University of Alberta

Investigating secondary science teachers' beliefs about what counts most as science education.

by

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To my family, friends, mentors, colleagues and students. Without your patience, support and encouragement, this project would not have been possible.

Abstract

This research aimed to investigate Alberta science teachers' beliefs about 'what counts most as science education'. By implicating teachers' beliefs in discussions about the science curriculum-as-planned by program developers and the science curriculum-as-lived in the classroom, factors influencing how Alberta's science programs are interpreted and enacted in classrooms were revealed and explored. The results of this study suggest teachers beliefs are influenced by contextual factors such as school setting, teaching experience, the nature of the courses taught, and departmental examinations. Functioning as key referents, these factors were found to influence not only what science teachers believe is most important, but also what teachers reported they emphasize most in their classrooms. When examined more closely, the key referents also offered an explanation as to why teachers' beliefs are often not enacted in their classrooms, thus clarifying tensionalities they experience between the curriculum as they perceive it and the curriculum as they live it.

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Chapter 1: Introduction

Where is the teacher in curriculum talk?

> *Within the dialectics of science education, the teacher is captive of the curriculum, which is often decided by others, and his / her prior experiences. However, what is taught and particularly the emphasis on how it is taught depend in part on the teacher's perceptions, not only of the purpose of teaching but also of science itself. The teacher's set of beliefs becomes an ideological force, which mirrors that of a section of society itself.*
>
> *Cross, 1997, p. 608.*

Cross's words conjure the sense of tension I feel as a high school science teacher trying to reconcile my own personal beliefs about the purpose of science education with the outcomes of the programs of study, in which I am held captive. As I reflect upon my years of teaching, I recognize this tension as a matter of understanding where I, someone with a unique set of experiences, exist both within and outside of the science curricula I teach. I wonder how my own ideas about what is important in science education compare with the programs of study? How do my beliefs impact the way I deliver, and the way students perceive, the science curriculum in my classroom? Am I alone in asking these things?

Cross (1997), Carson (1990), Aoki (1991, 1993), and others asked similar questions. Carson for example, asked, "Where is the teacher in curriculum talk?" (p. 21). His refusal to accept teaching as little more than a process of "technical doing", has encouraged educational researchers to acknowledge and explore how teachers' beliefs, identities and understandings influence their craft. For Aoki (1991), the exploration of teachers' stories and beliefs about the "curriculum-as-planned" and the "curriculum-as-lived", creates a space of "indwelling" (p. 163), where teachers become much more than mere technical doers. Indwelling creates opportunities to explore and honor the dialectic between the curriculum-as-lived and the curriculum-as-planned, allowing for a new understanding of the teachers' role within classroom dynamics. When the dialectic is observed, it becomes apparent that curriculum-as-lived by teachers is often different from the curriculum-as-planned by policy-makers. Such differences arise when teachers negotiate tensions among written curriculum, teachers' identities, relationships, actions and beliefs. Exploring the difference may not only help educators to understand those tensions better, but may also help educators, teachers and curriculum developers to ease them. In Aoki's words:

> *"…the quality of curriculum as lived experiences is the heart and core as to why we exist as teachers, principals, superintendents, curriculum developers, curriculum consultants and teacher educators. Curriculum planning should have at its central interest a way of contributing to the aliveness of school life as lived by teachers and students" (Aoki, 1991, p. 165).*

Research Purpose

With Aoki's (1991) words in mind, the purpose of this research is to indwell between the Alberta science curriculum-as-lived and the curriculum-as-planned by investigating teachers' beliefs about what 'counts *most* in science education'. To further understand tensions that arise between teachers' beliefs and the programs of studies, this research explores some factors that potentially influence teachers' beliefs, and how they are reportedly enacted in classroom practice. Investigating the factors that contribute to teachers' beliefs about what is most important in science education will help educators understand what aspects of teaching and learning science are emphasized in classrooms and why. In addition, this investigation aims to explore the continuities and discontinuities between curricular goals and science teaching practices. Educators and policy makers can use this information to direct professional development, curriculum planning and teacher education programs in an effort to relieve some of the competing tensions that arise between the programs of studies, teacher beliefs and consequent classroom practices.

Research Questions

Tobin, Tippens and Gallard (1994) suggest, "teacher beliefs are a critical ingredient in the factors that determine what happens in classrooms"(p. 64). Every teacher is assumed to arrive in his or her classroom with a unique set of experiences, values, and knowledge, which ultimately shapes his or her beliefs about science teaching and science education. Differing demands from different teaching assignments, classroom compositions, school organization, and course-loads may potentially influence teachers' beliefs about what is most important, and in turn impact how teachers enact their beliefs in classrooms. Considering teachers' beliefs as a key part of the dialectic between the curriculum-as-planned and the curriculum-as-lived, four key research questions emerge. They are:

1. What do secondary teachers in Alberta believe are the most important emphases or goals of teaching science?
2. Why do science teachers hold a particular set of beliefs?
3. What contextual factors influence science teachers' beliefs about what is most important in science education?
4. How do science teachers' beliefs relate to classroom practice?

The main assumptions underlying this research are; teachers' beliefs can be investigated; they are dependent upon the teaching context; and teachers' beliefs do influence classroom practice. These assumptions are supported by research conducted by

Brickhouse, 1990; Brosseau, Book, & Byers, 1988; Cronin-Jones, 1991; Deemer, 2004; Eberic, 2008; Farrow 1999; Grossman & Stodolsky, 1995; Lumpe, Haney, & Czerniak, 1988 & 2000; and Roehrig & Kruse, 2005.

First Memories: On the importance of belief and purpose

I believe all teachers, like myself, experience some angst when deciding what to emphasize in their teaching and how to go about it. It doesn't take very long before a new teacher realizes there is much more to teaching science than presenting concepts and covering learning objectives listed in the programs of studies. What teachers feel they need to emphasize and what they deem to be important often comes down to teachers' values about teaching, learning and science education in general.

When I began my career as a teacher, my first assignment was teaching science at a combined junior-senior high school. In addition to making sense of the programs of study, I was charged with teaching back-to-back classes that included students from extreme ends of the academic spectrum. First period of each day, I taught Grade 9 science to a group of students who required individualized program plans and a modified curriculum. I struggled to determine not only what, from the written program of studies, was most important for my students to learn, but also how to go about helping them find personal meaning in the science I was teaching them. Daily, my students asked me why they should learn science. They wanted to know how learning science would help them in life. During second period, I taught Chemistry 30. Almost all of my chemistry students were university bound with aspirations of careers in medicine or law. They wanted to know every detail related to the chemistry program, not because they were genuinely interested in learning chemistry, but because they wanted to achieve top grades that would secure their positions at university. What to teach wasn't an issue because my chemistry students demanded to know it all. How to teach it meaningfully was more problematic. Preparing my students for post-secondary studies required much more than transmitting knowledge about chemistry. I knew they needed broader skills that would help them with their studies, but couldn't decide which were most important. Again, I struggled with determining what to emphasize most.

If I didn't know why what my students were learning was important, or what they needed to know to live better lives in post secondary or elsewhere, how could they know? If my students couldn't understand why they were learning something, why should they work at learning it? The programs of studies offered little guidance. There were philosophical statements about 'foundational pillars' and 'key learner outcomes', but nothing that gave me a clear, unified sense of purpose for the science I was teaching. It was all left open for interpretation, so I reflected upon what *I* believed to be important by considering why I emphasized some things in my science classroom and not others. I also considered whether or not my beliefs about science were of service to my students and discovered that while my basic beliefs about what was important in science education were fairly consistent, they varied as I switched from one course to the next. My teaching context influenced how I expressed my beliefs and what I emphasized. For my grade 9 science class, I emphasized the everyday connections between the content and students' lives. In my Chemistry 30 class, I emphasized the problem solving and technical skills they would need for post-secondary studies. In retrospect, I also discovered, that my beliefs guided the purpose of the lessons I taught. If I was going to help create a sense of purpose in my students, I had to engage my beliefs.

Related Studies and Research Context

A significant portion of educational research has been dedicated to investigating teachers' beliefs and the impact of their beliefs on curriculum implementation. Much of the previous work relevant to science education focuses on one of three areas; the influence of teachers' beliefs about science on classroom practice (see Brickhouse 1990; Cronin-Jones, 1991; Eberic, 2008; Keys, 2005; Farrow 1999; Lederman & Zeidler, 1987; Lumpe, Haney &Czerniak (1998); Nespor, 1987; Pomeroy, 1993; Roehrig & Kruse, 2005; and Wallace and Kang, 2004), teachers' beliefs about curriculum design (see Cheung & Ng, 2000; Jeans, 1998; Lin, Hu & Changlai, 2005; and vanDriel, Bulte & Verloop, 2007; and contextual factors that influence science teachers' beliefs (see Brosseau, Book & Byers, 1988; Chu, 2009; Deemer, 2004; Grossman & Stodolsky, 1995; Markik, Eilks & Ralle, 2009 and vanDriel, Bulte Verloop, 2005, 2007 & 2008. Although the research has identified and categorized the nature of teachers' beliefs, factors influencing beliefs and how beliefs are enacted in the classroom, very few studies offer a detailed discussion of why or how teachers' beliefs, in concert with written science programs, influence classroom practice. In consideration of teachers' beliefs as part of the indwelling between the curriculum-as-planned and the curriculum-as-lived, this research contextualizes teachers' beliefs relative to the written programs of study within which teachers are legally bound.

This research focuses specifically on *Alberta* science teachers' beliefs. Alberta is an excellent context for study because the philosophical foundations and goals of secondary science programs are made explicit in all of the programs of studies. In addition, the philosophical framework is the same for all programs regardless of grade level or discipline. This means perspectives about what are important in science education, as written in Alberta's science programs, are both consistent and known. By examining Alberta junior and senior secondary science teachers' beliefs, this research contextualizes teachers' beliefs about science education as part of teachers' indwelling between the curriculum-as-planned and the curriculum-as-lived.

Theoretical Framework

In Alberta, all secondary science programs, regardless of subject area share a common vision that students will develop scientific literacy. Scientific literacy is defined in Alberta's science programs as a goal of science education where students will:

> "…develop the science-related knowledge, skills and attitudes that students need to solve problems and make decisions, and at the same time help them become lifelong learners— maintaining their sense of wonder about the world around them…They also need to develop the broad-based skills required to identify and analyze problems; to explore and test solutions; and to seek, interpret and evaluate information. " (Alberta Learning, 2003, p. 1; Alberta Education, 2005, 2007, p. 1)

Four foundational pillars; attitudes, knowledge, skills, and science, technology and society (STS), characterize those critical aspects of Alberta's science programs that support scientific literacy (Alberta Learning 2003a, 2003b; Alberta Education, 2005, 2007a, 2007b, 2007c, 2007d). The four pillars are arguably the most conspicuous and enduring aspect of Alberta's science programs, serving as the key structural elements that organize all of Alberta's science programs regardless of content, subject area or grade level. Within the context of this research, the four pillars present a locally relevant framework for investigating teachers' beliefs about what is most important in science classrooms across Alberta.

Alberta's four foundational pillars for science literacy reflect an adaptation of Robert's (1982, 1983) widely accepted 'curriculum emphases' framework. The curriculum emphasis concept is non-prescriptive, and consequently gives teachers a high degree of flexibility in selecting different emphases at different times. With no explicit weightings assigned to any of the four foundational pillars, teachers are free to emphasize those aspects they believe are most important in their classes.

While the four foundational pillars described in the Alberta program of studies are by no means exhaustive, they do identify some of the science emphases most frequently cited in the existing literature (see Chu, 2009; Markik, Eilks & Ralle 2009; and vanDriel, Bulte & Verloop 2005, 2007, 2008). The four foundational pillars are also featured in the Pan Canadian Protocol for Science Education (Council of the Ministers of Canada, 1997), which has informed the general curricular outcomes for science in Alberta, British Columbia, Saskatchewan, and the Atlantic provinces. Ontario identifies three of the four foundational pillars including knowledge, skills and STS, with attitudes being interwoven throughout the programs of studies rather than stated as a specific general outcome (Ontario Ministry of Education, 1999, 2008). The province of Manitoba identifies all four foundations for scientific literacy plus one additional foundation called “unifying concepts”(Manitoba Education, 2001). The consistency in which the Canadian provinces apply the four foundational pillars suggests conclusions drawn from this research may potentially be generalized not only across Alberta, but also across Canada.

Relating this Research

As part of a class discussion about the nature of research, one of my university instructors explained, “ …whether intended or not, all research is an intervention” (G. Thomas, personal communication, April, 2010). I hope this research will also become an intervention that encourages teachers, educators and curriculum writers to reflect upon and celebrate differences in teachers' beliefs and how they perform their craft. Aoki (1993) reminds us that we can live within difference, which he calls a "multiplicity of betweens" (p. 207). By occupying this space, we legitimize the lived curriculum bringing curriculum developers, educational leaders and practicing teachers into meaningful conversations about what counts most in science education.

Chapter 2: Literature Review

Introduction

The primary goal of this study is to investigate science teachers' beliefs about what is most important in science education, and to explore how teachers beliefs and the written curricula are implicated in the space between the curriculum-as-planned and the curriculum-as-lived in the classroom. In this chapter, I engage a brief history of science education to tease out a framework, for conceptualizing and categorizing teachers' beliefs. By reviewing related educational research I also provide a working definition describing what teachers' beliefs are and how they are relevant to teaching practice. Lastly, I turn to other research surrounding science teachers' beliefs about what is most important in science education to identify factors that potentially influence Alberta science teachers' beliefs about and enactment of science curriculum.

Scientific Literacy and Purpose for Science Education

Researchers such as Duggan and Gott (2002) have repeatedly asked the question, "What sort of science education do we really need?" Over the past three decades, educators, curriculum developers, and policy makers have also considered this question in an effort to analyze and reform science programs. Bennett (2003) identified two important factors, still relevant today, that have influenced science education reform over the past thirty years. First, changes in societal values created the expectation that schools "provide access for all young people to an education which is both relevant and serves as preparation for later life" (p. 14). What was deemed as relevant has been, and still is, continually changing. Second, the growing presence of scientific and technological developments and their impacts on everyday life has created new demands on student learning. Hodson (2003), suggested science education requires, "…more emphasis on technology and the applications of science [and] greater attention to the social processes used to generate, test and scrutinize knowledge claims" (p. 649). If students are to utilize and make decisions about continually changing technologies, they must learn how science and technology develops, changes and impacts society. An important question then becomes; what aspects of technology, scientific application or the social processes involved with technological and scientific innovation, are most important for students to learn?

Although many changes in thinking about the purposes and aims of science education transpired during the past three decades, a clear and focused goal for science education has yet to emerge. Bennett (2003) characterizes the 1980's as a "decade of action and reaction" (p. 16) where educators' and policy-makers' aimed to justify school science as a compulsory subject that would produce an informed and motivated citizenry and ensure a continuous supply of future scientists to continue the process of scientific and technological innovation. Although the intent of compulsory science education was to be "relevant and accessible" (Bennett, 2003, p. 14) to all students, research in the late 1980's revealed some major shortcomings. Studies conducted in the late 1980's and early 1990's suggested students were not as accomplished in their scientific knowledge and skills, as previously expected, nor were they interested in pursuing careers or further studies in science or technology (see Fensham, 2004; Ogens, 1991; and Osborne, 2003). In their 1998 paper "Beyond 2000", Millar and Osborne argued a specialist curriculum designed to train future scientists did not adequately stimulate or prepare pupils for the responsibilities of future citizenship. As a result, the 1990's saw a more generalized approach to science education, captured by the phrase, "scientific literacy".

