, she wanted to use herself as an example in any opportunity that presented itself. Second, she did so because the conceptual chemistry course was designed with this intent in mind. Last, she used real-world examples because she believed it gave her kids something to relate to.
There is the notion that real-world examples work well when they are integrated or incorporated into science and other subjects instead of set apart and used separately. According to Davis and Petish (2005), integrated knowledge involves citing and linking multiple ideas of different types, such as principles, definitions, real-world experiences, and classroom experiences. Costa, Hughes, and Pinch (1998) believed that the easiest, and in many cases the most feasible, way to get students to appreciate the dynamics of controversy in science is to have them read about various controversies and discuss them in class. Davis and Petish (2005) added that science learners who appropriately link several types of ideas have a better understanding of science content. Also, Reeder and Moseley (2006) stated that integration provides an opportunity for students to make natural and meaningful connections between and among multiple content areas. Both Christopher and Shelly saw real-world examples as a means to help students make connections between the chemistry content and the occurrences of the natural world. The real-world examples presented in their classes were examples of curriculum integration because they were used to further explain how chemical processes functioned. Both brought in several real-world examples, such as the Dixie Plant Explosion or the events of Chernobyl, for students to grapple with throughout all of their socioscientific issues-based lessons. In many instances, these real-world examples initiated the start of the lessons.

**Hands-On Activities.** Driver (1995) contended that students are likely to understand more when given opportunities to explore their conceptual frameworks through experimental and discussion activities. Frieré et al. (2009) recommended investigations as a type of hands-on activity for classroom use. They defined investigations as:

- Multifaceted activities that entail several actions such as: making observations; questioning; searching for information in books, on the Internet or in other sources;
planning the investigation; revising previous knowledge; analyzing and interpreting data by using different tools; answering initial questions; and communicating results (Frieré et al, 2009 p. 47).

Christopher’s hand-on activities mainly consisted of laboratory experiences related to socioscientific issues. For example, towards the end of the school year, Christopher gave students an opportunity to perform a lab where they identified cations and anions in solution. Students were able to understand how the procedures they performed in the lab were also used to perform tests on water quality. Shelly used a lot of hands-on activities because she realized that her students were visual learners. She often incorporated a lot of demonstrations and laboratory activities into her socioscientific issues-based lessons. For instance, in the class discussion on DNA evidence, Shelly had her students perform a DNA fingerprinting lab in order to understand how different factors could be used to identify a suspect.

Carlson, Humphrey, and Reinhardt (2003) argued that using hands-on activities, such as investigations, allow students to learn by questioning, making predictions, developing hypotheses, and creating models and theories, as well as provide teachers opportunities to help students connect their own ideas with scientific, founded ideas and to reflect on their learning. Both Christopher and Shelly aimed to help students make connections between content and socioscientific issues as they provided these hands-on learning opportunities. Both believed that these hands-on activities provided students with practical understandings of chemistry concepts. As such, both included hands-on activities as a supplement to classroom discussions on socioscientific issues in their chemistry classes.
Planning for and Enacting Socioscientific Reasoning

Specific Topics. Krajcik and Mamlok-Naaman (2006) argued that ideas are often taught in isolation from each other without an organizer that can pull them together in a way that reflects the larger picture. This often leads to students seeing what they are learning as separate from their own interests and lives. Both Christopher and Shelly organized a lot of their socioscientific issues-based lessons around central topics. The mediating factor of planning lessons in this way was their belief that their students would more easily make connections. Christopher liked to organize his socioscientific issues-based lessons around big topics. He mentioned, “‘A lot of times, I try to plan lessons that are sometimes centered around it and that will be the big topic and this is what we’re going to do and this is what you’re going to see out of this kind of thing’” (Initial Interview, lines 151-153). This was the case because Christopher believed that having big topics provoked meaningful thought amongst his students. Shelly centered all of her socioscientific issues-based lessons around the central topic of the thematic units she taught. Her lessons were structured in this way because it was easier for her to plan and it helped her students to make connections between the overarching theme of the unit and the socioscientific issue discussed.

Locus of Control. According to Njus and Brockway (1999), locus of control is defined as an individual’s belief regarding the causes of his or her experiences and the factors to which that person attributes success or failure. Schunk (2008) added that it is a motivational concept that refers to generalized control over outcomes. Rotter (1966) argued that there are two types: external locus of control and internal locus of control. He stated:

When a reinforcement is perceived by the subject as following some action of his own but not being entirely contingent upon his action, then, in our culture, it is typically
perceived as the result of luck, chance, fate, as under the control of powerful others, or as unpredictable because of the great complexity of the forces surrounding him. When the event is interpreted in this way by an individual, we have labeled this a belief in external control. If the person perceived that the event is contingent upon his own behavior or his own relatively permanent characteristics, we have termed this a belief in internal control (Rotter, 1966, p. 1).

Both Christopher and Shelly’s attempts to foster socioscientific reasoning were influenced by external loci of control. Both enacted lessons in which uncontrollable instances, such as time constraints mediated the experiences. For instance, with Christopher, this came in the form of laboratory exercises taking longer than anticipated to complete. In one example, the chemical reactions lab lasted the entire class period due to the evaporation procedures taking longer than expected, so Christopher had to move his discussion about nuclear energy to the next class period. For Shelly, this came in the form of events that she felt that she had no control over. For instance, Shelly’s discussion of global warming was cut short due to a school assembly for juniors and seniors at Clearview High School. In another instance, Shelly’s acid rain lesson was enacted in a different way than planned due to the encouragement of her principal to use the death of Osama bin Laden as a teachable moment. In all of these instances where Christopher and Shelly believed they had no control of the outcomes, they continued to try to engage students in the societal issues at hand.

Fostering Socioscientific Reasoning

Classroom Discourse. According to Sadler (2006), discourse is defined as verbal expressions or conversation. Zeidler et al (2005) argued that classroom discourse plays a critical role in the development of students’ reasoning skills and their views about science. Sadler (2006)
furthermore defined argumentation as a type of discourse where there is an “expression of reasoning in the context of ill-structured, controversial, and debatable problems that may possess multiple, plausible solutions and be viewed from a variety of perspectives” (p. 325). Dawson and Venville (2010) added that argumentation is one way of providing structure to assist school students to develop and practice decision-making skills. Newton, Driver, and Osborne (1999) believed that argumentation is beneficial for three reasons: (1) it provides students with opportunities to understand the norms and language of scientific debate and how knowledge is constructed in science, (2) it promotes science learning as students build conceptual understanding, and (3) it gives students opportunities to fully participate in society as they reason, think critically, understand, and present arguments in a logical and coherent way.