The 1990's challenged educators to make the goals and intents of science education as clear and measurable as possible. Armed with the newly coined slogan, "scientific literacy" and a newfound determination to improve student achievement, the 1990's were "characterized by increasing centralized control, increasing curriculum prescription and increasing accountability" (Bennett, 2003, p. 18). Science curricula became more reductionist, emphasizing measurable facts and theories *of* science over more generalized knowledge *about* science. Although there was a shift from a "specialist" curriculum designed to meet the needs of future scientists, towards more generalized compulsory curriculum focused on scientific literacy, 'science for all' was still far from being realized. Educators needed a curriculum framework that could clearly define the means to achieving scientific literacy, while maintaining science content objectives that could be objectively assessed.

Many curriculum documents positioned specific science content, the nature of science, and issues involving the relationships between science, technology and society, as separate and discrete curricular objectives. For example, in the 1994 version of the Alberta Chemistry 20 / 30 programs of studies (Alberta Education, 1994), the programs' rationale and philosophy, general learner expectations, specific learner expectations and the discrete content-related outcomes in the program were physically separated. The rationale and general learner expectations made up the *front matter* of the curriculum, and the specific learner expectations, considered by teachers as the content of the programs, made up the *back matter*. Following this design, textbook authors often placed topics about the nature of science and examples relating science, technology and society at the beginning or at the end of textbooks, where they were usually ignored. Subject specific content made up the main body of text and consequently stood out as the privileged, and most frequently assessed aims and objectives in science education (Roberts, 1995). Other, more general aspects of science teaching and learning were often ignored.

Roberts' Curriculum Emphasis Framework

After an historical review of elementary and secondary science curricula across North America, Roberts (1982, 1988, 1995) identified seven themes or companion stories of science education, which he called "curriculum emphases". These stories established

> … a coherent set of messages *about* science (rather than *within* science). Such messages constitute objectives which go beyond learning the facts, principles, laws and theories of the subject matter itself- objectives which provide answers to the student question: "Why am I learning this?" (Roberts, 1982, p. 245)

Roberts' curriculum emphases provided a way to define specific aspects of scientific literacy that could be located within the subject matter, rather than being taught as loosely defined add-ons. As a framework for science education Roberts' curriculum emphases allowed curriculum writers and instructional materials developers to address scientific literacy in terms of *why* students study science and it gave educators a way to consolidate reductionist subject – bound curriculum topics with broader concepts such as the nature of science and the roles of science and technology in society. Effectively, curriculum emphases provided a way for educators to integrate the *front matter* and the *back matter* of the Alberta programs of studies giving both reasons and context for what science students learned in class. Each of these themes was, and still is, encapsulated in whole or in part in many mandated curricula and textbooks used throughout North America. Roberts' (1983) emphases include:

1. **Everyday coping** – orients science teaching toward the application of science to objects and events of fairly obvious importance to the student. (p. 13)
2. **Structure of science** – orients teaching in such a way that the student comes to understand how science functions as an intellectual enterprise. (p. 13)
3. **Science-technology-decisions** – draws attention to the limitations of science, but also to its strengths in dealing with practical affairs of mankind. Science is distinguished from technology as the development of knowledge is distinguished from it's application… (p. 14)
4. **Scientific skill development** – has science subject matter taught in the service of developing sophisticated conceptual and manipulative skills, such as observing, measuring, experimenting, hypothesizing, etc. (p. 14)
5. **Correct explanations** – focuses heavily on the ends of scientific inquiry rather than the means. The emphasis is familiar to anyone engaged in science teaching as the "master now, question later" strategy. (p. 14)

6. **Self as explainer** – concentrates on the similarities between a student's explanatory activities within his / her cultural context, and the explanatory ideas of scientists within their own cultural matrix. (p. 15)

7. **Solid foundations** – answers the student query about the purpose of learning "this stuff" in a straightforward manner: "to get ready for the 'stuff' you are going to learn next year". (p. 15)

Roberts (1988) aptly pointed out different emphases were in fashion at different times throughout history, depending upon the social factors influencing science curriculum policy at the time. From this, he implied no one emphasis was 'right' or 'better' than the others, suggesting different emphases could be selected at different times and for different purposes. Roberts also acknowledged, his seven emphases were not necessarily the only aspects of science education, implying changing times and contexts could lead to the identification of new and different emphases.

Alberta's Science Curriculum Emphases

In the mid 1980's the Alberta government, with its rich supply of natural resources, aspired to become a scientific and technological leader amongst the Canadian provinces and in the world. To meet this goal, the department of education was charged with providing school science programming that would enhance students' comfort with, understanding and ultimate acceptance of technology. In 1984, the Science Council of Canada also released the results of a nation-wide study recommending greater attention be given to Science, Technology, and Society (STS) issues. As a result, Alberta Education restructured Alberta's science curricula, transitioning from a single discipline, "layer cake" (Roberts, 1995, p. 495) model established in the late 1970's, in favor of a more generalized and integrated program. To ensure science content was taught with scientific literacy in mind, four key structural elements functioning as curriculum emphases, emerged. Today, these elements, known as the four foundational pillars, make up the philosophical framework for all of Alberta's secondary science programs.

The Alberta science programs of the early 1990's intended to "unify the goals of science education" (p. 2) by broadening the subject content learned in each instructional year, accurately presenting the nature of science, and focusing on the interactions between science, technology and society (Alberta Learning, 1990). This vision for secondary education in Alberta was to provide

> the best preparation for students to anticipate the shape of the future [defined as] a broad general education with emphasis on critical and creative thinking, communication, personal development, science and technology and an understanding of the community (Alberta Learning, 1990, p. 2)

The two concepts of science, technology and society (STS) education and curriculum emphasis were merged to create the four foundational objectives of the Alberta secondary science programs (Alberta Learning, 1990). These same objectives were also collaboratively developed and adopted in 1995 by the Council of Ministers of Education, Canada as a way to, " delineate four critical aspects of students' scientific literacy" (p. 1) and are also presented in the foundation statements for science literacy in Canada within the *Pan-Canadian Protocol on School Curriculum*. Within this new framework, the foundations are matched with specific topics in science, creating a unified and balanced curricular structure that would bring the new vision for science education and scientific literacy to fruition. The four foundational pillars, as stated in the Pan

Canadian framework (Council of the Ministers of Education, Canada, 1997) and in the current Alberta programs of studies (Alberta Education, 2003a, 2003b, 2005, 2007a, 2007b, 2007c, 2007d), are:

> **Foundation 1:**
>
> **Science, Technology and Society, and Environment (STSE)** – Students will develop an understanding of the nature of science and technology, the relationships between science and technology and the social and environmental contexts of science and technology. (Alberta Learning, 2003a, p. 3)
>
> **Foundation 2:**
>
> **Skills** – Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results for working collaboratively and for making informed decisions. (Alberta Learning, 2003a, p. 3)
>
> **Foundation 3:**
>
> **Knowledge**– Students will construct knowledge and understandings of concepts in life science, physical science and Earth and space science, and apply these understandings to interpret, integrate and extend their knowledge. (Alberta Learning, 2003a, p. 3)
>
> **Foundation 4:**
>
> **Attitudes** – Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society and environment. (Alberta Learning, 2003a, p. 3)

A review of other, recent studies investigating science teachers' beliefs about what is most important in science education reveals similar curriculum orientations (see Cheung & Ng, 2000; Lin, Hu & Changlai, 2005; Markik & Eilks & Ralle, 2009; vanDriel, Bulte, & Verloop, 2007) with minor differences in the number (usually one more or one less) and wording of categories. Viewed from a curriculum emphasis framework, where emphases are seen as objects of choice (Roberts 1982), minor differences in these orientations are not only accepted, but also expected.

As objects of choice, Alberta's four foundational pillars, not only garner varying degrees of allegiance by policy-makers and curriculum writers, but also by teachers. As a result, programs designed around a curriculum emphases model may be enacted differently than they were intended, thus creating a gap between the curriculum-as-planned and the curriculum-as-lived. Roberts (1982) attributes this discrepancy to two factors; *teacher interpretations*, where teachers' images of the intents of the curriculum differ from those of curriculum developers, and *teacher loyalties*, where teachers understand the intentions of the curriculum emphases, but either disagree with or choose not to incorporate those emphases in their teaching. This research views the combination of teacher interpretations and teacher loyalties as being expressed in *teachers' beliefs*.

Teachers' Beliefs in Educational Research

Defining Teacher Beliefs

Before conducting an investigation of teacher beliefs, it is important to clarify what is meant by the construct 'teacher belief' and how it differs from other related constructs such as teacher attitudes, teacher identities and teacher knowledge (Pajares, 1992). Nespor (1987) suggested belief systems share four key characteristics that distinguish them from other knowledge and attitudinal systems. These include; *existential presumptions, alternativity, affective and evaluative characteristics and episodic structures*. In short, beliefs involve assumptions and perceptions about phenomena (Koballa, 1988). They imply the believer's ability to see unrealized alternatives of action, and they are emotionally re-enforced by experienced episodes and events.

Eisenhart, Shrum, Harding and Cuthbert (1988) defined beliefs as "propositions or statements of relation of things accepted to be true" (p. 53). They distinguished beliefs from knowledge by arguing beliefs are characteristically evaluative, while knowledge is not. They also explain beliefs offer, "a way to describe a relationship between a task, an action, an event or another person and an attitude of a person toward it" (p. 53). Koballa (1988) further distinguished beliefs from attitudes by reasoning beliefs are both descriptive and evaluative whereas attitudes are strictly evaluative. Unlike beliefs, attitudes don't consider relationships between objects and attributes, or the outcomes of those relationships. Attitudes simply reflect positive or negative emotions towards an object or event without reason.

Teachers' beliefs can also be subsumed by, but not used interchangeably with other related terms such as Shulman's (1986) *pedagogical content knowledge*. For Shulman, such knowledge included:

> for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples

> and explanations – in a word, the ways of representing and formulating the subject that make it comprehensible to others (p. 9).

Barnett and Hodson (2001) similarly referred to *pedagogical context knowledge,* which extended Shulman's pedagogical content knowledge to include teachers' understandings and considerations of the broader social context within which schooling occurs. As with Nespor's (1987) characteristic of *alternativity*, pedagogical content knowledge and pedagogical context knowledge both assume the teacher has a number of alternative forms of representation at hand. Pedagogical content and context knowledge differ from beliefs because both forms of knowledge depend upon, rather then create teachers' beliefs to guide their choices of what representations they will emphasize. The act of selecting among representations implies an evaluation of pre-existing beliefs. It is assumed teachers' beliefs structures were in place before pedagogical content or context knowledge can be created.

Clandinin and Connelly (1998) described a similar form of evaluative knowledge in what they referred to as *personal practical knowledge*. Unlike beliefs, they suggest personal practical knowledge is more transient and subject to change. It is responsively and reflexively situated in personal, day-to-day experiences inside and outside the classroom. While personal practical knowledge may contribute to the development of teachers' belief structures, it is not necessarily oriented toward purposeful action, nor does it necessarily imply explicit relationships between tasks and actions.

Tobin and LaMaster (1995) define beliefs as:

> … knowledge that is viable in that it enables an individual to meet her goals in specific circumstances. Beliefs are tied to the situations in which actions are contemplated. (p. 226)

Their definition suggests beliefs are both action oriented and outcome oriented.
Each of these definitions suggests teachers' beliefs mediate between events, thoughts and actions in the classroom. Teachers' beliefs bring together a combination of knowledge, judgment and emotion to interpret interactions and to plan classroom activities. Belief systems serve to reconcile written curricula teachers' values and classroom conditions, thus guiding practice, cementing pedagogy and creating practical and personal pedagogical content knowledge (Gudmundsdottir, 1990).

For the purposes of this research, teachers' beliefs will be defined according to three characteristics. First, science teachers' beliefs are anchored in understandings of the relationships between the stated goals for science education and the enactment of science education in the classroom. Second, beliefs have an evaluative component that can be observed as teachers' expressions of what they value as being most important in curriculum. Third, expressed beliefs about science education are context dependent and consequently are not limited to the curriculum orientations presented in the programs of studies. Teachers' belief systems can include other orientations that stem from teachers' past experiences and prior knowledge.

Durability of Teacher Beliefs and Context

Most of the research on teacher beliefs draws two notable conclusions. First, many researchers contend teacher beliefs are resistant to change. Helms (1998) suggested teacher beliefs are closely linked to teacher identities where a sense of self comes from not only activities and affiliations, but also from what one believes to be true about education and teaching. To challenge a teacher's beliefs would be to challenge their identity as a teacher. Crocker (1983) and Lantz and Kass (1987) viewed beliefs as a part of teachers' functional paradigms and suggested a change in belief structures requires a huge paradigm shift. Eisenhart, Shrum, Harding and Cuthbert (1988), Nespor (1987) and Pajares (1992) implied the emotional or affective aspects of teacher belief systems make them tenacious and resistant to change. They maintained belief systems "limit dissonance, contradictions and chaos, and as such are emotionally compelling and difficult to change" (Eisenhart et al., p.54). Pajares reasoned beliefs influence perceptions, which in turn, influence and reinforce behaviors that are consistent with the original beliefs. Essentially, he argued, belief systems are self-validating and self-reinforcing, making them very difficult to change. Nespor supports this hypothesis and further proposes changing beliefs is more akin to a "gestalt shift" requiring a complete rethinking and re-interpretation of values, meanings and events rather than minor revisions to thinking as a result of new evidence. Regardless of the explanation for the tenacity of teacher beliefs, the research seems clear that teachers' beliefs are durable. If they are durable, then one can assume they are also measurable across educational contexts.

Teachers' beliefs appear to be linked to different teaching contexts. In a study investigating the role of school subjects in secondary school teaching, Grossman and Stodolsky (1995) found teachers held a number of subjects-specific beliefs about teaching and learning. They suggested shared beliefs occurred within subject sub-cultures, into which teachers are socialized. They argued subject sub-cultures serve to define the perceived possibilities and constraints within which teachers work, thus shaping their beliefs about the norms of teaching practice. Three other studies conducted by Brosseau, Book and Byers (1988), Deemer (2004) and Jeans (1998) investigated teachers' beliefs within other teaching subcultures. Brosseau, Book and Byers examined sub-cultures relative to school setting (urban, rural and suburban), gender, years of experience (pre-service and in-service), and level of school taught (elementary and secondary). Although school setting appeared to have little impact on teacher beliefs, they found significant differences between experienced and pre-service teachers' and between elementary and secondary teachers' beliefs. Jeans also found a difference between novice elementary and secondary teachers' beliefs about science and technology education, with elementary teachers privileging "technology rich" teaching opportunities and secondary teachers privileging "science rich" lessons. Deemer examined relationships between teachers' beliefs and classroom environments relative to the elementary, middle school and college settings. She concluded that not only were relationships amongst teachers' beliefs, instructional practices and classroom goal orientations very complex, but they also different across the elementary, middle school, high school and college settings.

Why Teacher Beliefs are Important

Turner and Peck (2009) pointed out that although the 1997 Pan-Canadian Framework for Science Learning Outcomes (Council of the Ministers of Education, Canada, 1997) affords equal status to all four foundations (knowledge, skills, STS and attitudes), teachers continue to privilege *knowledge* outcomes above all the others in science classrooms across Canada. Why is this the case? They suggested implicit messages found within curriculum support resources combined with standardized testing procedures reinforce knowledge as *the* privileged outcome. I propose teachers' beliefs are important factors determining which aspects of the curriculum are privileged over others.