In examining the rote classroom discourse in Christopher’s and Shelly’s SSI lessons, a mediating factor was student engagement. Both Christopher and Shelly used argumentation as a means for students to express their opinions about the topics being discussed. Christopher encouraged argumentation in his honors chemistry class because he believed that it always led to healthy debates. He mentioned, “I think with me, it really was just having discussions about it and just opening up their thought processes to making it a real-world thing” (Final Interview, lines 28-29). For example, in Christopher’s lesson involving the topic of nuclear reactors, students were given the opportunity to voice their opinions in relation to the energy policy in the United States. Christopher began this portion of the lesson by reading excerpts from President Obama’s remarks given on March 30, 2011 with regards to America’s energy security and the need to reduce dependence on foreign oil. Christopher then gave students opportunities to voice their opinions in light of this issue. Students began to give reasons on how to reduce America’s dependence on foreign oil. One student provided a suggestion and included reasons for giving
out ration cards, such as during World War II. A few students disagreed with this idea that was presented and began to chime in with their own solutions and reasons for these solutions. Other thoughts included requiring all citizens to drive electric cars, increasing the use of hydrogen fuel cells, putting solar panels on roofs, and digging up plastic in landfills. One example of argumentation in Shelly’s conceptual chemistry class occurred during the genetics/eugenics lesson. Shelly began the lesson by giving a definition of eugenics. She then gave students opportunities to voice their opinions as related to this issue. Students began to give their opinions with regards to when genetic engineering had gone too far and needed to stop and why it should be stopped at certain points. Students had differing viewpoints and reasons for when and why genetic engineering should stop. For instance, some students argued that genetic engineering should only be used for curing diseases and cited reasons for this opinion. Other students cited that there should not be any place for genetic engineering due to detrimental effects such as deformations and mutations. After students were given opportunities to explain their positions, Shelly concluded this portion of the lesson by commending students on all of the valid points they had raised and by reminding them that this was a controversial issue that would remain in the news for months and years to come. Both Christopher and Shelly encouraged argumentation in their classes, as this was, from their perspective, the main way through which socioscientific issues should be approached. Both believed that argumentation gave students opportunities to express their opinions with respect to the issues presented in their classes. Both believed that their students became active participants in lessons involving argumentation as compared to other types of lessons presented in class. These beliefs held by Christopher and Shelly aligned with the notion of Zeidler et al (2003), as these authors argued that argumentation should be used
in the context of socioscientific issues because it gives students opportunities to engage in
dialogue as they think about evidence, apply critical thinking skills, and formulate positions.

Disconnections. Chowning (2005) emphasized that within socioscientific issues-based
lessons the role of teachers must include helping students learn how to identify the facts of a
case, recognize the ethical dilemmas involved, and understand the different perspectives
presented. Both Christopher and Shelly experienced instances of disconnections while fostering
socioscientific reasoning. Fostering socioscientific reasoning, in many cases, was difficult for
Christopher as he experienced instances of disconnections between content and applications. For
instance, Christopher mentioned how sometimes it could be difficult to control conversations
because students liked to digress and bring in other topics for discussions. These digressions
would sometimes lead to disconnections between the intended socioscientific issue discussed and
the chemistry concept that it was related to. In other instances, there would be disconnections
between the socioscientific issue discussed and the laboratory activity performed. This was the
case in the chemical reactions unit. In this instance, Christopher gave students the opportunity to
perform a lab on chemical reactions and then led his students in a discussion on nuclear energy.
The chemistry reactions lab consisted of the students performing an experiment with vinegar and
baking soda in order to determine the limiting reactant, percent yield, and actual yield. This lab
was based on the concept of stoichiometry, which was a subset of the chemical reactions unit.
The discussion on nuclear energy was not related in any way to stoichiometry, thus causing a
disconnection between the concepts presented during the class period. Shelly also had instances
of disconnections. In her acids and bases unit, Shelly designated one class period to talk about
global warming, when she had previously told the students that this topic would be presented
after the acid and bases unit had concluded. This was due to an unplanned assembly that took
away tremendous amounts of class time. In this case, Shelly used this topic as a filler before the start of the assembly because she believed that she did not have enough time to get through the components of her lesson on that day, which included the students performing a lab on acids and bases. In another instance, at the conclusion of the class discussion centered around the death of Osama bin Laden, Shelly shifted gears to talk about acid rain. This disconnection was a problem for Shelly because during their discussions about the event, students saw the death of Osama bin Laden and the repercussions of his death as being related to the petroleum unit and not the acid and bases unit. Thus, even though Shelly followed her principal’s advice of using this event as a teachable moment, she struggled with moving the lesson back to the acids and bases unit with a discussion on acid rain because students wanted to continue to talk about the event’s relation to the petroleum unit. In these instances, both Christopher and Shelly included socioscientific issues in their lessons, but in a way that was not related to the content that was presented. For both Christopher and Shelly, these instances of disconnections caused them to have to plan other ways to refocus on the original issues presented in their lessons. Getting the students refocused on the original issues was important for both of them as they believed that these original dilemmas were more closely related to the chemistry content presented.

Hanegan, Price, and Peterson (2008) emphasized the importance of teachers encouraging students to make connections between content and context, especially in relation to argumentation. They argued that a teacher’s role should include determining if students have enough content knowledge to understand the issues presented in a lesson before engaging the class in argumentation. Both Christopher and Shelly tried to determine the level of students’ content knowledge in light of the issues presented by asking them questions about the topics before encouraging students to voice their opinions. For instance, Christopher questioned his
honors chemistry students about their knowledge with regards to the earthquake in Japan and its effect on nuclear reactors in this area before even engaging them in a discussion about the possibility of building a nuclear reactor in an area near Eastern High School. In areas where Christopher believed his students did not have sufficient content knowledge about the nuclear reactors in Japan, Christopher provided supplemental information through the use of PowerPoint slides. Shelly also asked students questions about their knowledge of the events leading up to the death of Osama bin Laden before encouraging her conceptual chemistry students to voice their opinions about this topic. Hanegan, Price, and Peterson (2008) also believed that if teachers determined that student knowledge was insufficient, then they should balance content knowledge, scientific findings, and public opinion in order to guide the class through argumentation on a socioscientific issue; this would help students retain emergent information needed for classroom success. This idea is important, as the authors noted, because as students develop greater content knowledge, they can contribute to a scientific argument and become more actively involved with the socioscientific world around them. Even though these disconnections occurred in both Christopher’s and Shelly’s lessons, both looked for ways to help their students understand the content knowledge by bringing in other relevant examples and sources in later instances.