In accordance with Bybee's (1993) proclamation that, "that the decisive component in reforming science education is the classroom teacher" (p. 144), many researchers have investigated the impact of teachers' beliefs on classroom practice and educational reform (Brickhouse, 1990; Cronin-Jones, 1991; Eberic, 2008; Keys, 2005; Lumpe, Haney & Czerniak, 1998; Roehrig, & Kruse, 2005). Brickhouse, for example, found that teachers' beliefs not only directed the explicit lessons they taught about the nature of science, but also influenced the way students learned science. Cronin-Jones investigated how science teachers' beliefs impacted curriculum implementation. She identified four categories of beliefs that strongly influenced curriculum implementation including beliefs about; how students learn, the teachers' role in the classroom, the ability levels of students and the relative importance of content topics. Of particular interest to this study, Cronin-Jones found teachers emphasized those aspects of science they believed were most important, while ignoring other objectives completely. She concluded, "teachers significantly alter curricula to make them more congruent with their own teaching contexts and belief systems" (p. 248). When teachers select some parts of the written curricula and ignore others, the gap between the curriculum-as-planned and the curriculum-as-lived widens, thus making curriculum reform an even more uncertain process.

Tobin, Tippins and Gallard (1995) suggested, "...future research should seek to enhance our understanding of the relationship between teacher beliefs and science education reform. Many of the reform attempts of the past have ignored the role of teacher beliefs in sustaining the status quo" (p. 64). This is not surprising in light of how tenacious beliefs are thought to be. To be truly effective, however, in understanding the products of educational reform and educational practice, research must go beyond studying relationships between teacher beliefs and curriculum implementation to include investigations into contextual factors that shape teachers' beliefs and the expression of their beliefs in the first place. That is the goal of this study.

Science Teacher Beliefs, Curriculum Emphasis and Teaching Context

Many studies have utilized a curriculum emphasis framework to investigate what science teachers believe is most important in science teaching and learning. vanDriel, Verloop and Bulte (2005, 2007) studied Dutch chemistry teachers' beliefs about curricula using a modified version of Roberts' (1982) curriculum emphasis. They found that although science teachers supported all three emphases; Fundamental Chemistry (FC), Chemistry in Technology and Society (CTS), and Knowledge Development in Chemistry (KDC), strongest support was given to Fundamental Chemistry. Support for this emphasis also appeared to be linked to the teachers' subject matter orientation, suggesting a teachers' specialized training in a particular subject contextualized what they believed was most important to teach. Those teachers with specialized subject knowledge favored a content knowledge focus (FC), while those teachers who felt their strengths lie in relating to students favored more relational and student-oriented emphases

(CTS). Teachers' belief orientations appeared to depend upon how they perceived their strengths and roles as teachers.

To expand upon the results of their 2005 study vanDriel, Bulte and Verloop (2008) conducted an additional study investigating teachers' beliefs about Dutch chemistry curriculum for two types of upper-secondary programs. The first program (VWO), identified as a pre-university education designed to prepare students for academic post-secondary studies is analogous to what we, in Alberta would refer as the 'academic' (Chemistry 20,30) stream (Alberta Education, 2007b). The second, program (HAVO) was a more general science program intended to prepare students for a future vocational studies. The chemistry components of the Alberta Science 20,30 (Alberta Education, 2007d) or Science 14, 24 (Alberta Education, 2003b) programs would be similar. Although again, both groups of teachers supported all three emphases, teachers in the WVO program most strongly supported the Foundational Chemistry emphasis, while teachers in the HAVO program gave equal support to Fundamental Chemistry and Chemistry in Technology and Society. These differences suggest teacher beliefs about the importance of particular emphases may be also shaped by the intents and purposes of the programs they teach. The WVO program required teachers to prepare their students for further academic training, of which foundational understandings were very important. Teachers did not perceive Knowledge Development in Chemistry and Chemistry in Technology and Society to be critical in preparing students for post-secondary studies. The HAVO program required teachers prepare their students for technological training, thus necessitating an emphasis on both Fundamental Chemistry and Chemistry in Technology and Society.

Markic, Eilks and Ralle (2009) conducted a similar study when they investigated upper and lower level German Chemistry teachers' beliefs about science curricula using the same three curriculum emphases. A translated version of vanDriel, Bulte, and Verloop's (2005) questionnaire was used to identify the beliefs of teachers teaching lower secondary chemistry programs in German grammar schools and of those teaching upper, non-grammar school secondary programs. The data confirmed vanDriel, Bulte and Verloop's work, suggesting academic stream influenced which emphases teachers believed were most important. Upper secondary teachers gave the most support for the Foundational Chemistry Emphasis, inferring they perceived their role as building a solid background upon which future learning can be built. Lower level, grammar school teachers gave the most support for Knowledge Development in Chemistry (equivalent to an emphasis on the Nature of Science), causing the authors to conclude these teachers believed, "it is most important for students to learn to see chemistry as a culturally-determined and constantly developing system of knowledge" (p 4). Lower level programs appeared to be oriented towards promoting scientific literacy for citizenship, which was located within the more meaningful contexts of technology and society rather than within its theoretical subject matter.

Lin, Hu and Changlai (2005) investigated pre-service and in-service Taiwanese biology teachers' beliefs about their favored curriculum components. Utilizing a reportatory grid technique, they identified six curriculum domains or components of emphasis, in Taiwanese biology classes. From highest to lowest ranked, these were; applications of science (AS), manipulative skills (MS), scientific concepts (SC), social/ethical issues (SEI), problem solving skills (PSS) and history of science (HS). On a follow-up questionnaire, both pre-service and in-service teachers ranked all six components in the same order, however, pre-service teachers tended to rate the six components more evenly than did in-service teachers. The implication from this data is that as teachers became more experienced, beliefs about which curriculum emphases were deemed to be most important became more discriminatory and polarized.

Cheung and Ng (2000) found a similar trend when examining the relationships between teacher experience, science discipline, and curriculum orientation on their 33-item Science Curriculum Orientation Inventory (SCOI). They identified five distinct orientations that paralleled some of Roberts' (1982) emphases including; academic curriculum, cognitive processes curriculum, society-centered curriculum, humanistic curriculum and technological curriculum. Unlike their less experienced counterparts, experienced teachers reported favoring cognitive process and academic orientations over humanistic orientations. Science sub-discipline also related to teacher's curriculum orientations. Physics teachers were found to be less society-oriented, than biology, integrated science and chemistry teachers. Integrated science, or general science, teachers were found to favor humanistic orientations. Although specific reasons for these differences were not investigated, Cheung and Ng proposed public examinations that tested traditional content in disciplined subjects may have been an important factor influencing teachers' curriculum orientations and beliefs. Integrated science teachers on the other hand, were not as pressured by public examinations, and tended to use more student-centered activities to cultivate student interest.

Chu (2009) investigated what Alberta physics teachers' believed were the most important of Roberts' seven curriculum emphases. Chu concluded pre-service and novice teachers had more in common with each other, with respect to which curriculum emphases they valued most, than with experienced teachers. Less experienced teachers placed the highest value on teaching the structure and nature of science while more experienced teachers tended to value the methods and skills of science more. In addition, Chu found those aspects given the highest regard by a curriculum leader were not the same as those valued most by the physics teachers suggesting the discrepancy exists between the curriculum as written and intended by educational leadership and the curriculum as lived and interpreted by teachers.

All of the studies cited above conceptualized science teachers' beliefs within a framework that is comparable to or directly derived from Roberts' (1982) curriculum emphases. For a comparison of categorizations, see Table 1 below.

Table 1
A comparison of curriculum emphases across research contexts

<table>
<tr><th>Roberts' Curriculum Emphases (1982)</th><th>Alberta's four pillars framework (2003, 2005, 2007)</th><th>vanDriel, Bulte & Verloop framework (2005)</th><th>Cheung & Ng (2005)</th><th>Lin, Hu & Changlai (2005)</th></tr>
<tr><td>Solid Foundations</td><td rowspan="2">Knowledge</td><td rowspan="2">Fundamental chemistry</td><td>Academic Curriculum</td><td rowspan="2">Scientific Concepts</td></tr>
<tr><td>Correct Explanations</td><td>Cognitive Processes</td></tr>
<tr><td>Science, Technology, Decisions</td><td rowspan="3">STS</td><td rowspan="2">Chemistry in Technology and Society</td><td>Society Centered Curriculum</td><td>Social and Ethical Issues</td></tr>
<tr><td>Everyday Applications</td><td>Technological Curriculum</td><td>Applications of Science</td></tr>
<tr><td>Structure of Science</td><td rowspan="3">Knowledge Development in Chemistry</td><td></td><td>History of Science</td></tr>
<tr><td>Scientific Skill Development</td><td>Skills</td><td></td><td>Manipulative Skills</td></tr>
<tr><td>Personal Explanations</td><td>Attitudes</td><td>Humanistic Curriculum</td><td>Problem Solving Skills</td></tr>
</table>

Summary

Although each of the mentioned studies contributes to the puzzle of understanding teachers' beliefs about science education, when examined as a whole, they paint a picture that is somewhat fragmented and disjointed. Collectively, the studies reflect different science programs offered within different cultural settings. Consequently, each of the programs studied may be rooted in a different philosophical origin making it unclear as to whether differing beliefs can be attributed to different teaching contexts, or to different program philosophies. To smooth out the lines in this puzzle and sharpen the image of science teachers' beliefs and the factors that contribute to their beliefs, this study aimed to investigate science teachers' beliefs across multiple science programs that shared common underlying goals and philosophy. Alberta's secondary science programs served as an excellent model. Not only do all of Alberta's science programs share a common philosophical framework, but the underlying framework also provided a starting point upon which science teachers' beliefs about some of the more salient aspects of science education could be categorized and compared according to a curriculum emphasis model. By investigating Alberta science teachers' beliefs about Alberta's science programs, this research aimed to consolidate the trends found in previous research in order to paint a broader, more seamless picture of teacher beliefs as they relate to teaching context.

Chapter 3: Research Design and Methods

Research Methodologies

Ercikan and Roth (2006) argue all observed phenomena can be described in terms of quality and quantity. They suggest a distinction between qualitative and quantitative research is a matter of perspective rather than a natural dichotomy. According to Silverman (2006), the selected research methodology establishes the approach one takes when studying a phenomenon. It guides which aspects of phenomena the researcher attends to and sets the philosophical position from which the researcher interprets the results. Although some phenomena are well served by exclusively selecting either qualitative or quantitative methodologies, many complex phenomena, as is the case for this research, can be more thoroughly and meaningfully investigated when informed by both methodological positions.

Quantitative methodologies

According to Palys & Atchison (2008), quantitative methodologies are anchored in a positivist / post-positivist philosophical position which aims to, "uncover the facts and to understand the laws or principles that account for those facts" (p. 4). In the context of this research, I have viewed teachers' expressed beliefs as factual snippets of how they understood, interacted with and shaped the programs they taught. Adopting a positivistic position, I have assumed teachers' beliefs about what is most important in science education can be identified and categorized into pre-determined categories represented by Alberta's four foundational pillars for science literacy. By quantitatively counting categories and themes, differences in teachers' beliefs across contextual groupings such as teaching experience, school setting and the academic stream in which teachers taught, influenced their beliefs about what they felt was important in science education could be examined.

Qualitative methodologies

Qualitative methodologies are anchored in a philosophical position where "the researcher starts inductively…" (Creswell, 1998, p. 77) creating categories from the data collected, rather than specifying them in advance. Because categories are not pre-determined, qualitative research takes on a phenomenological or interpretivist position where the researcher interprets the data to find localized and contextualized meanings (Johnson and Onwuegbuzie, 2004). This means categorizations and emerging themes are not limited to discrete pre-determined categories, such as those presented by Alberta's four foundational pillars. In the context of this research, I wanted to know what science teachers' beliefs were, both within and outside of the four pillars framework. By invoking qualitative methods, I was able to identify a broader spectrum of teachers' beliefs and to explore some of the localized and contextualized factors explaining why they held certain beliefs. This approach also gave me the privilege of peering into the complex lives of teachers as they find and create meaning out of the programs they teach.

Mixed methodologies

While many researchers suggest the primary research question guides the choice of methodology, Newman, Ridenour, Newman and De Marco (2003) advocate a different strategy. Rather than focusing on a typology of research questions, they recommend a typology of research *purposes* is more productive in guiding the selection of research methodology. They argue that by iteratively considering the purpose of an investigation, researchers can better select methods that productively reflect the intent of the research questions. This is the approach I adopted when selecting a mixed methodology for this research.

This research aimed to engage and implicate science teachers' beliefs in conversations about the curriculum-as-planned and the curriculum-as-lived. Because of the complex nature of and variety of factors influencing beliefs, a single research question and consequently a single methodology was inadequate for addressing the purpose and intents of this research. Instead, the purposes of this research were best captured by four key research questions:

> *What do secondary teachers in Alberta believe are the most important emphases or goals of teaching science?*
>
> *Why do teachers hold a particular set of beliefs about the science curriculum?*
>
> *What contextual factors influence teachers' beliefs about what is most important in science education?*
>
> *How do teachers' beliefs relate to practice in science classrooms?*

To fulfill the aims and answer the key questions associated with this study, I relied upon a combination of both qualitative and quantitative strategies.   Qualitatively, I sought out themes and explanations that could not be predicted in advance, thus calling upon inductive methods and tools. Quantitatively, I tested relationships between emerging themes and teaching contexts previously identified in the literature (see Chu, 2009; Deemer, 2004; Farrow, 1999; Jeans, 1998; Ling, Hu & Changlai, 2005; Lumpe, Haney & Czerniak, 2000; Markik, Eilks & Ralle, 2009; Tsai, 2002; and VanDriel, Bulte & Verloop, 2005, 2007, 2008).   The interpreted qualitative data informed the quantitative data by identifying important categories that were then quantified and compared across contextual groupings. The quantitative data also informed the qualitative data by identifying potential relationships between beliefs and teaching contexts that merited further exploration in the one on one interviews. The interplay of qualitative and quantitative methods, as used in this study are hallmark characteristics of a mixed methodological design.

Research Methods

The mixed methods used in this study were modeled after a design used by Chu (2009) to investigate Alberta physics teachers' beliefs about the importance of Roberts' seven curriculum emphases. Using a questionnaire composed of three sets of rank ordered statements and one open-ended written question, as well as face-to-face interviews Chu collected both qualitative and quantitative data to explore relationships between teacher characteristics and their beliefs about curriculum emphases. The qualitative interview data was used to corroborate the quantitative findings and to interpret how teachers constructed meaning from the physics curriculum. In effect, the mixed methodology allowed Chu to achieve *Verstehen,* whereby an understanding of physics teachers' beliefs about curriculum emphasis, was both corroborated by, and complemented with the meanings teachers assigned to their beliefs (Onwuegbuzie & Leech, 2004).

Greene, Caracelli and Graham (1989) identified five general purposes of mixed-methodological studies, of which, *triangulation*, *complementarity* and *expansion* are most relevant to this research. These general purposes were achieved in this study using quantitative forced-ranking items, qualitative open-ended written response items and one-on-one interviews. The data were triangulated by comparing ranked item responses with the frequencies of key terms and phrases encountered in the open-ended questions and in the one-on-one interviews. The written responses and interview transcripts complemented the quantitative questionnaire items by confirming the ranked item results and by elaborating upon what those results meant to teachers and why. The written response and interview data also gave teachers the opportunity to expand upon and explain what they believed was most important in science education.

Ethical Considerations

To ensure that the appropriate ethical considerations were met, the plan for this study was reviewed and approved for its adherence to ethical guidelines by the Faculties of Education, Extension, Augustana, Campus Saint Jean Research Ethics Board (EEASJREB) at the University of Alberta. The following considerations were addressed: voluntary involvement, informed consent, protecting the privacy and anonymity of the participants and confidentiality.