Findings from the cross-case analysis showed that socioscientific issues were incorporated in Christopher’s and Shelly’s lessons for personal, practical, and formal reasons. Personal reasons included their experiences with people, places, and events. Practical reasons included their desires for students to make connections with the events occurring in society. Formal reasons included the teaching of issues that aligned with state standards and overarching themes of curriculum.
In summary, this section provided a cross-case analysis of Christopher’s and Shelly’s cases. As the researcher introduced the themes emerging from the two cases, she attempted to use these themes in order to examine the similarities and differences across the cases. The next section will provide a discussion and interpretation of the findings presented in this study.

**Discussion and Interpretation**

In the previous section the researcher provided a cross-case analysis of Christopher’s and Shelly’s cases. This section will provide a review and further discussion and interpretation of the findings from all three cases in relation to the research questions and existing literature.

This purpose of the study was to explore secondary chemistry teachers’ beliefs, plans for, and enacting of socioscientific issues-based lessons. As such, the sections are organized based upon the three research questions of the study, which were:

1) Why do chemistry teachers use socioscientific issues in their teaching?

2) How do chemistry teachers’ use of socioscientific issues reflect their underlying beliefs about:
   
   a. Nature of science?
   
   b. Chemistry?
   
   c. Chemistry teaching?
   
   d. Chemistry learning?

3) How do chemistry teachers plan for and enact socioscientific reasoning in a secondary chemistry classroom?
   
   a. To what extent do chemistry teachers foster socioscientific reasoning in these lessons?
Why SSI is used in Chemistry Teaching

The beliefs of Christopher, Shelly, and Linda as to why they incorporated socioscientific issues into their lessons aligned with researchers (Kolstø, 2001; Zeidler and Keefer, 2003; Zeidler et al, 2002) who argued that socioscientific issues portray science in the real world. The three participants believed it was important for their students to have socioscientific issues incorporated into their chemistry lessons as a way to help students better understand the content matter. They believed that these experiences with socioscientific issues more accurately reflected “the multi-disciplined nature, discourse, and activities of the scientific pursuit” (Pedretti, 2003, pp. 220-221). As such, all participants saw chemistry as more than a content-driven subject. They saw chemistry as a subject matter with many principles that related to everyday life. They saw the subject as an important part of the processes that occur in society. Because these secondary chemistry teachers saw the importance of chemistry, they were open to new approaches to teaching and learning. These new approaches included the incorporation of socioscientific issues. The teachers’ openness to including socioscientific issues in their lessons demonstrated their desire for students to not only grasp the content knowledge, but to also understand how the content knowledge did have a place in their everyday lifeworlds. In other words, chemistry was not merely a decontextualized subject for them; an SSI approach, from their perspective, was a way to help students explore the different ways that chemistry played a role in societal issues.

SSI and Underlying Beliefs about Nature of Science

Science educators have developed a variety of rationales for including instruction about the nature of science in the science curriculum (Bell, 2008). Some of the reasons included: (1) it has been shown to enhance students’ understanding of science content (Songer & Linn, 1991),
(2) it has been related to increased student interest in science (Lederman, 1999; Meyling, 1997; Tobias, 1990), (3) it portrays science as an adventure instead of the memorization of disconnected facts (McComas, Clough, & Almazroa, 1998), and (4) it helps to develop students into scientifically literate citizens (Bell, 2008). Simmons and Zeidler (2003) contended that students can develop logical and moral reasoning skills and gain a deeper understanding about important aspects of the nature of science by engaging in carefully selected moral problems in the domain of science. The researcher interpreted that all three chemistry teachers believed in the importance of explicitly including nature of science tenets in socioscientific issues-based lessons. They believed that by explicitly including nature of science tenets, students would have a better understanding of the processes involved in the nature of chemistry and thus understand the importance of chemistry in relation to its role in the natural world. This was especially emphasized by Christopher as he mentioned that he wanted his students to think about “*how their natural world works*” (Initial Interview, lines 272-273). Within their socioscientific issues-based lessons, Christopher and Shelly explicitly emphasized nature of science tenets which included dimensions regarding its tentative nature, its empirically-based nature, its involvement with human inference, its involvement with a combination of inferences, and its socially and culturally embedded nature (American Association for the Advancement of Science, 1993; Lederman, 1992; National Research Council, 1996). Only Shelly explicitly emphasized the nature of science tenet of subjectivity as she mentioned, “*one small mistake or change and it totally changes theories and laws. And that’s what I try to tell them is that just because this is what we thought for so long does not mean that it’s written in stone. Even if it’s written in stone doesn’t mean it can’t be x’d out*” (Final Interview, lines 106-110). By allowing their students to engage in nature of science tenets, these teachers hoped that their students would have a deeper
understanding of the content matter so as to prepare their students to become scientifically literate citizens.

**SSI and Underlying Beliefs about Chemistry**

All three teachers had beliefs about how they felt their students learned chemistry best. This aligned with Kagan’s (1992) argument that teacher belief is defined as the implicit assumptions that teachers hold with respect to students, learning, classrooms, and the subject matter. In this study, all three participants believed that their students were apathetic towards the subject matter of chemistry. The chemistry teachers’ beliefs aligned with the argument of researchers (Morell & Lederman, 1998; Osborne, 2007; Osborne, Driver & Simon, 1998) who emphasized that this lack of interest is due to the lack of personal relevance for the students. Thus, because of their beliefs about student apathy, all three chemistry teachers understood the stigma that had been placed on chemistry as being an irrelevant subject. As this was the case, all three participants understood they had a role to play in getting rid of this stigma. Their role included helping students see how chemistry played an important part in their lives. All three chemistry teachers also understood the repercussions of not getting rid of the stigma, which, from their perspective, would be to continue to have scientifically illiterate citizens. Thus, all three chemistry teachers believed in the importance of socioscientific issues-based lessons in order to make the subject matter relevant to their students in hopes that when they completed the course, they would have a better understanding of the value of chemistry as it related to their everyday lives.

**SSI and Underlying Beliefs about Chemistry Teaching**

Researchers (Bybee, 1997; Driver et al, 1996; Eilks, 2000; Holbrook, 2003; Osborne, 2007; Pedretti & Hodson, 1995) argued that socioscientific issues should be included in order to
enhance the scientific literacy in learners. Zeidler et al (2002) added that the inclusion of moral and ethical issues in the science curriculum helps to achieve scientific literacy. Findings from the study suggested that all participants understood the role that socioscientific issues played in helping students to become scientifically literate citizens. However, only Christopher and Shelly engaged in these teaching practices in order to help their students achieve scientific literacy. They were willing to wrestle with the messiness and the uncertainties that were attached with socioscientific issues in order to help their students become informed decision-makers.

According to Orpwood (2001), for many teachers, scientific content knowledge remains the most important science education outcome, perhaps a reflection of its importance in standards and assessments. Thus, as novice teachers, Christopher’s and Shelly’s willingness to include socioscientific issues-based lessons while addressing the state-mandated standards demonstrated their dedication to carrying out the teaching methods they believed in, even throughout the challenging instances they encountered.

**SSI and Underlying Beliefs about Chemistry Learning**

Dori, Tal, & Tsauhu (2003) added that teaching science through socioscientific issues increases learning in content domains. Findings from the study suggested that all three teachers believed that socioscientific issues-based lessons were important in helping their students to grasp the content in a better manner. Not only did all three teachers believe that it was important for students to learn the content, the findings illustrated that these teachers believed that it was important for students to have more than a basic understanding of the content. For all of the participants in the study, it was important for their students to have a deeper understanding of chemistry, despite the fact that there were no end-of-course exams in any of the chemistry classes involved in this study that would measure their students’ understanding of chemistry.
principles. Thus, the teachers believed in challenging their students to learn more than just the basic principles. They all believed that socioscientific issues-based lessons provided this challenge for their students.

**Planning for and Enacting Socioscientific Reasoning**

Schwab (1971a) believed that the planned and enacted curriculum were important components of curriculum design because they promoted knowledge (facts, ideas), skills (induction, deduction, physical skills), and attitudes (values, feelings, sensitivities). Both Christopher and Shelly tried to plan their lessons in order to promote knowledge, skills, and attitudes as they incorporated socioscientific issues-based lessons. However, Christopher’s and Shelly’s lessons were not always enacted as planned. In these cases, they still did their best to provide students with opportunities to develop conceptual understandings. These findings indicate that both Christopher and Shelly understood the importance of the planning process, and believed it was integral to ensuring student success in chemistry. For instance, Christopher mentioned how he continually searched the Internet for news events and stories that provided real-world examples in the context of the socioscientific issues discussed in class. Shelly emphasized the importance of the planning process as she noted how she stayed after school until 6:00 p.m. on many occasions in order to further prepare for upcoming lessons by examining the socioscientific issues more closely and by gathering resources that she believed would help the students better understand the issues and concepts discussed. Findings also shed light on the messiness of socioscientific issues-based lessons as they were not always enacted as planned. This finding highlighted the need for teachers to be confident and flexible in their enactment of socioscientific issues-based lessons due to unpredictable outcomes.
Although Linda believed in the importance of planning for socioscientific issues, it was not enacted in her lessons. This idea related to Haney and McArthur’s (2002) notion of peripheral beliefs. They defined peripheral beliefs as beliefs that were stated but not enacted. It was also consistent with researchers ((Brickhouse, 1990; Brickhouse & Bodner, 1992; Bryan, 2003; Gardiner & Farrangher, 1997; Haney & McArthur, 2002; Haney et al., 1996; Luft, 2001; Simmons et al., 1999; Thomas, Pederson, & Finson, 2001; Yerrick et al., 1997) who argued that teachers’ espoused beliefs and classroom actions are often in contrast. Welch, Klopfer, Aikenhead, and Robinson (1981) asserted that this mismatch between espoused beliefs and classroom actions could be the result of teachers often feeling ill-prepared for student-directed learning styles. This could lead to teachers adhering to their most stable, oldest beliefs (Bryan, 2003; Haney & McArthur, 2002; Richardson, 1996; Tobin, 1990). This appeared to be a factor in Linda’s decision to teach her unit in a more traditional manner.

**Fostering Socioscientific Reasoning**

Both Christopher and Shelly used classroom discourse in their socioscientific issues-based lessons. Zeidler and Nichols (2009) advocated the use of classroom discourse, such as argumentation and debate, because they maintained that students are being engaged in thinking and reasoning processes and are mirroring discourse practices that occur in real life in order to advance intellectual and scientific knowledge. Both Christopher and Shelly believed that discourse allowed their students to interact with one another, and thus foster higher-order thinking skills. In spite of Christopher’s and Shelly’s need for “control”, they were willing to relinquish some control over their classes in order to foster dialogue. Both Christopher and Shelly believed that it was important for students to have opportunities to express their opinions so that the connections their students made were a result of their own understandings and not the
views that Christopher and Shelly held with regard to the topics presented. Relinquishing some control over their classes was a part of Christopher’s and Shelly’s goals to help students see the value in chemistry and to think about how it related to the world around them. The findings demonstrated that for these teachers, chemistry was more than just a rote-learning subject; it could be interactive as students discussed their thoughts and opinions about socioscientific issues.