The voluntary nature of all parts of this study was communicated to teachers via; e-mail, a letter of introduction, password only access to the questionnaire, the opening paragraph of the questionnaire, and in the interview consent form. All participants were required to provide informed consent for both the online questionnaire and the one-on-one interviews. Because the questionnaires were electronically administered, written consent could not be obtained. Instead, a paragraph presented at the beginning of the questionnaire notified potential participants that informed consent would be implied once they submitted their questionnaire responses. Participants were also informed that once they electronically submitted their information, their data could not be withdrawn from the study. Written consent for the one-on-one interviews was obtained by requiring participants sign a letter outlining the conditions of participation and explaining how and when teachers could withdraw from the study without penalty or prejudice. A copy of the letter of consent can be seen in Appendix A.

The identity, privacy and confidentiality of participants were secured at all times. The online questionnaire was anonymous and participants were not asked to provide any information that might identify them. In addition, participants were unable to view the responses of other participants. To protect the privacy and confidentiality of the interviewees, all participants were assigned pseudonyms during the transcription process. Only general demographic information relevant to examining the contextual factors investigated in this study were collected. To ensure participants' interview responses were both respected and validated, an electronic copy of the interview transcript was e-mailed to the participants for member checking. When participants' member checked their transcripts, they also had opportunity to withdraw or modify some or all of their data.

Participants

A convenience sample limited to in-service secondary science teachers representing a wide variety of teaching contexts was targeted for this study. This criterion was used to ensure all teacher participants were actively working with the entire programs of studies for their subject areas. It was important that participants were able to reflect upon the breadth and scope of Alberta's science programs when reporting their beliefs. Pre-service teachers were not expected to be as familiar with the complete programs of studies, and were therefore excluded.

Participants were asked to some provide basic demographic information about their teaching context. Contextual groupings were sorted and compared to identify demographic differences relating to differences in teachers' beliefs. Three sets of teaching contexts were identified as being significant in the literature. These included school grade setting, academic stream, and years of teaching experience. The criterion used to establish sub-groups, and the codes assigned to them in the data are explained below. For a summary of the teacher demographics and contextual groupings, see Appendix C.

School Grade Setting – Junior, Senior and Junior-Senior

Although the Alberta programs of studies states the same goals for science education in both, junior and senior high school science courses, the stage of student development and program ends, are fundamentally different suggesting junior and senior high schools may represent different teaching contexts with different teaching pressures. A natural distinction between junior and senior high school programming determines the grade levels represented in many schools.   A few schools offer both junior and senior high programming, thus creating a third sub-group. For the purposes of this study, teachers were categorized by school grade setting as follows:

Junior high teachers (JH)

Junior high teachers, referred to those teaching at least one of Science 7, Science 8 or Science 9 in a school offering programming up to and including Grade 9. Teachers in this category may also be responsible for teaching modified or enriched versions of these courses. Teachers with a combined junior and senior high teaching load were placed in a different category.

Senior high teachers (SH)

Senior high teachers, included those teachers teaching at least one of Science 10, Science 10-4, Science 20-4, Science 14, Science 24, Science 20, Science 30, Biology 20, Biology 30, Chemistry 20, Chemistry 30, Physics 20 or Physics 30 in a school offering programming to students in Grades 10 through 12. Teachers in this category may also be responsible for teaching modified or enriched versions of these courses. Teachers whose teaching load included a combination of junior and senior high science courses were placed in an alternative category.

Junior-Senior high teachers (JS)

Teachers in the junior-senior high category were identified as science teachers with a teaching load that included some combination of the junior high and senior high courses as described above, either within the same school, or in different schools. Because this group represents a unique teaching context, it was categorized separately for the purposes of data analysis.

Academic Stream

Academic stream is often associated with different purposes and different levels of science education. For example, higher-level academic courses, such as Chemistry 30 and Physics 30, are accepted for entrance into many post-secondary science programs. Non-academic courses such as Science 14 and Science 24 are not, and subsequently are often intended to lead students towards vocational career paths. General Science courses are designed to create opportunities for further learning, either in academic or general science streams, or in non-science post-secondary programs. Because the expected outcome of students exiting academic, non-academic and general science courses differs, teachers teaching these courses may hold different beliefs about the most important outcomes of those courses. The criteria used to identify these sub-categories based on academic stream are:

General Science Teachers (Gen)

General Science teachers were identified as teaching only general science courses at either the junior high school or senior high school level. These teachers have not taught any science courses considered to be "academic" or "non-academic" (see definitions below) within the present school year. Teachers included in this category taught courses such as; Science 7, Science 8, Science 9, Science 10, Science 20 and Science 30.

Academic Science Teachers (Ac)

Academic teachers were identified as teaching at least one academic or advanced science course that would potentially lead students towards a post-secondary program in the sciences or science-related fields. In addition to general science courses, teachers included in this group will have taught at least one of; Biology 20, Biology 30, Chemistry 20, Chemistry 30, Physics 20, Physics 30, IB science, AP science, or a science course designated as "Honors" or "enriched" within the previous school year and have not taught any non-academic courses as defined below.

Non-Academic Science Teachers (Non-Ac)

Non-academic science teachers were identified as teaching at least one non-academic or remedial science course that would **not** lead students to pursue further post-secondary studies. Teachers included in this group taught at least one of; Knowledge and Employability (K&E) Science, Science 10, Science 14, or Transitions Science at the junior or senior high level during the previous school year in addition to other general science or academic science courses.

Experienced and Novice Teachers

Although the extent of teaching experience is expected to be a factor shaping teachers' beliefs about what is most important in science education, establishing criteria to distinguish between "experienced" and "novice" teachers can be problematic or somewhat arbitrary. Teachers who are considered experienced in some contexts may be considered novice in others. For the purposes of this study, "experienced" and "novice" were benchmarked according a teachers' exposure to major changes in the provincial programs of study. An "experienced" teacher is considered to be one who has taught science not only during and since the last program revision, but one who has also taught at least three years of the previous programs. By requiring experienced teachers to have taught three years of the previous programs, the classification "experienced" implies a familiarity with both the old and the new programs of study.

The Alberta science programs underwent revision at different times between 2003 and 2007. To ensure all teachers classified as "experienced" met the criteria described above, the earliest revision (Alberta Learning, 2003) was taken as the benchmark year for all participants. This means an "experienced" teacher must have been teaching science in Alberta for at least three years before 2003. Using these criteria, experienced and novice teachers are defined as follows:

Experienced teacher (Exp)

An experienced teacher is one who has taught science in Alberta for the past ten or more years.

Novice teacher (Nov)

A novice teacher is one who has taught science in Alberta for less than ten years.

Data Collection Tools

Two major sources of data were collected and analyzed to help answer the key research questions. These included an online questionnaire consisting of demographic teaching context questions, open response questions and closed response questions, and semi-structured one-on-one interviews. A summary of the tools used to answer each of the four research questions is shown in Table 2.

Table 2
Tools used to address specific research questions

Tool used	Research Questions			
	What do secondary teachers in Alberta believe are the most important emphases or goals of teaching science?	*Why do teachers hold a particular set of beliefs about the science curriculum?*	*What contextual factors influence teachers' beliefs about what is most important in science education?*	*How do teachers' beliefs relate to practice in science classrooms?*
Demographic questions			x	
Ranked item questions	x		x	x
Open response questions	x	x	x	x
One-on-one semi-structured interviews	x	x	x	x

The online questionnaire was designed to collect demographic, quantitative and qualitative data. The demographic questions identified contextual groupings within the research sample that were later compared to illuminate differences in teachers' beliefs according to teaching context. The open response questions qualitatively identified those aspects of science education teachers believed were most important, without limiting the breadth of their reported beliefs. They were also intended to confirm or disconfirm the results of the ranked item questions and they gave participants the opportunity to explain why certain emphases were important. The ranked-item questions were intended to categorize and count teachers' beliefs about Alberta's four foundational pillars. Since the four pillars imposed pre-determined categories of what is most important in science education, the ranked item questions aimed to understand teachers' beliefs about the science curriculum *planned* by Alberta's program developers. By comparing the open responses and the ranked items, a picture of teachers' beliefs regarding the science curricula as planned versus the curricula they lived emerged. The online questionnaires also proved to be an inexpensive and effective tool for collecting information about teachers' beliefs from teachers representing a broad geographic area and a variety of teaching contexts (Bloch, 2006; and Jackson, 1988). A copy of the questionnaire can be found in Appendix B.

The one-on-one interviews served to confirm trends found in the open response and ranked item data and explain why those trends existed. The semi-structured interviews were loosely scripted to probe the details about what teachers believed to be most important in science education, and to help understand the factors that they felt were significant in influencing their beliefs and how they enacted those beliefs in the classroom.

Questionnaire Construction

The questionnaire used for this research consisted of five major sections:

- Demographic information: This section included questions regarding gender, years of experience, degrees held, areas of specialization, school grade setting, grades taught, science courses taught, number of different courses taught and average class size.
- Teachers' beliefs about their own teaching context: This section included one set of four ranked item questions and two open response questions about teachers' beliefs with respect to their present teaching situations.
- Teachers' beliefs about science education: this section included one set of four ranked item questions and two open response questions about teachers' general beliefs with respect to science education.
- Teachers' reported emphasis in their classrooms: This section included one set of four ranked item questions and two open response questions asking what teachers emphasized when planning for instruction in their classrooms.
- Additional comments: Teachers were given the opportunity to add more information and were given instructions for how to voluntarily participate in a one-on-one interview.

In the demographic information section of the questionnaire, parameters for contextual factors such as school size, courses taught, classroom size, gender, teaching experience and academic education were assigned and categorized ahead of time.

Participants' responses entailed selecting from a number of choices that most accurately applied to their teaching context. All of the contextual categories were cross-tabulated with the ranked item data to identify the most salient contextual factors relating to teachers' belief structures. Divisions within categories such as school size were the same as those used in the data analysis. The one exception was years of experience, where teachers were compared according to whether they were defined as novice or experienced.

The second section of the questionnaire asked teachers to reflect upon their beliefs as they related to their own teaching context by asking two open response questions:

1. What is the one thing you hope every student, leaving your science class at the end of the year, knows or thinks about science?
2. Considering your current teaching context, what aspect(s) of science learning do you believe is/are most important?

Both of these questions were designed to identify what teachers' believed to be most important in their science classes, with the first question focusing on the products of science teaching and the second focusing on the processes of teaching science. Next, teachers were presented with four statements from Alberta's foundational pillars, and asked to rank them in order of importance on a scale of one to four. A rank of one signaled a statement was most important while a rank of four indicated a statement was least important. The statements were worded exactly as they are presented in the Alberta science programs of study. Using identical wording ensured the content and spirit of the statements as found in the curriculum documents, was preserved. Using the same wording was also expected to cue teachers' familiarity with the statements, thus encouraging them to reflect upon their beliefs with respect to the programs of studies.

Although a rank order design is arguably more complicated and potentially confusing for respondents (Jackson, 1988), it was purposefully chosen to force participants into prioritizing their beliefs rather than simply responding with wholesale agreement or disagreement. On the electronic version of the questionnaire, teachers could assign a rank number only once, preventing them from assigning the same rank number to more than one item.

The third section followed a format very similar to the second with the perspective modified to reflect teachers' beliefs about science education. The two open response questions asked were:

1. Why should all students study science?
2. Considering science education in general, what aspect(s) of science do you believe is/are most important for all students to understand?

As in the previous section, teachers were asked the same general question in two slightly different ways that again, may be seen as a product and process approach. Teachers were also prompted to put the four foundation statements in rank order, only this time, considering their overall beliefs about science education, rather than their own teaching context. Consistency in response patterns across these two perspectives was interpreted as confirming the questionnaire's reliability.

The fourth section of the questionnaire asks teachers to reflect upon how they plan instruction and what they choose to emphasize in class. To maintain consistency, a similar format to the previous two sections was used. The two open response questions were:

1. Reflecting upon what you do in your own science classes, what aspect(s) of science do you purposefully emphasize most in your teaching?
2. What factors most influence what you choose to emphasize while teaching science?

Unlike earlier questions, the second question asked in this section was not intended to reflect the first, but rather to identify reasons for what teachers emphasized in their classrooms. Teachers' explanations were then categorized and further explored in the one-on-one interviews. Teachers were also asked rank what they emphasized in their classes with respect to the four foundational statements. Differences between teachers' beliefs and reported actions were established by comparing the responses in this section to those in the previous two sections.

In the last section of the questionnaire teachers had the opportunity to provide additional comments or reiterate any information they felt was relevant. They were also given directions to contact the researcher if they elected to participate in a one-on-one interview.

Questionnaire Administration

I selected an electronic administration of the questionnaire using *surveymonkey.com,* over a traditional paper and pencil method to overcome geographical and time barriers associate with data collection and to make it more convenient for participants. By assigning a login password, the electronic administration gave me control over who had access and could respond to the questionnaire. A link and password was sent to prospective participants by e-mail. Without the direct link, or a password, the questionnaire was inaccessible to anyone who was not invited to participate in the study.

Invitations to participate in this study were sent to all secondary science teachers teaching in one of Alberta's larger school divisions. Aside from convenience, I chose this particular school division because it represented a wide variety of school types, programming and teaching contexts. Of the 95 invitations sent out, 30 (32%) teachers responded by completing the questionnaires. For an impersonal survey where respondents don't have direct contact with the researcher, the response rate was not atypical (Palys & Atchison, 2008).

Interviews

All questionnaire respondents were invited to participate in a semi-structured one-on-one interview. Invitations were extended in the introductory email sent, in the information letter and at the end of the online questionnaire. Of the 30 survey respondents, 9 teachers, volunteered to participate. Pseudonyms were used to preserve the anonymity of the interviewees. See Table 3 for a summary of interviewees identified by pseudonym and their related teaching contexts.

Table 3
Teaching contexts of interviewees.

Pseudonym	School Grade Setting			Academic Streams Taught			Experience	
	Sr. High	Jr. High	Jr. Sr. High	Academic	Non-Academic	General Sci	<10	10+
Ms. A	x			x	x	x	x	
Ms. B	x			x	x	x	x	
Ms. C	x			x	x	x	x	
Mr. D	x					x		x
Ms. E	x			x	x			x
Ms. F			x	x		x		x
Mr. G			x	x		x	x	
Ms. H		x				x	x	
Mr. I		x				x		x

Interviews lasting approximately 20 to 30 minutes were audio taped and transcribed. Because they were anonymous, questionnaire responses could not be matched with specific interviewees. To locate the interview responses within the contexts investigated, a summary of relevant demographic information was obtained during the interview.

The purposes of the one-on-one interviews were to obtain a deeper understanding of teachers' beliefs, to identify contextual factors that influenced their beliefs and to investigate how those beliefs are enacted in the classroom. To achieve these goals, I conducted semi-structured and loosely scripted interviews, seeking responses that expanded upon the open-ended written response questions asked in the questionnaire. In order to avoid guiding teachers toward any specific emphasis or cuing them to discuss a particular foundation, I scripted the interview questions so that none of the potential curriculum emphases categories were identified in the question. Any mention of specific emphases or foundations in the interviews came directly from the teachers. Once a teacher did mention a particular emphasis, then I probed for clarification about their beliefs related to that emphasis. For a summary of the general interview questions see Appendix C. Interview data were analyzed by first categorizing teachers' beliefs using the four foundational pillars as a framework, and then by identifying and counting other emerging themes. Specific comments or references to one or more of the four foundational statements were coded and tallied, cross-referenced with the demographic information and then compared to the questionnaire data. Interviews were also analyzed for alternative beliefs that emerged by identifying and coding statements not accounted for by the four foundational pillars. These were offered as additional conceptualizations of what teachers believed counts most as science education.

One of the most valuable aspects of one-on-one interviews was that they created an opportunity to investigate *why* teachers reported certain beliefs about science education. Hearing why teachers held a particular set of beliefs helped identify the most relevant contextual factors that may not have been evident in the survey data. It also provided some insight into how teachers struggle to negotiate between what they believed they should emphasize in science education and what they felt they were pressured to emphasize.

Data Analysis

In the spirit of mixed methodologies, data analysis and interpretation were informed by both qualitative and quantitative methods (Morse, 2003). Qualitative data were encoded, counted, combined with and compared to the quantitative data to reveal and confirm emerging themes across teaching contexts. The qualitative also data provided rich descriptions and explanations for relationships within identified themes.

Analysis of the ranked item data

Two methods of analysis were used to interpret and analyze the ranked item data. First, frequencies of teachers' top rankings were counted and compared to determine which statements teachers' believed were most important. Frequencies were also compared across contextual groupings identified in the demographic data. Those statements that teachers most frequently ranked number "one" were interpreted as being most important. Likewise, those statements ranked "number four" with the highest frequencies were interpreted as being least important. The second method used involved calculating a weighted mean ranking for each statement. In finding the weighted mean, both the rankings and the frequencies of rankings were considered. Since the most important item was given a ranking of "one", the statements with the lowest weighted mean were identified as being most important to teachers. The differences in weighted means for each statement were compared across contextual groupings. Relatively broad differences in mean rankings between contextual were interpreted as signaling that a contextual factor influenced teachers' beliefs. When there was little difference between rankings across contextual groupings, the context was considered to have minimal impact on teachers' beliefs.

Due to the small sample size, statistical measures could not be reliably used to identify statistically significant differences in mean rankings or the frequencies of number one ranked items across contextual groups. Alternatively, differences between mean rankings and ranking frequencies were interpreted qualitatively by inspection. Data from interviews and the open response questions were also considered to confirm inferences made about the differences between contextual groups.

Analysis of the open response questionnaire data

Data from the open response questions on the questionnaire were qualitatively analyzed by identifying emerging themes and quantitatively analyzed by counting the frequencies in which teachers reported themes. Since four themes; attitudes, knowledge, skills and STS, were identified by the ranked item data, they were also used as a partial list of belief categories emerging from the open response data. For a response to be placed under one of the four existing categories, teachers had to mention key phrases or key words belonging to the descriptions from the category heading as written in the ranked items. Any key words or phrases that could not be clearly sorted into the original four categories were assigned their own category. For example, "making sense of the world", was a frequently encountered phrase. Since the language of this and similar phrases didn't fit one of the four foundational pillars, a new category, called "everyday coping" was created. Every time a new phrase appeared, it was either placed in a new category or added to a related category. Only those themes that appeared more than once were counted and included as part of the quantitative data.

Once a complete list of the most salient categories was created, a counting themes approach was used to quantify and compare teachers' responses across contextual sub-groupings (Onwuegbuzie and Teddlie, 2003). The frequency in which each teacher's responses fell into each category was counted and tabulated. To control for repetition within individual teachers' responses, a theme mentioned more than once by a single teacher, was only counted once. Each teacher could, however, identify multiple phrases that counted in multiple categories. Once the emerging categories were created and counted, they were compared to identify differences across contextual sub-groups within the sample population.

Analysis of the interview data

Palys and Atchison (2008) propose, "relational research is often seen as a first step towards explaining phenomena, since theoretical interests or views often lead you to be curious about the relationships between two particular variables in the first place" (p. 43). Themes and relationships between and among contextual sub-groupings emerging from the open response and ranked item data provided the first step toward explaining why teachers held specific beliefs about what counts most in science education. The one-on-one interviews extended that first step to further explain the beliefs teachers held. Themes were identified and classified using both the four foundational pillars and newly emerging categories. Given the small sample size however, themes emerging from the interview data were not counted, but rather quoted directly. In addition to interpreting themes, specific contents from the interview data were analyzed to understand what teachers saw as causal factors for their beliefs and the enactment of their beliefs. Peshkin (2000) cautions that the interpretive process in research is not objective free of the researchers' own values. In an effort to maintain some degree of objectivity, direct quotations from the interviews were taken at face value as opposed to interpreting or classifying phrases used to explain the relationships between teachers' beliefs, teaching context and enactment of beliefs in the classroom. Once all of the data were collected, analyzed and interpreted, teachers were asked to member-check their quoted data for accuracy and contextual reliability.

Triangulation and comparison of data sources

All data were compared and triangulated to identify potential convergence, inconsistency and / or contradiction in the results (Mathieson, 1988). True to a mixed methodology, each stage of the data analysis was dependent upon the other stages. The ranked item data informed how the open-response and interview data would be coded and counted and the open-response and interview data were compared to the ranked item data to confirm trends in teachers' beliefs. When the frequencies of emerging themes were cross-referenced with the demographic information, relevant contextual factors that potentially influenced or explained teachers' beliefs were revealed. These factors were then further probed in the one-on-one interviews and compared to those arising from the open response questions. Throughout the entire data analysis process, the patterns and emerging themes from one set of data were compared with the others to help create a broad and rich picture of teachers' beliefs about science education and the factors that influence their beliefs and the enactment of their beliefs in the classroom.

Quality Considerations

In addressing issues of legitimization, Tashakkori and Teddlie (2003) proposed the term *inference quality* be used to describe the incorporation of internal validity, trustworthiness and credibility of interpretations for mixed methods research. They define inference quality as:

> …the degree to which the interpretations and conclusions made on the basis of the results meet the professional standards of rigor, trustworthiness and acceptability as well as the degree to which alternative plausible explanations for the obtained

results can be ruled out. Inference quality consists of design quality, interpretive rigor, interpretive agreement and interpretive distinctiveness (p. 709).

In order to enhance the inference quality for this study, I engaged methods that assessed the validity and reliability of the quantitative data, qualitative data, and inferences made from both types of data (Creswell 2009). Of particular interest to this study were issues related to *content validity*, *descriptive validity* and *interpretive validity* (Johnson and Turner, 2003).

Content validity can be described as the degree to which an instrument represents the domain studied. The purpose of the closed response questionnaire items was to represent teachers' beliefs about Alberta's foundational pillars. Content validity for these items was established by presenting the four statements by using *exactly* the same wording that was found in the Alberta programs of studies. By using the same wording, and analyzing the statements according to their face value, there was no need for me, or the participants to interpret what the statements meant. The questionnaire also included open response written items, which were used to validate the closed response items. Since both types of questions were intended to gather information about teachers' beliefs about science curricula, there were some expected similarities in responses between the two. While the open-response questions gave teachers the opportunity to elaborate upon their beliefs, they were also expected to verify the top ranked beliefs teachers identified in the closed response items. To check for consistency between the closed and open response questions, surveys were distributed to approximately six pilot participants who were asked to answer and provide feedback on the validity of the questionnaires.

Descriptive and interpretive validity respectively refer to the extent to which an account is accurately reported by the researcher and to the degree in which the researcher portrays participants' meanings (Johnson and Turner, 2003). To improve descriptive validity, emerging themes from the open response items were coded using the language and wording as it was presented in the data itself. Before a response was coded as representing one of the foundational pillars, key words from the foundational statements must have been evident. Emerging themes and phrases not captured by these key phrases were assigned their own categories. For a list of key words and their associated categories, see Table 4 in the results section. Participants were also given the option to member check the interview data to improve the interpretive and descriptive validity of the interpreted results. They were specifically asked to review the data for accuracy and to verify or clarify the researcher's interpretations of the data.

Chapter 4 – Results and Data Analysis

Introduction

The mixed methods approach used in this study was designed to collect qualitative and quantitative regarding science teachers' beliefs about what is most important in science education. The results were used to identify science teachers' beliefs, to compare their beliefs with what they emphasized in their classes and to identify contextual factors that influenced both their beliefs and the enactment of their beliefs in the classroom. Of approximately 90 teachers, who were contacted via E-mail and invited to participate, 30 teachers responded by completing the on-line survey and 9 teachers participated in one-on-one interviews. A demographic profile of survey respondents is shown in Appendix D.

The questionnaire's open response and ranked item questions quantitatively identified three key aspects of science education that participants believed were most important. They were developing positive attitudes towards science (attitudes), developing skills for scientific inquiry (skills), and making science relevant and meaningful to help student live and cope within the world (everyday coping). The one-on-one interviews provided rich data that helped explain why teachers held specific beliefs and identified some factors that influenced how their beliefs were reported and enacted. The data suggested that although teachers possess strongly held beliefs about what is important, their beliefs were often not materialized when planning classroom activities. External factors including school grade divisions, academic stream, standardized assessment and years of teaching experience were found to be significant pressures influencing what teachers emphasized in their classrooms.

Identification of Themes / Belief Categories

The primary research question asks: What do secondary science teachers in Alberta believe are the most important goals of teaching science? Although the foundational pillars in the Alberta science programs of studies (Alberta Learning, 2003a, 2003b; Alberta Education, 2005, 2007a, 2007b, 2007c, 2007d) provided a basic framework within which teachers' beliefs could be identified and categorized, one other significant belief theme emerged in the open response and interview data.

Everyday coping

Almost all of the teachers surveyed believed one of the most important purposes of science education was to help students "understand their world" and make connections between science and students' lives. They hoped their students would find personal and practical meaning in learning science that went beyond a factual understanding of basic facts and concepts. The participants also suggested that by "understanding their world", students would be connected with scientific information and consequently be empowered to make decisions and live productively within the world. Although the concept of "understanding their world" might be categorized under the STS(E) or knowledge pillars, the data showed teachers ranked STS(E) and knowledge as being of minimal importance even though they frequently mentioned "understanding their world" as being very important. Because of this discrepancy, I was not comfortable coding "understanding their world" within one of the foundational pillars categories and consequently created a new category based on Roberts' (1988) "everyday coping" emphasis. Roberts described the "everyday coping" emphasis as a, "meaning system necessary for understanding and therefore controlling everyday objects and events" (p. 45). The key ideas of *meaning-*

making and *connecting science to everyday events* personally experienced by or witnessed by the students are hallmark aspects of the everyday coping emphases that I interpreted as being equivalent to "understanding their world". By adopting "everyday coping" as a placeholder, I was able to avoid potentially misinterpreting and inappropriately categorizing what teachers meant by "understanding their world". Table 4 illustrates the key phrases used to identify "everyday coping" and other categories from the qualitative data.

Table 4
Key Response Categories and Related Science Curriculum Emphases (Adapted from Alberta Education, 2005; Chu, 2009; Roberts, 1988)

Response category	Key phrases or terms used to identify category
Skills	Skills, process skills, solving problems, reporting, inquiry, lab work, hands on work, experimentation, research, practical applications, manipulative skills, informed decision-making, asking questions
Attitudes	Excited about science, curiosity, appreciation of science, interest in science, hooked on science, mutual respect, positive attitudes, stewardship, safety
STS(E) – Science, Technology, Society and Environment	Nature of science, relationships between science, technology and society, social contexts, environmental contexts, technological decisions
Knowledge	Knowledge, understanding of concepts, apply knowledge, interpret, content knowledge, integrated knowledge, develop pre-requisite knowledge, explanation, solid foundation
Everyday Coping	Understand the world, understanding / explaining everyday phenomena, explain / understand their world, explain their lives, connections between science and everyday life, relate science to life, finding meaning, apply to everyday life, inter-relationships, finding science in everyday life, making connections

Nature of Science and STS

Although an emphasis on the nature of science is described as part of the pillar labeled Science, Technology, Society (and Environment) (STS(E)) in the Alberta programs of studies (Alberta Learning, 2003, Alberta Education, 2005, 2007), it is worth pointing out that most teachers considered STS(E) and the nature of science as separate goals for science education. When alluding to STS(E) outcomes, teachers almost exclusively focused on the interactions between and among science, technology, society and the environment, often explicitly using the term “STS” when referring to these interactions. When teachers responded with a nature of science emphasis, they made no overt connections between STS and the nature of science. Instead, they referred to specific aspects of the nature of science as separate categories. For example, they used phrases such as “the role of empirical evidence” (participant # 30) and the “evolving nature of scientific knowledge” (participant # 20) to capture the nature of science. Because the nature of science is explicitly included under the STS(E) foundation, I did not consider it to be a separate category. Further studies however, may benefit from examining teachers perceptions, understandings and beliefs regarding nature of science and STS(E) separately to determine whether they can or should be meaningfully combined or treated as discrete emphases.

Teachers’ belief about what is most important in their classrooms

When asked to rank the aspects of science education that were most important to them in their classrooms, “attitudes” and “skills” significantly outranked “knowledge” and “STS”. A comparison of “attitudes” and “skills” as the number one ranked aspect revealed 42% of the teachers reported “attitudes” was most important and 40% identified skills as most important. This may suggest that either the sample group of teachers were evenly divided on which emphasis was most important, or that most teachers valued both emphases equally.

Product versus process of science teaching

When teachers were asked to identify one thing they hoped their students would leave their science classes thinking or knowing about science, 38% identified “attitudes”, and only 17% reported skills were the most important products of science. The emphasis, “everyday coping” emerged as the second most frequent response. “Skills” did not appear to be as important as an outcome or product of teaching science in individual classrooms, as did “attitudes” and “everyday coping”. Interestingly, when asked about the most important aspect of science learning **in** their classrooms, the majority of teachers (55%) identified “skills” as being most important (see Table 5). One possible explanation is that teachers viewed “skills” as an important *process* in science teaching, whereas they viewed “attitudes” and “everyday coping” as important *products* of teaching science. Another possibility is that teachers perceived “everyday coping” as the ultimate product of science education. As *the* product, “everyday coping” might represent the culmination of student development in the other areas of science literacy including; skills, attitudes, knowledge and STS(E), as opposed to being a separate emphasis or aspect in itself. Until this relationship can be ascertained, I chose to treat “everyday coping” as a separate category.

Table 5.
Teachers' beliefs about what is most important in their own classrooms.

Identified aspects of science education	Ranked items – What teachers believe is most important in their science classes (n=30)	Question 1 – What teachers believe students should leave their classes knowing or thinking about science (n=29)	Question 2 – What aspect science teachers believe they should emphasize in their science classes. (n=29)
Attitudes	**12 (40%)**	**11 (38%)**	4 (14%)
Knowledge	4 (13%)	0 (0%)	1 (3%)
Skills	**13 (43%)**	5 (17%)	**16 (55%)**
STS(E)	1 (3%)	2 (7%)	1 (3%)
Structure of Science	n/a	3 (10%)	2 (7%)
Everyday Coping	n/a	**8 (28%)**	2 (7%)
Habits of Mind	n/a	1 (3%)	3 (10%)

* One participant failed to respond to the written response questions.

If teachers do distinguish their beliefs according to the products and processes of teaching science, then what are the sources of this distinction? The interview data suggested some teachers interpreted the programs of studies as setting different goals for the products and processes of science teaching. Ms. A for example explained:

> *"… the program of studies says it is important to develop an integrated knowledge about he world and that attitude is really important, but then there is such a large content portion in the back matter of the program of studies. I think there is a disconnect between what they [Alberta Education] want students to do, and what they ask them to do".*

For Ms. A, the content portion, or "back matter" of the programs of studies informed what she believed should be emphasized in the process of teaching science, while the front matter, or philosophical foundations as captured by the four foundations, guided what she believed should be the products of science education.