**Limitations and Constraints to Incorporating SSI**

Literature on science education reform emphasized the importance of aligning teacher beliefs with reform goals (Czerniak & Lumpe, 1996; Lynch, 1997). However, according to Lynch (2000), teachers need to understand the reform, believe in it, and be willing to change their practices. Zeidler et al (2011) believed that most teachers like the idea of relating science teaching to socially-relevant issues and are willing to try implementing a socioscientific issues-based unit. However, very few are willing or able to restructure their courses such that socioscientific issues become a central organizing feature (Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006). This was the case with Christopher as he mentioned, “I don’t have a problem putting things aside to a certain extent but at the same time, I would like to keep my job. So if I’m not teaching what the state says we have to teach, then I’m not doing my job as defined by them. I probably should be fired if I had a discussion about stuff every single day and didn’t teach anything that we’re supposed to” (Initial Interview, lines 365-369). Shelly’s goal was to center socioscientific issues-based topics around the central themes of the units taught. As a novice teacher, this was beneficial for her. Although Linda did not teach any socioscientific issues-based lessons during the study, she believed in it and would like to continue to do so in the future.
According to Zeidler, Bell, Sadler, and Eastwood (2011), the incorporation of socioscientific issues into curriculum requires a teacher to have a high level of content mastery, a confidence in teaching abilities, and a knowledge of content beyond the science text. Sadler (2011b) also mentioned that teachers may struggle with incorporating socioscientific issues because it requires a willingness to struggle with uncertainties. He stated, “Teaching science such that the representation of science content is the exclusive or at least primary focus is much easier than assuming the challenge and ‘messiness’ of SSI” (Sadler, 2011b, p. 357). In two of the cases presented in this study, the participants attempted to incorporate socioscientific issues-based lessons. However, the SSI topics were chosen by the participants, which helped to guide how the lessons flowed and reduced the teachers’ struggles with uncertainties. Christopher’s future plans include his increase in content mastery as he plans to work with a professor at a nearby university. Shelly’s various experiences and degrees illustrated her vast content knowledge as she was able to include information from a lot of different perspectives in her lessons.

Another constraint to the incorporation of socioscientific issues stems from the use of actual SSI cases and how information about the historical outcomes can shape the use of these issues (Wong, Zeidler, & Klosterman, 2011). According to Sadler (2011b), this could present challenges for the use of issues that are constantly evolving. This is because even though SSI’s are supposed to be open-ended and resolved, it is possible that some issues become resolved due to “scientific or technological advancement or policy enactment” (Sadler, 2011b, p. 357). As such, this leads to SSI’s in educational contexts potentially shifting as the issue itself evolves. This was highlighted in one aspect of Christopher’s case when he introduced the Dixie Sugar Plant explosion. When he asked the students to consider ways that this explosion could be
avoided, many pointed to the age of the building as being the main risk factor. In the minds of
the students, this issue had been resolved due to reports of the building’s age. Therefore, this
example represents an SSI that potentially shifted due to the issue itself evolving as news reports
about potential causes for the explosion continued to emerge.

In summary, this section provided a discussion and interpretation of the research findings
as related to relevant literature. The next section will discuss implications of this study.

**Implications of the Study**

This study explored the practices of three inservice secondary chemistry teachers as
related to the incorporation of socioscientific issues-based lessons. The importance of this study
stemmed from the need to understand why and how chemistry teachers incorporate
socioscientific issues into their curriculum in an era where much emphasis is placed on the
technical nature of the content of chemistry. The previous sections provided a cross-case analysis
of two of the secondary chemistry teachers who incorporated socioscientific issues into their
lessons and a discussion and interpretation of the findings. This section will discuss the
implications of the present study. It is divided into four areas which include: (1) theoretical
implications, (2) methodological implications, (3) implications for inservice secondary chemistry
teachers, and (4) implications for future research.

**Theoretical Implications**

Based on the interpretation of the findings, five important implications emerged as
significant. These implications included:

1) Teachers who included socioscientific issues-based lessons believed that chemistry was
more than a content-driven subject.
2) Socioscientific issues-based lessons were used as a way to get rid of the stigma that chemistry is irrelevant.

3) Teachers who incorporated socioscientific issues-based lessons understood the complexities of chemistry and therefore believed it was important for students to also understand these complexities as they provided opportunities for students to grapple with dilemmas that were presented.

4) Teachers who incorporated socioscientific issues-based lessons were willing to wrestle with the uncertainties of SSI-lesson outcomes.

5) Teachers who incorporated socioscientific issues-based lessons reflected confidence and flexibility in their practice.

These theoretical implications point to the inherent nature of socioscientific issues-based lessons with respect to teachers’ roles in implementing socioscientific reasoning practices. These implications suggest that teachers’ dispositions can potentially influence students’ understandings of socioscientific issues. Thus, it is important for current and future teachers who implement or plan on implementing socioscientific issues-based lessons to examine their own dispositions in light of these new assertions.

The frameworks for this study included teacher beliefs, situated learning, and Schwab’s notion of curriculum. This section will discuss the implications of the interpretations of the study as related to these theoretical frameworks.

**Teacher Beliefs.** Beliefs have been measured by various written instruments. However, in this study the secondary chemistry teachers’ beliefs were examined through interview data and observations. The researcher believed that this study provided support to Kagan’s (1992) assumption that a teacher’s professional knowledge is situated in context, content, and person.
Many factors came into play as the secondary chemistry teachers negotiated their beliefs with respect to including socioscientific issues-based lessons. The researcher interpreted that people, places, and events played a role in the secondary chemistry teachers’ beliefs in why socioscientific issues-based lessons were incorporated. The secondary chemistry teachers’ abilities to negotiate their beliefs reflected the context-dependent nature of teaching. In the present study, the terms beliefs and knowledge were not used synonymously, but were recognized by the researcher as closely related constructs. The researcher treated beliefs as the secondary chemistry teachers’ premises and propositions about socioscientific issues resulting from personal experiences that were mostly emotionally-laden.

**Situated Learning.** Findings from this study elaborated on situated learning by emphasizing that socioscientific issues-based lessons are viewed as communities of practice where teachers enact routines and are influenced by shared aims. Each of the secondary chemistry teachers brought their own personal experiences with schools and teaching into the classroom, and this proved to be a mediating factor in what was learned and how it was learned in the classroom setting. As such, situated learning provided a framework for the present study in that it was used as a way to examine the teaching methods of secondary chemistry teachers who planned and enacted socioscientific issues-based lessons. This theoretical underpinning helped the researcher focus on the actions of these teachers as they situated their lessons in the context of contemporary issues related to the subject matter of chemistry.