Other teachers like Ms. C, saw the process of teaching science as supporting the products of teaching science. For her, a focus on scientific "skills" in the classroom led up to and supported the product of "everyday coping". Ms. C elaborates:

> *"For me, the most important thing about teaching science is problem solving, and then being able to use what you are learning in the classroom in real life. I think labs are an important part of science, not just for the practical part, but for knowing how to set up a problem and solve it. That's a good skill for life in general."*

Ms. H also saw the a skills emphasis as a process supporting the product of science education but her focus was on developing positive "attitudes" towards science. When reflecting upon what she wanted students to get out of her science classes, Ms. H said:

> *" I think the whole point of science is to get kids interested in life in general, and everything in life has to do with science… At the end of the day when they walk out, I want to make sure my kids loved learning in my class."*

Ms. H saw "skills" as the means by which students were engaged in science, life and learning. When comparing the process of learning science to other subjects, she explained:

> *"The 'hands on' piece is the most important piece. Science is so much more hands on [than social or math] and students are allowed to question. In science, you can take little pieces of the curriculum and students can actually see it with their own eyes. They can touch and see things rather than just sit there and listen. It engages more of their senses... more of them."*

Teachers' beliefs about what is most important in science education.

When teachers were asked to rank the foundational pillars according to what they believed to be most important in science education, a pattern similar reflecting teachers' beliefs within their own classrooms emerged. Again, "attitudes" and "skills" were ranked first most often (see Table 6), however the qualitative data told a slightly different story.

Table 6
Teachers' top ranked emphases

	Beliefs about most important aspect in science classes you are teaching (n=30)	Beliefs about the purpose of science education in general (n=30)
Attitudes	12 (40%)	10 (33%)
Knowledge	4 (13%)	4 (13%)
Skills	13 (43%)	14 (47%)
STS(E)	1 (3%)	2(7%)

An analysis of the individual open-response questions revealed that teachers overwhelmingly believed "everyday coping" was the most important purpose for science education, even though they more frequently identified "attitudes" as most important in their classrooms. When referring to an "everyday coping" emphasis, teachers explained they wanted students to:

> "*…have a good grasp of why everyday scientific phenomenon affect them*" (Participant 21, JS, Nov, Ac)
>
> "*…understand the world they live in and how to meet the problems they will face within the world*" (Participant 22, SH Nov, Ac)
>
> "*…understand connections between science and our everyday lives*" (Participant 3, SH, Nov, Gen)
>
> "*…to help them use science in their everyday lives*" (Participant 15, SH, Nov, Ac)
>
> "*…understand how the world works and to use this knowledge to make the world a better place by making informed decisions*" (Participant 10, JS, Nov, Ac)

Again, while perhaps these statements could be categorized under the "STS(E)" or "knowledge" headings, discrepancies in the ranked item data did not suggest this was the case.

Almost unanimously, the interviewees centered their discussions on helping students make connections between science and their everyday lives. None of the teachers indicated these connections could or would be established within the span of one science course. Alternatively, teachers like Ms. B purposefully acknowledged other learning opportunities from television media, popular culture and students' personal experiences helped create connections between students' lives and the science they are learning. Ms. B saw the instruction she gave in her classes as one part of a much larger whole for science education, which would ultimately contribute to students' being able to find meaning and function productively in the world. Other teachers explained how an "everyday coping" emphasis depended upon the study of multiple science subjects as well as other subjects such as math or social studies. Specifically, Mr. D told a story of his own son's experience in school, where he trained to become an electrician. Mr. D explained:

> *"He* [Mr. D's Son] *probably would have benefitted from the Science 30 because in Science 30 he would have done calculations similar to what he had to do in his electricians training. I guess he could have also gotten the information in physics as well but he wasn't in physics. He didn't get great marks in Math, but he had been exposed to the concepts he needed, so he at least knew the direction he should be going."*

Mr. D's story illustrates how learning in other science and math courses would have prepared his son for the tasks he would encounter later in life. Even though the discrete content knowledge may not have been exactly what he needed, the familiarity with processes and basic skills Mr. D's son learned allowed him to cope providing a sense of direction. Mr. D's view of science education saw multiple science and non-science courses as contributing to the skills and knowledge students needed to find meaning in and cope with everyday tasks.

Teachers' reported classroom emphasis

When comparing what teachers believed to be most important in science education to what they reportedly emphasized in their science classes, some inconsistencies arose. Despite believing "skills", "attitudes", and "everyday coping" were most important the majority of teachers reported emphasizing "knowledge" most in their classrooms. For a comparative summary of results see Table 7.

Table 7
Top ranked teacher beliefs and classroom emphasis.

	Beliefs about most important aspect in science classes you are teaching (n=30)	Beliefs about the purpose of science education in general (n=30)	What teachers emphasize most in their science classes (n=30)
Attitudes	**12 (40%)**	**10 (33%)**	9 (30%)
Knowledge	4 (13%)	4 (13%)	**10 (33%)**
Skills	**13 (43%)**	**14 (47%)**	7 (23%)
STS(E)	1 (3%)	2 (7%)	3 (10%)

The discrepancy between what teachers believe to be most important and what they report they emphasize in their classes is disconcerting. Why wouldn't teachers emphasize what they believed to be most important? To answer these questions, other factors influencing teaching situations and teachers' beliefs must be examined.

Factors influencing what teachers emphasize in the classroom

Teachers were asked to comment on why they emphasized some aspects of science and not others. Of 28 respondents, only 6 said they emphasized what they believed was most important. The remaining participants identified other external factors as influences on what they emphasized in their classrooms. These included; students' interests, standardized examinations, current events, time, and class sizes. Of the factors identified in this study, student interests and standardized examinations appeared to have the most significant influence on how and what teachers reported they emphasized in their classrooms (see Table 8).

Table 8
Factors influencing teacher's enactment of science curricula

	Student Interests	Teachers' Beliefs	Standardized Exams	Programs of Studies	Time	Class Size	Other
Frequency (n=28)	8	6	6	3	2	1	2

Student interests

The ultimate goal of education is to develop students to their fullest potential. If students are thought to possess unique interests, talents and skills, then educating them requires teachers pay attention to the skills and interests their students already have. For many of the teachers interviewed, a student-centered approach that places students' interests, experiences and abilities as a focus for what is emphasized, was an important part of making science interesting and relevant to their students. The teachers who felt this way reasoned student-centeredness supported the cultivation of positive "attitudes" towards science and learning science. For Mr. G, a student focus was important for achieving both of these goals. He explains:

> *"I guess all their [his students'] interests are going to be different and specific to certain areas, but as long as you have found something along the way of the journey that is of interest to them then… It's getting them [students] interested and hooking them in, so they can explain and understand most of the things they see and do on a daily basis".*

For other teachers, a student focus was aimed at helping students to become more independent thinkers and learners, and more skilled at inquiry. Mr. I explained he emphasized student questioning in his classroom as a way of discouraging kids from memorizing content knowledge. For him, student driven questions and inquiries helped students move beyond memorizing facts, and toward understanding why things happen. When students learn to ask questions, Mr. I believed they also became more capable of seeking out knowledge and constructing understandings for themselves.

Standardized assessments

A number of teachers, particularly those who taught classes that culminated in assessments such as Provincial Achievement Tests (PAT's) or Diploma Examinations, explained that standardized achievement tests not only directed their emphasis on content knowledge, but that these courses were also heavy in content. Ms. A, for example explained that in diploma courses it is difficult to emphasize attitudes and skills and de-emphasize knowledge because knowledge is what will be tested on the exams. She said:

> *"... if I were to teach like that (emphasizing skills and attitudes over content) in my Bio 30 class, which is what I would like to do, I would put my students at a disadvantage on the diploma exam, which is worth 50% of their mark."*

Mrs. E shares a similar perspective and furthers her explanation by pointing out that since the written response portion was removed from the science Diplomas, the exams fail to measure the other aspects of the curriculum. She explains:

> *"You spend your time on the content because that is what is examined both on the diploma exam and those are the things that are easily testable in both the Diploma and the non-diploma testing situations".*

What is emphasized on standardized tests appears to drive what teachers emphasize in their classrooms. Mrs. E further suggests, students whose teachers don't emphasize the content knowledge may even be penalized because, "…they didn't spend enough time on the content and didn't memorize enough things". She sees the pressure to focus on content knowledge as extending beyond the Diploma exam when she states,

> *"... the why of what they [students] are learning is important is often not even brought up, never mind on the diploma exam, but by teachers in general who feel*

pressured to prepare students for what they are going to find in University, on the diploma exam and on tests, period."

The interview data suggested diploma subject teachers were not the only ones who felt the content knowledge of diploma courses, diploma exams and Provincial Achievement Tests limited their ability to teach what they felt was important in their classrooms. Mr. G is a relatively new teacher who has not yet taught diploma or PAT courses. His perception from other teachers was that,

> *"... in diploma courses there is so much in the curriculum that it just cuts out [the time to explore interesting topics]... and you don't have time to answer those [students] questions."*

He didn't have to teach diploma or PAT courses to develop the perception that they were rigid, inflexible and demanding. Ms. A shared a similar sentiment, but for different reasons. She explained:

> *"I think the barrier comes in with the standardized assessment and what parents and students have become accustomed to expecting in the academic courses".*

It seems that there is an expectation shared by students, parents and teachers, that diploma and other academic courses emphasize content knowledge over other aspects of science teaching and learning. As a result, it is very difficult for teachers not to meet those expectations.

Teachers' perceptions of the programs of studies

For many of the participant teachers, the program of studies defined what they felt they had to teach, not necessarily what they believed was important to emphasize. Some described the programs of studies as "inescapable" (Mrs. F) or "lurking in the background" (Ms. B), inferring that while they may not agree with their contents, the programs of studies still had considerable influence over what they did in their classrooms on a day to day basis.

Summary of all teachers' beliefs about science education

Analysis of the data revealed three key aspects that teachers believed to be most important in science education. They were attitudes, skills and everyday coping. Attitudes and everyday coping were reported as most important when teachers were asked to consider the products of science education. An emphasis on skills appeared to be important with respect to the process of science teaching. The distinction between teachers beliefs relative to product and process was explained by teachers characterizing a skills emphasis as a means to an end, where the end meant developing positive attitudes towards science and learning science, or giving students the tools and understanding understand and cope with the world around them.

Emerging Trends Among and Between Groups

One of the aims of this study was to identify contextual factors that potentially influence teachers' beliefs about science education. My tentative hypothesis that contextual factors including school setting as organized by division, experience teaching Alberta science courses, and the academic stream in which teachers taught, was tested by comparing belief patterns and identifying trends within groupings.

Comparing Grade Divisions – Junior High, Junior-Senior High and Senior High

It's all about attitude

When teachers' responses were grouped and analyzed by grade division, senior high teachers ranked "skills" more highly than "attitudes", and both junior high and junior-senior high teachers ranked "attitudes" slightly higher than "skills". Senior high teachers also ranked an STSE emphasis higher than both junior and senior high teachers did. These trends were reflected on both the ranked item questions pertaining to teachers' beliefs about what is most important in their classrooms and teachers' beliefs about what is most important in science education as a whole, respectively. For a summary of the mean rankings assigned according to the divisions taught see Table 9.

Table 9
Mean rankings (1 = most important, 4 = least important) of emphases perceived as important in teachers' own classes by grade division.

	Junior High Teachers Average Ranking (n=9)	Senior High Teachers Average Ranking (n=15)	Junior Senior High Teachers Average Ranking (n=6)
Attitudes	**1.9**	**2.4**	**1.5**
Knowledge	2.8	2.9	2.8
Skills	**2.0**	**1.9**	**2.3**
STS(E)	3.3	2.7	3.3

Across all three grade-groupings the frequencies in which "attitudes" and "skills" were identified as being important, were overshadowed by the prevalence of the category labeled "everyday coping". All of the teachers who responded believed personalizing science and making science relevant to students' lives was very important. Although I did not determine whether teachers believed "everyday coping" was a culmination of the other four foundations, or whether it was a category in itself, it's prevalence in the data was striking. A comparison of response frequencies for each category is shown in Table 10.

Table 10
Frequency of category identification in the open response items by division.

Response category	Junior High Teachers (number of responses) (n=9)	Senior High Teachers (number of responses) (n=15)	Junior-Senior High (number of responses) (n=6)	Total (n=30)
Attitudes	5 (56%)	7 (47%)	4 (67%)	16(53%)
Knowledge	2 (22%)	0	1 (17%)	3 (10%)
Skills	6 (67%)	5 (33%)	3 (50%)	14 (47%)
STS(E)	**1 (11%)**	**7 (47%)**	**2 (33%)**	10 (33%)
Everyday coping	**8 (89%)**	**10 (67%)**	**5 (83%)**	**23 (77%)**

What do we mean by STS(E)?

Another trend at appeared in the ranked item data was that the senior high teachers seemed to assign greater importance to STS(E) in science education than did junior and junior-senior high school teachers. Perhaps senior high teachers have a greater awareness of the STS(E) connections in the senior high science programs, or feel more pressure to incorporate an STS emphasis in their teaching from external sources. Some teachers may also feel that an STS emphasis reflects an "everyday coping" approach to science. In the one-on-one interviews, only one teacher made the connection between STS and students' lives explicit. Mrs. F, a junior-senior high teacher explained;

> *"I think the main purpose [of science education] is to eventually show them [students] how to think and relate things together… To make those connections… That is the STS basically. It is connecting the roles of technology and society in the classroom that the student needs to be critical about what they read."*

For Mrs. F, an STS emphasis brought together the knowledge, thinking and events in students' lives to help students make connections between what they are learning and how they cope in their world. None of the other respondents suggested they saw a relationship between STS(E) and everyday coping. If the other teachers perceived STS(E) and "everyday coping" to be one in the same, one would have expected STS(E) to have ranked much higher in both parts of the survey. To clear up confusion, future research might be well served to include the category "everyday coping" within the items to be ranked, thus forcing teachers to consider "everyday coping" as being different from "STS(E)". Perhaps then a clearer picture of where teachers place their priorities, and how they perceive the "everyday coping" and "STS(E)" emphases might emerge.

Not all "skills" are equal

The qualitative data, suggested teachers held different conceptualizations about what was meant by "skills" depending upon whether they taught junior or senior high school. For the junior high teachers in this study, "skills" were conceptualized as the "hands on" or physical aspects of science learning particularly related to actively doing laboratory work. For example, when asked about the role of laboratory work in science learning and teaching, Ms. H specifically referred to skills as being physical, rather than intellectual. When referring computers as an alternative to labs she stated:

> *"A lot of focus is on technology and we are getting away from the hands on stuff. They are seeing it on computers, but they are not actually mixing the chemicals. What I am afraid of is that, even though it is great to have the technology, the kids won't be able to feel and smell it…"*

Ms. H believed that without the physical experiences of laboratory work, students would not develop the same kinds of "hands on" skills and consequently wouldn't be as engaged in learning science.

The participating senior high teachers conceptualized "skills" as being more intellectual and less manipulative. Mrs. E explained:

> *"More and more to me, skills are analytical, more evaluative and less mechanical. The technology still changes so fact that in order to teach the students to use the latest technology, it is outdated before we can order it out of a catalogue, and so that becomes less important. The idea of being flexible to be able to learn something new, and understand the principles behind it becomes more important."*

Mrs. B also privileged intellectual skills over manipulative skills but her reasons were different. Although she said she wished she could do more "hands on" work with her students, she said:

> *"When there's over 40 students in a class, laboratory work just doesn't work. You can't physically fit students in the lab as it's not safe to have many students in the lab and you can't give enough individual attention to those students to make the lab work effective."*

As a result, Mrs. B focused more on the intellectual aspects of solving problems rather than on the physical skills associated with problem solving. She noted however that while this strategy was adequate for her academic students, her non-academic students needed to physically experience the problem solving process to learn it.

A reluctance to emphasize knowledge

All of the participants expressed a similar frustration feeling obligated to emphasize content knowledge, although they believed other aspects of science education were more important. They perceived the program of studies as being restrictively content-focused and believed provincial examinations forced them to emphasize knowledge over everything else. Some of the comments they made were:

> *"The curriculum is lurking in the background all the time…* " - Mrs. B (SH teacher)

> *"The curriculum can be restrictive."* – Mrs. C (SH teacher)

> *" In reality, when you are in the classroom, you have to deal with the end of the [curriculum] document, the content pages, which prescribes more of the detail of the subject matter you have to teach."* – Mrs. E (SH teacher)

"At the end of the day you focus on the content because of how much the school and the school board focuses on the diploma exams. You want your kids to be able to perform well on them. We are not free. The curriculum is there and you cannot avoid it." Mrs. F (JS teacher)

"Unfortunately, most of it [science education] is for the knowledge [because]… for the most part, that's all we test." – Mr. I (JH teacher)

Junior-Senior High School

Response patterns for junior-senior high school teachers showed characteristics of both the junior high teachers and the senior high teachers. Although the sample size for junior-senior high teachers was small, individual interviews suggested, junior-senior teachers' beliefs, were influenced by the pressures of both junior and senior high school. Like junior high teachers, junior-senior teachers were concerned with engaging students and nurturing positive attitudes towards science and learning science. Mr. G suggested cultivating an interest in and positive attitudes towards science was important to students' success later on in high school. He added, getting students interested in learning and encouraging them to find personal meaning in science was part of a life-long process. He also believed positive attitudes towards science are what help students to discover their interests, which he felt helped them to select courses in high school.

The responses of junior-senior high school teachers were also more polarized than those of the junior high teachers, resulting in a greater difference in mean rankings between "attitudes" and "skills". Although the relatively small sample size may account for this difference, skills were reported as both less important than attitudes and reflected the intellectual aspects of problem solving over the manipulative aspects.

Comparing Academic Streams

Teachers' beliefs about what is most important in their science classrooms are potentially influenced by the nature and goals of the programs they teach. To examine the relationship between program and teachers' beliefs, a comparison of the frequencies of the top ranked aspect was made between teachers teaching only general science courses, some general and academic science courses, and those teaching at least one non-academic course. Results of this comparison are illustrated in Table 11.

Table 11
Frequency of top ranked emphasis regarding what is most important in the teachers' classroom according to academic stream

	General Science Only (n=11)	General Science and Academic Science (n=11)	Teaches at least one non-academic course (n=7)
Attitudes	6	3	3
Knowledge	0	2	2
Skills	5	5	2
STS	0	1	0

None of the general science teachers ranked "knowledge" or "STS" as most important. When all rankings were considered, they consistently ranked these to aspects third or fourth, and ranked attitudes and skills first and second respectively. This was consistent with the rankings of all teachers. Teachers who taught academic science courses most frequently ranked "skills" the highest, followed by "attitudes", "knowledge" and "STS(E)". Two teachers from the non-academic category also ranked "knowledge" as being of highest importance, however, when their individual questionnaires were examined, it turned out that these two teachers also taught academic courses. I was unable to establish whether or not teaching academic courses influenced the teachers' beliefs regarding the importance of a knowledge emphasis, as none of the participants represented a non-academic only teaching environment.

When the open response data regarding what teachers believed to be most important in the classes they taught were analyzed, some new trends emerged. Most significantly, participant # 26 who taught academic classes frequently identified "STS(E)" to be an important aspect in their classes, despite not reporting this in the ranked item data. Further analysis the key phrases academic teachers used, which were identified under the STS category, showed that the teachers' did not conceptualize an emphasis on the nature of science as being a part of STS. This is somewhat surprising since the wording "will develop an understanding of the nature of science…" (Alberta Education, 2003 p.3) was explicit in the foundational pillars description of an STS(E) emphasis.

The open response data confirmed other trends identified in the ranked item data. For example, general science teachers reported "attitudes" and "skills" as being equally important and more important than the knowledge, STS, and everyday coping emphases. Aside from a higher than expected emphasis on STS or the nature of science, academic teachers ranked skills as being quite important. Those participants who taught non-academic courses identified attitudes, skills and everyday coping as being most important. An emphasis on knowledge was not mentioned at all, thus confirming my suspicions that the two teachers who ranked knowledge as important did so in consideration of their academic classes.

The decision to categorize "non-academic" teachers as those who taught at least one non- academic course in addition to a combination of other courses was made in response to the interview data. Almost all of the teachers interviewed held the same beliefs about what they felt was important for all of their classes whether they were general science, academic or non-academic science courses. This study suggested teaching non-academic classes might be one important factor influencing which emphases teachers believed were most important in all their science classes. For example, when asked about the goals for her non-academic, Knowledge and Employability (K&E) versus her academic, Biology 20 and Biology 30 classes, Mrs. A responded:

> *"I teach in my K&E program the way I wish I could teach everyone else... I think the attitude they [my students] come out with is what is most important. I think this has changed with me teaching special Ed."*

Mrs. E, who teaches Science 24, a non-academic course and International Baccalaureate (IB) biology held a similar perspective when she explained:

> *" I think the non-academic courses are closer to what I see as an ideal for all courses because they are lower on content and higher on principles."*

Mrs. B, an Advanced Placement (AP) Biology teacher who also teaches Science 14, explained that while she may have the same overall goals for her students, she did focus on different sub-goals in different classes. She summed up this perspective when she said:

> *"It's kind of funny because I do a lot of the same things with my Science 14's as I do with my AP's, but they get slightly different things out of it. The AP's are learning more about the process, whereas, the Science 14's are getting more of the hands on opportunities. I would do the same things with both groups, but there are different sub-goals I want them to have."*

In reflecting upon a recent lab she had done where the student made root beer, Mrs. B further explained:

"The purpose of the lab at the AP level was to go through cellular respiration. While the goal for the Science 14's was still to learn about cellular respiration, it was more important that they could do something neat with it and learn a process they could apply to real life. Both groups still really liked the fact that they got to make root beer in the end."

Even though Mrs. B acknowledged different classes would value different things in the lab, she selected one activity with the overall goal of engaging her students, albeit in different ways. As sub-goals, the academic AP students would focus more on the process of cellular respiration and the non-academic Science 14 students would focus more on the real world product. Mrs. B's account is consistent with the questionnaire data in that she favored "skills" as the primary emphasis for her academic AP biology class and on an "attitudes" and an "everyday coping" emphasis for her non-academic Science 14 class.

The role of experience on teachers' beliefs

The novice teachers in this study identified "knowledge" as being more important than their experienced counterparts did (see Table 12). This trend was seen across all three teaching contexts; in the teachers' own classroom, with respect to science education and in what teachers reported they emphasized most.

Table 12
Teacher's mean rating (1 = most important, 4 = least important) of knowledge as the most important aspect of science education.

Mean ranking of "knowledge"	Novice teachers with less than 10 years experience	Experienced teachers with more than 10 years experience
Teacher's own science classes	2.5	3.3
Science education	2.5	3.2
Teacher's reported emphasis	1.9	2.7

The most striking relationships between teachers' beliefs and experience appeared in the one-on-one interviews. Two teachers in particular verbalized how their beliefs had changed over time. Mrs. A for example said:

> *"When I first started teaching, it was all about content delivery. Biology was important because it was Biology, and chemistry was important because it was chemistry, and that is how I was teaching. I think the more I taught K&E and Special Ed, I began to shy away from content because it became less important."* (SH, NAc, Nov)

Mrs. A also offered some explanations for why all teachers' beliefs might change over time. She said:

> *"I think for new teachers and student teachers that they are very worried about the content portion."*

She explained that when new teachers are not comfortable with the subject material themselves, that is what they focus on. It is only after they master the subject content that they feel confident enough to focus on their own philosophical beliefs about what is most important. Mrs. E's change in belief was a matter of developing her skills and efficiency as a teacher and of coming to appreciate the needs of her students. She explained:

> *"Over the years I have become less content focused and more efficient at covering it and more nature of science focused. The longer I do this job, the less I find a difference [between academic and non-academic goals] and the more I think it needs to be both content and nature of science. When I was younger, I used to concentrate on the concepts of the non-academic courses more than the content and visa versa for the academic courses. Now it has become just the same. They are equally important for both groups"*

Although the experienced teachers reported less of a focus on content knowledge, when asked what advice they would give to new teachers in planning an instructional emphasis, their focus turned back to the content knowledge. For example:

> *"I ask them to work from the back toward the front. I tell my student teachers to look at the curriculum topics and textbooks. Once they know what they are going*

to test, then they can teach those things and the rest of the time they can spend doing things that are maybe a bit more open ended." – Mrs. E

"I would tell them to be very organized so that they can get all those concepts done" – Mrs. C

It seems that experience not only changes teachers' beliefs, but that it helped them acknowledge the necessity of their previously held beliefs.

Personal experiences and interests and teacher beliefs

Some of the teachers' beliefs about what is most important in science education grew out of both positive and negative experiences they had personally encountered when they were students studying science. Some teachers' reported their beliefs modeled those of the teachers from whom they had learned, while for others structured their beliefs around avoiding aspects emphasized by previous teachers with whom they had negative experiences.

Personal interests also appeared to shape what teachers believed to be important in science education. It is human nature to want to share your passions with others, and therefore, one would expect science teachers to have at least some personal interest in science themselves. The fact that almost all of the research participants held an additional degree in science suggests this is likely the case. If the teachers were not interested in science to begin with, it is unlikely that they would have invested the time and effort into studying science in university. Some teachers reported their own specific areas of interest influenced both their beliefs and what they emphasized in their classrooms. For example, Mrs. C said she loves the biological sciences and noted she consequently spends more time on the biology unit when teaching science 10, simply because she enjoys it. Mrs. E expressed a keen interest in the philosophy of science and consequently said she found emphasizing the nature of science and the philosophical and epistemological aspects of scientific knowledge in her classes was most fulfilling.

Summary

While the basic set of core beliefs about what counts most as science education is reasonably consistent, differences arose according to; whether teachers consider the process versus the products of science education, the academic streams and grade levels teachers are teaching, and how experienced teachers are in teaching science. While is may be assumed teachers' beliefs are relatively stable, this research has suggested that beliefs can change across contexts and over time. Although the literature suggests beliefs do have a significant impact on classroom practice, this research has also displayed evidence to the contrary. What teachers report they emphasize in class seems to be more influenced by external pressures from curriculum, student differences, time and standardized assessments than by teachers' beliefs.

Chapter 5 – Discussion and Conclusions

The main purpose of this research was to investigate and implicate Alberta science teachers' beliefs about what is most important in science education within the contexts of the curriculum as written and interpreted in the Alberta science programs of studies and the curriculum as it is lived in the classroom. To explain differences between the curriculum-as-planned and the curriculum-as-lived, I turn to Tobin, Tippens and Hook's (1994) concept of *referent*. A referent is, "…a guide for action, context specific, and is an organizer of the beliefs an individual deems to be relevant to the situations in which personal actions are to occur. The referents given the highest priority have the greatest impact on how the teacher acts" (p. 246). This research identified five potential referents that appeared to impact teachers' beliefs about science programs and their enactment of those programs. They included; school grade division, academic stream, years of experience, provincial examinations and teachers' interpretations of the four foundational pillars. Also considered as contextual factors that influence teachers' beliefs and guide their enactment of curriculum, the referents in this research are used to answer the key research questions.

Revisiting the Research Questions

What do secondary teachers in Alberta believe are the most important emphases or goals of teaching science?

The science teachers participating in this study identified "skills", "attitudes", and "everyday coping" as being the most important emphases, and "knowledge" and "STS(E)" as being least important. What individuals believed to be most important varied slightly according to the referent teaching context and whether they considered the products or processes of science education. Generally, the participating teachers' beliefs were student oriented and focused on helping their students prepare for future experiences at school, at work and at home. When considering the products of science education, the teachers acknowledged most of their students would not likely continue with careers in science, and consequently, felt an emphasis on content knowledge wasn't as important as an emphasis on creating enjoyable and meaningful learning experiences for their students. With respect to process, the teachers felt it was more important to emphasize the skills their students would need to be successful in the courses they were taking and in the courses they would take in the future. In all cases, the teachers believed their students should learn science so they could more successfully live and cope within the world around them.

Why do science teachers hold a particular set of beliefs about the science curriculum?

Although no two teachers expressed exactly the same reasons for believing a particular emphasis was important, some interesting patterns did emerge. The participating science teachers' beliefs did not appear to be influenced as much by the content of the program of studies, than by how they interpreted the goals of the programs and key referents such as teaching contexts, teaching experience, and departmental exams.

This research showed the teachers interpreted the four foundational pillars and the programs of studies according to their own perceptions of the keywords used to identify the pillars, rather than by the detailed descriptions of the pillars as written in the programs of study. The "skills" emphasis for example, was interpreted to include *either* manipulative *or* intellectual skills despite the programs of studies stating a skills emphasis included both. How a teacher interpreted the skills emphasis seemed to influence how important they believed a skills emphasis to be. For example, if a teacher interpreted skills to mean only the hands on aspects of science, and they valued laboratory work, they would assign the skills emphasis a higher rating than a teacher who saw skills as being more intellectually focused. Likewise, many teachers interpreted an STS(E) emphasis to include only interactions between science, technology and society but did not consider nature of science as part of the STS(E) pillar. Those teachers who believed nature of science was important, but didn't see it as part of the STS(E) emphasis rated the STS(E) emphasis lower than those who considered nature of science part of the STS(E) pillar.

All of the teachers in this study were exposed to multiple referents, meaning they taught a variety of courses representing different academic streams and sub-disciplines, they had different experiences as teachers and students, and they experienced different degrees of pressure from departmental examinations. Consequently, it appeared the participating teachers valued different emphases depending upon the key referent that was operating. Some referents, such as teaching junior high school and years of experience seemed to be higher priority referents that served to structure teachers' overall beliefs about what is most important in science education, while other referents appeared to be less significant.

What contextual factors influence science teachers' beliefs about what is most important in science education?

Not all contextual factors investigated were found to influence teachers' beliefs. For example, when teachers' beliefs were compared according to gender, school size, number of courses taught, and academic degrees held, there were only minor differences between groups. The key factors that did appear to potentially influence teachers' beliefs were; grade division taught, academic stream and years of teaching experience. While specific personal experiences, preferences and personal contexts were not identified in this study these factors were also suspected of having an impact on what teachers believed.

How do science teachers' beliefs relate to practice in science classrooms?

Contrary to research conducted by Brickhouse (1990) and Cronin-Jones (1991), the data from this study suggested that teachers do not necessarily emphasize what they believe is most important. Instead, external pressures and key referents such as provincial examinations seemed to have a potential influence on what science teachers planned to emphasize in their science classes than their beliefs did. Consistent with Aoki's (1991) notion of "tensionality" (p. 159) within the curriculum as planned and the curriculum as lived, participants in this research appeared to experience competing tensions between what they believed to be the most important in teaching science, what they perceived was most important from the programs of studies, and what they felt they *should* emphasize in their science classes. The relationship between planning and instruction was not established in this research however common sense suggests teachers would be unlikely to emphasize aspects of science that they had not planned to address.

Key referents and contextual factors influencing teachers' beliefs

School Grade Division

The needs, interests and goals of junior high school students are different than those of senior high students. For example, junior high students all have at least three or more years of mandatory science learning ahead of them while many senior high students are nearing the end of their formal schooling. Consequently, positive attitudes towards science and learning science would serve junior high students well in their future studies, by helping them to engage with the topics they are learning. The junior high science programs also reflect a more general approach toward science, covering a variety of introductory topics and skills. Senior high programs are more specialized focusing more on abstract concepts unique to each science discipline. Once introduced to a variety of science topics and sub-disciplines, junior high students have the opportunity to discover new interests and make choices for further study in senior high school. Senior high school students nearing the end of their secondary careers have already made those choices. Instead, their energy is focused on preparing for life outside of school, whether it be for life in the workforce or in future post-secondary studies. As a result, specific skills and attention to potential career and life choices may be more helpful to senior high school students.