**Schwab’s Notion of Curriculum.** Findings from this study expanded Schwab’s notion of curriculum by elaborating on the complexities involved with revising curriculum practices in order to move beyond traditional science teaching practices and instead emphasize process over content. The researcher believed that this study extended Schwab’s notion of curriculum as
related to his emphasis on the planned and enacted curriculum in that it provided examples of the processes involved in planning and enacting socioscientific issues-based lessons in the context of secondary chemistry classes, which is an area not previously studied by researchers. The implications of the findings in this study in light of Schwab’s notion of curriculum were the inherent need for teachers to carefully consider their roles in planning and enacting socioscientific issues-based lessons so that fostering student learning is inevitable.

**Methodological Implications**

According to Nieto (1999), “No case study of a single individual can adequately or legitimately portray the complexity of an entire group of people. This is an especially important reminder because educational theories, no matter how helpful or insightful, are generalizations that do not explain every case” (p. 190). This study used a purposeful sampling approach (Patton, 2002) according to three criteria: (1) the participants must be secondary chemistry teachers, (2) the participants must teach on a block schedule, and (3) the participants must be known for their commitment to including socioscientific issues in their teaching of chemistry. If other teachers had participated in the study, the portraits of the secondary chemistry teachers’ incorporation of socioscientific issues may have been different. This study does not attempt to generalize beyond the cases of the three participants of this study.

Within-case and cross-case analysis were employed in this study. Stake (1998) defined comparison as “an epistemological function competing with learning about and from the particular case. Comparison is a powerful conceptual mechanism, fixing attention upon the few attributes being compared and obscuring other knowledge about the case” (p. 97). Thus, “generalizations from differences between any two cases are much less to be trusted than generalizations from one. Illustration as to how the phenomenon occurs in the
circumstances of the particular exemplar can be valued and trustworthy knowledge” (Stake, 1998, p. 98). As such, thick descriptions (Denzin & Lincoln, 2003) were used at the within-case level of analysis. In order to confront issues of generalization, the researcher hoped the readers learned about the secondary chemistry teachers’ experiences with socioscientific issues-based lessons through the thick descriptions provided for each case.

Interpretive naturalistic case study emerged as an appropriate approach to understand how selected factors contributed to shaping secondary chemistry teachers’ uses of socioscientific issues-based lessons. Case study design was chosen in order to explore a bounded system over time through detailed, in-depth data collection methods that involved multiple sources of information. Denzin and Lincoln (2003) concluded that “There is no clear window into the inner life of an individual. Any gaze is always filtered through the lenses of language, gender, social class, race, and ethnicity” (p. 31). Thus, the researcher recognized that the readers may create different portraits of the secondary chemistry teachers’ experiences with regards to socioscientific issues-based lessons.

The researcher employed the use of a modified version of Sadler’s (in press) assessment of socioscientific reasoning. The purpose of using this assessment was to understand to what extent socioscientific reasoning was being fostered in the secondary chemistry classrooms. Although Sadler’s (in press) original model is a new framework that characterizes diversity of socioscientific reasoning practices among students, the researcher modified the framework so that it would reflect diversity of socioscientific reasoning practices among teachers. The researcher also added the category of morals and ethics into the new construct in order to include Zeidler and Nichols’ (2009) belief that socioscientific issues include moral and ethical
dimensions. Sadler (in press) pointed out that the development of such measures will allow the research community to answer questions including:

(1) To what extent is socioscientific reasoning transferable across contexts? (2) How does socioscientific reasoning develop over time? (3) How can instruction support socioscientific reasoning practices? (4) What kinds of learning experiences are most suitable for supporting socioscientific reasoning practices? (p. 10).

The implication of modifying Sadler’s (in press) assessment of socioscientific reasoning is that it provided readers with an understanding of how the researcher characterized the secondary chemistry teachers’ fostering of socioscientific reasoning. This, in turn, gives readers a basis for understanding how the researcher interpreted the data.

**Implications for Secondary Chemistry Teachers**

The present study contributed to the understanding of the nature in which socioscientific issues-based lessons are incorporated in chemistry classes. The researcher’s interpretations suggested that in-service secondary chemistry teachers attempting to incorporate socioscientific issues into their lessons will need support in the form of professional development if they are to successfully present these types of lessons to their students. It is further implied that:

1) Professional development workshops or courses should be offered that provide opportunities for in-service chemistry teachers to gain ideas and unique perspectives as to how to approach teaching socioscientific issues-based lessons. Findings from this study indicated that even though both Christopher and Shelly understood the complexities of socioscientific issues, both included SSI’s as add-ons to their lessons. Thus, these professional development workshops would be beneficial in that they would allow chemistry teachers to understand different ways of making SSI’s the centerpieces of
lessons and units. In Linda’s case, although she believed in socioscientific issues-based lessons, she did not incorporate any during this study. Thus, these professional development workshops and courses, particularly when accompanied by sustained support, could also serve as a way to encourage chemistry teachers to engage in this manner of teaching instead of continuing with traditional manners of teaching chemistry.

2) Science teacher educators should structure methods courses that consider planning for and enacting socioscientific reasoning. The learning environment should help preservice science teachers establish a working definition of socioscientific issues and socioscientific reasoning, provide examples of where these types of lessons are encouraged, give preservice science teachers the opportunity to plan and model a socioscientific issues-based lesson, and make preservice science teachers aware of possible constraints and limitations of teaching SSI-based lessons. Findings from this study showed that all three participants defined socioscientific issues in different ways. For instance, Linda believed that socioscientific issues were related to societal issues but did not include ethical and moral dilemmas. On the other hand, Christopher believed that socioscientific issues consisted of a tie between science and political issues. Thus, a focus on SSI-based instruction in pre-service teacher education programs would help pre-service teachers have a better understanding of the characteristics of socioscientific issues and different approaches to embedding them in classroom practice. This study also illustrated examples of socioscientific issues being presented in a per-lesson basis and in a per-unit basis. Giving pre-service science teachers the opportunity to plan and enact SSI lessons would help them to better understand how to develop unit and lesson plans around a particular issue and still include the teaching of the state mandated standards.
Just as Christopher and Shelly experienced limitations and constraints to their socioscientific issues-based lessons, having pre-service teachers plan and enact model lessons might also give them opportunities to discuss with their peers some of the possible limitations and constraints they may face as they enact these model lessons.

**Why this Study is Meaningful**

The implications of the study seemed to indicate that the incorporation of socioscientific issues-based lessons is a viable way of teaching chemistry in a time where much emphasis is placed on making sure that all state standards are taught. This study was important in providing in-service science educators with alternative examples of teaching a content-driven subject. Since socioscientific reasoning is still a relatively new field of research in the science education community, this study provided evidence of the benefits and limitations to incorporating socioscientific issues-based lessons in secondary chemistry classes.

**Implications for Future Research**

One area for future research could center on how secondary chemistry teachers plan for and enact whole units and courses centered around socioscientific issues. Although Shelly’s case represented a snippet of what this could look like, more research needs to be done in this area. In fact, Sadler, Amirshokoohi, Kazempour, & Allspaw (2006) mentioned that very few teachers are willing or able to restructure their courses such that socioscientific issues become a central organizing feature.

Another area of future research could be investigating ways in which inservice secondary chemistry teachers assess information about controversial issues as credible and appropriate for classroom instruction. Both Shelly and Christopher brought in a lot of outside resources as a way
for students to view multiple perspectives. Research needs to be done to see how secondary chemistry teachers assess this information and why this information is chosen.

A third area of future research could include examining the forms of assessment used by secondary chemistry teachers while incorporating socioscientific issues. This would include investigating how these teachers assess their students and what factors determine whether or not a student has mastered a concept in light of the inclusion of socioscientific issues.

A fourth area of future research could include an examination of the experienced curriculum of secondary chemistry students who are in classes where socioscientific-issues based lessons are taught. By experienced curriculum, the researcher is referring to Jackson’s (1992) notion of the curriculum that the students have an opportunity to learn, grasp, or understand. This would enable educators to understand what students are learning and how this learning may have an impact on their lives.

A fifth area of future research could include an examination the new Georgia Performance Standards as related to the incorporation of socioscientific issues-based lessons. The new science standards call for applications of biotechnology within science courses taught at the secondary level. Future research could examine the extent to which the new standards have an impact on secondary chemistry teachers’ willingness to incorporate socioscientific issues-based lessons.

A sixth area of future research could include developing a framework for capturing the process of socioscientific reasoning. Sadler’s (in press) model of assessment of socioscientific reasoning exemplifies characteristics of socioscientific reasoning rather than processes of socioscientific reasoning. Thus, the researcher’s categorizations of the secondary teachers’ fostering of socioscientific reasoning seemed to indicate mismatches between what the teachers
expressed and what they enacted. A new model could include addressing such processes as transfer, nature of science, higher-order thinking, and decision making.

A seventh area of research could include examining the planned and enacted curriculum of experienced chemistry teachers who incorporate socioscientific issues-based lessons. It is to be noted that both Christopher and Shelly were induction teachers at the time of the study. As such, their incorporation of socioscientific issues-based lessons more than likely differed from those teachers who are considered to be experienced teachers. According to Feiman-Nemser (2001), the induction years are an important time of development in a teacher’s career because this is when a teacher’s beliefs, knowledge, and practices are strengthened. Future research with experienced chemistry teachers could examine their beliefs in relation to the incorporation of socioscientific issues and how their beliefs play a role in their planning and enacting of SSI-based lessons.

Conclusion

The findings of this study have provided some insight into three secondary chemistry teachers’ experiences with socioscientific issues-based lessons. In the context of ongoing concerns about students’ disengagement with chemistry and the importance of the development of scientific literacy, the researcher suggested that socioscientific-issues based lessons in the context of chemistry curriculum hold great potential for the increase in students’ scientific literacy skills. This study and other research over the past two decades have provided a great deal of insight into the ways classroom teachers incorporate the use of socioscientific issues into their lessons. However, the challenge of incorporating socioscientific issues-based lessons continues to exist as state standards and assessments continue to have huge impacts on how lessons are taught. This research has illustrated that even in a content-driven subject such as chemistry, there
is a place for socioscientific issues-based teaching. It is the researcher’s hope that this study will guide future support for implementation of socioscientific issues-based lessons in secondary chemistry teaching as a means for fostering student learning and engagement.
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Appendix A

Consent Form for Teachers

Secondary Science Teachers’ Use of Socioscientific Issues in the Teaching and Learning of Chemistry: An Interpretive Study

I, __________________________________, agree to participate in the research study entitled “Secondary Science Teachers’ Use of Socioscientific Issues in the Teaching and Learning of Chemistry: An Interpretive Study”. This research is being conducted by Gerri Cole, a doctoral student at the University of Georgia, in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Science Education. The research will be supervised by Deborah J. Tippins, PhD. I understand that my participation is voluntary. I can refuse to participate or stop taking part without giving any reason and without penalty or loss of benefits to which I am otherwise entitled. I can ask to have all of the information about me returned to me, removed from the research records, or destroyed.

The reason for this study is to explore how secondary teachers’ beliefs influence the way in which they plan for, translate, and experience socioscientific issues in their teaching of high school chemistry. This research may provide evidence on areas of strength and need in teacher education programs and teaching in general so as to help to better teacher development across the continuum of teaching experience.

I may benefit from this study by being able to reflect upon my own teaching practices and by becoming aware of ways in which both I and developing teachers deal with teaching issues in the classroom, including teaching methods and management. The potential benefits to society or humankind include:

1) providing an alternative method for teaching high school chemistry;
2) giving science educators an opportunity to examine the ethical and moral issues involved in teaching controversial topics; and
3) allowing for science educators to examine their own beliefs and how their beliefs influence their thinking about teaching and learning.

If I volunteer to take part in this study, I may be asked to do the following things:

1) Allow the researcher to record my open and public discussions, comments, and answering of questions when they are part of the class. No students will be included in our recordings in the classroom.
2) Be personally interviewed at least four times, with each interview lasting roughly one hour. All interviews will be audio-recorded.
3) Provide artifacts of teaching and learning. These may include but are not limited to: lesson plans, personal reflections, and teacher notes.

I will not receive any monetary compensation for participation in this study. No discomforts, stresses, or risks are expected in this study.
The only people who will know that I am a research subject are members of the research team. No individually-identifiable information about me, or provided by me during the research, will be shared with others. All information collected will be stored in a secure, locked location.

If you have any further questions or concerns about the research, now or during the course of the project, feel free to contact the researcher at (706) 549-5619. I hope you will enjoy this opportunity to share your experiences and viewpoints with us. Thank you very much for your help.

Sincerely,

Gerri Cole
Deborah J. Tippins
Professor, Mathematics and Science Education

My signature below indicates that the researchers have answered all of my questions to my satisfaction and that I consent to volunteer for this study. I have been given a copy of this form.

_________________________________________  __________________
Signature of Researcher                      Date

_________________________________________  __________________
Signature of Participant                     Date

Please sign both copies, keep one copy and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 612 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu
Appendix B
Interview Protocols
Appendix B1
Questionnaire for Participant Selection

Secondary Science Teachers’ Use of Socioscientific Issues in the Teaching and Learning of Chemistry: An Interpretive Study

1. How long have you been incorporating SSI into your lessons?

2. What levels (i.e. CP, Honors, AP, etc.) of chemistry do you incorporate socioscientific issues?

3. How is SSI incorporated (i.e. in particular lessons or throughout whole units)?

4. What topics have lent themselves to the incorporation of socioscientific issues in your classes?

5. What types of resources (if any) have you used as you have incorporated SSI into your lessons?

6. What have been some benefits to incorporating SSI in your lessons?

7. What have been some difficulties with incorporating SSI in your lessons?

8. What types of strategies do you use as you incorporate SSI in your lessons?

9. What has been the level of student participation in lessons that incorporate SSI as compared to the lessons that do not incorporate SSI?

10. What future plans do you have with the incorporation of SSI into your lessons?
Appendix B2
Initial Interview Questions for Participants

Secondary Science Teachers’ Use of Socioscientific Issues in the Teaching and Learning of Chemistry: An Interpretive Study

1) Tell me a little bit about your personal background. Tell me a little bit about your academic background. Describe the courses that you took in college.

2) Why did you choose to study science in your postsecondary education? Describe your experiences with science throughout your life.

3) How did you end up becoming a chemistry teacher? What experiences led to your being here?

4) Tell me about the chemistry classes you are teaching this semester. Tell me about the students in your chemistry classes.

5) In your view, why is it important for students to learn science? What is your goal as a science educator?

6) How do you think your students learn science best? How do you think your students learn chemistry best?

7) How would you define a socioscientific issue? In what ways is a socioscientific issue similar to or different from a (a) social issue and a (b) scientific issue?

8) What role do you think ethics should play in the chemistry classroom? Describe any ethical issues that you and your students have discussed in your chemistry classes. In your view, why was this an ethical issue?

9) What are your plans for addressing socioscientific issues in your chemistry classroom for this semester?
Appendix B3
Pre-Interview Questions for Participants

Secondary Science Teachers’ Use of Socioscientific Issues in the Teaching and Learning of Chemistry: An Interpretive Study

1) Describe the socioscientific issue that is at the heart of this lesson.

2) Tell me about any previous experiences you have with incorporating socioscientific issues in teaching this topic.

3) What do you intend for the students to learn from this lesson? Why is it important for students to know that?

4) What do students need to know prior to this lesson?

5) What do students need to know and be able to do in this lesson today?

6) What aspect of your knowledge of students influenced your planning of this lesson?

7) How will you monitor your students’ learning while you are implementing this lesson?

8) What do you expect your students will know at the end of this lesson?
Appendix B4
Post-Interview Questions for Participants

Secondary Science Teachers’ Use of Socioscientific Issues in the Teaching and Learning of Chemistry: An Interpretive Study

1) How did the lesson go today?

2) Could you tell me the most important/interesting moments from the perspective of the students’ learning of chemistry?

3) What surprised you about this lesson?

4) What do you think the students got out of the lesson today?

5) What would you do differently with incorporating socioscientific issues if you were to teach this lesson again?
Appendix B5
Final Interview Questions for Participants

Secondary Science Teachers’ Use of Socioscientific Issues in the Teaching and Learning of Chemistry: An Interpretive Study

1) What role did you play as a teacher in fostering students’ understanding of socioscientific issues in these lessons?

2) What do you feel is the most effective approach for including socioscientific and ethical issues in your chemistry teaching? Why?

3) What are the challenges or issues you face in teaching about socioscientific issues?

4) As a teacher, how do you think you will balance content that students need for later schooling with what students need for life in general?

5) How did your life experiences influence your beliefs about the teaching of socioscientific issues?

6) How did your experiences during this semester influence your beliefs about the teaching of socioscientific issues?
Appendix C  
Original Model of Sadler’s (in press) Assessment of Socioscientific Reasoning

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<th>Level 2</th>
<th>Level 3</th>
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<td>Complexity</td>
<td>Offers a very simplistic or illogical solution without considering multiple factors.</td>
<td>Considers pros and cons but ultimately frames the issue as being relatively simple with a single solution.</td>
<td>Construes the issue as relatively complex primarily because of a lack of information. Potential solution tends to be tentative or inquiry-based.</td>
<td>Perceives general complexity of the issue based on different stakeholder interests and opinions. Potential solutions are tentative or inquiry-based. Assesses the issue from multiple perspectives.</td>
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<tr>
<td>Perspectives</td>
<td>Fails to carefully examine the issue.</td>
<td>Assesses the issue from a single perspective.</td>
<td>Can examine a unique perspective when asked to do so.</td>
<td>Assesses the issue from multiple perspectives.</td>
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<tr>
<td>Inquiry</td>
<td>Fails to recognize the need for inquiry.</td>
<td>Presents vague suggestions for inquiry.</td>
<td>Suggests a plan for inquiry focused on the collection of scientific OR social data.</td>
<td>Suggests a plan for inquiry focused on the collection of scientific AND social data.</td>
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<tr>
<td>Skepticism</td>
<td>Declares no differences among stakeholders.</td>
<td>Suggests that differences likely exist among stakeholders.</td>
<td>Describes differences among stakeholders.</td>
<td>Describes differences among stakeholders and discusses the significance of conflicting interests.</td>
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Appendix D
Curriculum Map for Shelly Thomas’s Conceptual Chemistry Class
## Conceptual Chemistry Curriculum Map (Physical Science GPS) – 2010-2011

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<td><strong>SPS1a- Atom structure</strong></td>
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<td>SPS2c- Use IUPAC nomenclature</td>
<td>SPS2b- Binary ionic compounds</td>
<td><strong>SPS5a- Compare and contrast</strong></td>
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