It not surprising that school grade division appears to serve as a potential referent guiding what teachers believed were the most important aspects of science teaching and learning in their classes. Teaching junior high students goes along with an expectation that teachers will motivate students to embrace continued learning opportunities. Students who are excited and interested in learning science are expected to do well at school. In senior high school students must be readied for adult life by developing the skills they would need to cope with life outside of school, or make decisions about post-secondary and career choices. The teachers in this study seemed to feel students with well-developed science process skills would be more successful in post-secondary studies, particular in the sciences. They also felt the problem solving skills learned in science classes could also be transferred to other aspects of life. The senior high teachers' emphasis on everyday coping reflected their desire to ensure students could use what they learned in science class to make decision in and understand their world outside of science class.

A third grade division grouping, including teachers who taught both junior and senior high school science classes, presented an opportunity to investigate which divisions' needs served as the highest priority referent shaping teachers' beliefs. Expectedly, junior-senior high school teachers appeared to share characteristics of both junior high and senior high school teachers however their response patterns suggested the junior high referent was most prevalent. Junior-senior high school teachers work in a unique situation where they may teach the same group of students many times throughout their secondary careers. These teachers have the opportunity to experience first hand, the impact that emphasizing positive attitudes potentially has on their students' successes as they continue through and eventually leave secondary school. Most other junior high school teachers are disconnected from the effects of their work with students, as the students become someone else's responsibility in high school. They often don't have the benefit of seeing the longer-term payoffs for the work that they do. Many senior high school teachers will only teach a student once or twice, in a specific subject in the students' high school career. They have less time and opportunity to focus on developing students' attitudes and may assume that by senior high school, students' attitudes, whether positive or negative, are already shaped. The senior high school teachers in this study also perceived their roles as preparing their students for careers, future studies, and adult life and believed emphasizing the discrete or transferrable science skills would have greatest potential impact on their students' future careers.

Academic Stream

VanDriel, Verloop and Bulte (2005, 2007) identified academic stream and subject specialization as factors influencing teachers' beliefs about what is most important in science teaching and learning. They found teachers who taught within an academic stream of chemistry valued chemistry content knowledge, (fundamental chemistry) most, while vocational stream teachers believed an emphasis on 'chemistry in technology and society' was most important. Teachers appeared to integrate the goals of the stream in which they taught. VanDriel et al.'s results also suggest teachers' identities as subject specialists or subject generalists may influence their beliefs about what is most important. In this study, teachers who saw themselves as subject specialists valued the discrete content knowledge associated with their subject area. Generalist teachers, on the other hand, had a tendency to focus on other, more general aspects of the science programs they taught.

The data collected in this research confirmed the spirit of VanDriel, Verloop and Bulte's (2005, 2007) findings, but not the details. Academic stream teachers tended to believe an emphasis on skills were most important, while non-academic stream teachers believed an emphasis on attitudes were most important. Academic teachers seemed to view skills as contributing to their students' future academic studies, and felt developing problem solving and technological skills was a goal of academic courses that would ready their students for further studies in science. The non-academic teachers in this study acknowledged most of their students would not likely continue studying science beyond high school, and so specific science skills such as using a microscope or titrating a solution were less important. Instead, they perceived positive attitudes towards and connections with everyday science as the more important aspects.

The non-academic referent was given the highest priority amongst teachers who taught both academic and non-academic courses. A number of teachers said they felt the goals and emphases they perceived as most important in non-academic courses were the ideal for all the courses they taught. Generally, non-academic courses are more practical and student oriented than subject focused. They tend to emphasize connections between life and science, and are consequently more in tune with the teachers' pre-existing belief that science education should help students understand and cope within the world around them. It appears that when a referent is already consistent with previously defined beliefs, it is given higher priority than one that is not.

Teachers' identities as science generalists or subject specialists also seemed to act as key referents, guiding what they believed was most important. Subject specialists privileged academic and manipulative skills specific to their discipline and subject generalists emphasizing attitudes and connections between the science content and life. Whether teachers' identities emerged as a result of what they taught and believed, or directed what they taught and what they believed was not determined within the limits of this research, but it is an interesting relationship worthy of further exploration.

Years of Experience

Previous research conducted by Cheung & Ng (2000), Chu (2009) and Lin, Hu and Changlai (2005) suggested less experienced teachers, including pre-service teachers, held more humanistic beliefs and goals for science education than their more experienced counterparts. The literature also suggested that as teachers became more experienced, they placed a greater emphasis on knowledge (Cheung & Ng), and on skill development as conceptualized by Roberts' (1982, 1988) 'structure of science' emphasis (Chu).   The results of this study were inconsistent with the literature cited and suggested teachers tended to drift away from prioritizing knowledge outcomes as they became more experienced, more confident and aware with the needs of their students.

When questioned during one-on-one interviews, the teachers admitted emphasizing knowledge was more important to them earlier on in their careers, and particularly when they felt uncomfortable with their own knowledge subject matter they were teaching. A number of teachers explained, as they became more confident and efficient in teaching the content knowledge, they felt they had more opportunities to focus on other aspects of science education that they felt were more important. As teachers became more proficient at teaching science, their own understandings of the nature of science, the processes of science, and interactions amongst science, technology and society also presumable grew. It seemed that for the teachers in this study, the knowledge emphasis served as the foundational building block upon which other aspects of science could be built.   Until the foundation was well laid, teachers didn't feel they could justify or cope with emphasizing other aspects of science.

Departmental Examinations

The province of Alberta has incorporated mandatory standardized assessments in the form of grade 9 achievement tests and grade 12 diploma examinations into its science education programs for over two decades. As a result, many teachers potentially feel pressured to ensure their students achieve high marks on these exams because students' marks are often interpreted as indicators of a teachers' effectiveness. Although I did not intend to collect data regarding the impacts of standardized testing on teachers' beliefs, Alberta's provincial examinations emerged as a potential pressure influencing what teachers perceived as being most important when teaching science and what teachers ultimately emphasized when planning science instruction.

Assessment led teaching is not a new phenomenon in the educational literature, or in science education. Other researchers including Cheung and Ng (2000) and Chu (2009) also noted high stakes examinations influenced what teachers thought they *should* emphasize in their classes. Turner and Peck (2009) explained the nature of these standardized examinations re-enforce teachers' privileging knowledge over all of the other curricular outcomes and emphases. Like many other high stakes paper and pencil tests, the types of outcomes that are easily and objectively measured on provincial examinations are limited. Factual recall of content knowledge is most efficiently tested and consequently makes up the majority of questions on these tests. Provincial examinations also have a limited ability to objectively measure student attitudes and skills, especially in science. They are also high stakes for both students and for teachers. Alberta Grade 12 Diploma examinations count for 50% of a students' final mark. As a result, teachers are pressured to emphasize knowledge over the other aspects of science teaching and learning to ensure their students perform well on the exams. I believe this pressure at least partially accounts for differences between what teachers reported they believed was important and what they said they emphasized most in their classes was considered. Why else wouldn't teachers emphasize what they believed was important?

Other important findings

In addition to an emphasis on attitudes, skills and everyday coping, all of the teachers who participated expressed the hope that their students would find personal meaning and connection with what they learned in science class. Although I used the Roberts' (1982, 1988) everyday coping emphasis to categorize this sentiment, I don't believe a single category truly captures the essence of the teachers' passion and concern for science and their students. It was evident in both the questionnaire and interview responses that the science teachers who participated in this study were all student oriented and enjoyed teaching science. Every teacher expressed a hope that their students would become willingly engaged with learning science, both in their classrooms and beyond. In retrospect, I have also come to appreciate that what teachers believe to be worthwhile in science education and what they hope to accomplish with their students cannot be easily categorized and counted. The written responses and interviews from each teacher included nuances and connections to all four of Alberta's foundational pillars, all seven of Roberts' curriculum emphases and more. To limit teachers' expressions of their passion to pre-determined categories does not adequately pay tribute to the work and thinking that they do.

Review of Methods and Methodology

My intention was to identify and compare differences in science teachers' beliefs by collecting quantitative data and quantifying some of the qualitative data. The qualitative data from the open response questions and one-on-one interviews was intended to confirm or disconfirm and further explain the quantitative results. While mixing methodologies proved to be a reasonable approach to classify and compare science teachers' beliefs, there were limitations inherent within the methods used to support each methodological approach.

Limitations of quantitative methods

One of the greatest shortcomings of the quantitative methods used was that I was unable to collect sufficient data to statistically evaluate differences between contextual groups. All of the differences and trends identified came from a holistic and qualitative review of the relative frequencies and rankings of each category. I did not have enough data to determine whether these differences were statistically significant or not, and therefore, my assumption that the apparent differences were significant may be flawed. Collecting data from a larger, more diverse sample would improve my confidence in the results and would have allowed me to determine whether or not differences between contextual categories were statistically significant.

The categories used to rank and count data limited the breadth of and quality of the quantitative data that could be collected. In the ranking portion of the questionnaire, respondents were limited to reporting their beliefs as they were conceptualized within each of the four foundational pillars. One respondent failed to rank the four foundational pillars and stated in the additional remarks section that he / she felt ranking the four pillars was irrelevant to what they believed to be important. All of the respondents also identified other aspects, that fell outside of the four foundational pillars were important. Expanding the list of potential belief categories to include Roberts' (1982) seven curriculum emphases would have allowed teachers to address a wider range of what they believed to be important. This may have also had an effect on the quantity of qualitative data the teachers provided, by expanding the range of possibilities for their comments.

The ranking scale used was awkward and problematic. Teachers were asked to assign the top ranked item with a score of one and the lowest with a score of four. This meant that a highly valued statement was given a lower overall number, a relationship that is counter-intuitive when analyzing the data. Fortunately, the written responses seemed to coincide with the ranked responses, thus confirming it was unlikely the respondents used the scale incorrectly. The issue arose however when mean scores were reported in the data analysis. When reading and interpreting the results, one must be mindful that the scale is inverse with low scores signifying higher priority beliefs.

The four-point spread between the highest and the lowest ranked scores also meant that when mean scores were considered, they often did not appear markedly different. Due to the small sample size, one response ranking an item highest or lowest could easily skew the overall appearance of the results. To correct for this, I chose to use the frequency of response ratings rather than the weighted means to illustrate those aspects teachers believed were most important. The fact that the scale was a forced ranking also prevented teachers from communicating the degree to which they believed a statement was important. Some teachers may have viewed skills and attitudes to be of similar importance yet they were forced to assign different rankings to each one. Alternatively, I could have selected a *Likert scale* (as cited in Palys & Atchison, 2008) or other graduated bipolar rating scale rather than a forced ranking. This would have allowed me to create a broader scale, capturing varying degrees of agreement, that might have been more discriminatory and consequently allowed me to include more belief categories for teachers to respond to. A *Likert* or similar scale combined with more categories and a broader sample size might have given me a better picture of teachers beliefs and allowed me to determine whether differences across contextual groupings were statistically significant.

Qualitative methods

The qualitative methods used in this study were intended to draw out those beliefs that went beyond the four foundational pillars categories and to offer more detailed explanation of teachers' beliefs and the factors that contribute to their closely held beliefs. Although the written response items on the questionnaire did meet these stated goals, I was disappointed with the volume and quality of data collected. Having compared the open response items closely with the four pillars rankings, I found many teachers limited their responses to a reassertion of their rankings. I had hoped teachers would use the written space to explain how they interpreted the four foundational pillars and to identify other aspects that might be important to them. Perhaps the questions asked should have been more pointed and more detailed to clarify my expectations. Grouping all of the written response questions together into one section may have also encouraged teachers to provide more thoughtful and forthcoming responses.

Quantifying the qualitative data was problematic in that it was often difficult to decide in which category a response should be placed. Teachers in this study did not use the same language as in the four foundational pillars or Roberts' curriculum emphases to express their beliefs. Consequently, interpreting and categorizing phrases associated with beliefs statements proved to be a difficult and imprecise endeavor. Errors that may have occurred when categorizing teachers' responses would be compounded further when responses were counted and tallied. When an expression of belief was presented multiple times, it was counted only once. I did not assume that the frequency of expression suggested anything about the strength of the belief. This may have been problematic in that some teachers with multiple and weak beliefs were counted in multiple belief categories, while others with one strong belief was counted only once. Perhaps asking teachers to identify one belief that is most important to them from a selected list may have solved this problem.

One of the key research questions asks what teachers believe to be *most* important in science education. When I asked about what is *most* valued, I assumed this could determined quantitatively, however I found teachers' belief statements were very difficult to quantify. Although I utilized a frequency of appearance strategy, this did not allow me to communicate or assign a numerical value to the strength of the teachers' individual beliefs. Instead it illustrated those beliefs that were most frequently expressed but failed to differentiate between teachers who repeatedly expressed a similar belief pattern because they felt strongly about it and those who simply repeated their responses. A numerically based rating scale such as the Atkinson "satisfaction scale" (see Palys & Atchison, 2008, p. 175) could have been used to avoid this problem.

While the interviews were productive in providing valuable data and insight about teachers' beliefs, the participant sample is suspect. A total of 9 teachers volunteered to participate in the interviews. Of those teachers, more than half were actively pursuing a graduate degree or had recently completed a graduate degree. Since most of the interviewees were graduate students themselves, the sample was not representative of the teaching population. Interviewees had interests in this research beyond their roles as teachers. Some participated for the sake of the research experience and others had personally explored some of the questions asked in other courses. I was previously acquainted with almost all of the participants and so and their responses may have reflected what they anticipated I hoped to find rather than what they truly believed. Unfortunately, with the limited time available for a Masters' thesis and a limited population from which to draw voluntary research subjects, this could not be avoided. Given more time and a larger sample population the reliability of the results could be improved.

Mixed methodology

Despite the limitations and shortcomings of the discrete methods and tools used in this research, overall I was satisfied with my choice of mixed methodologies. This research has given me the opportunity to experience first-hand the strengths and weaknesses of quantitative and qualitative methods as well as an appreciation of how mixed methodologies allow the two methods to inform and enrich one another. Dr. Todd Rogers, a University of Alberta professor and presenter in one of my previous graduate courses explained all research data is inherently qualitative and quantitative, depending upon which characteristics we choose to attend. By using a mixed methodological approach, I was forced to attend to both aspects of the same data, thus causing me to appreciate the nuances associated with both approaches.

The mixed methodology used seemed very appropriate for this research. In order to make direct comparisons and evaluate data according to constructs such as *most* and *least*, a quantitative approach was very useful. It allowed me to group teachers according to contexts and compare belief patterns amongst groups. To ferret out the meaning and significance of *most* and *least*, the qualitative data was essential. Without the qualitative data, I would not have gained the same insight into the complexities and potential reasons behind the beliefs that teachers hold.

Validity and Reliability

The three sets of data:

- ranked survey items
- open response survey items
- interview data

were compared to establish validity and reliability of the survey. Jackson (1988) defines validity as, "the extent to which a measure reflects the concept, reflecting nothing more or less than that implied by the conceptual definition" (p. 8). In this study, validity is established by comparing the consistency of open and closed responses among three data sources from the surveys. First, participants' responses to the questions, *considering science education as a whole, what do you believe is most important for all students to develop,* were analyzed to identify the single most important aspect of science education for each teacher. This aspect was then compared to the top ranked item from the survey question asking teachers to rank their beliefs about the purpose of education in general. The most significant aspect identified in the written response items was paired with the respondents' top ranked aspect from the forced ranking items to identify patterns and consistencies. For a summary of the results, see Table 13.

Table 13
Comparison of open response question 2 with ranked item data.

Frequencies of aspects identified as most important in open response question 2. (n=29)	Frequencies of aspects identified as most important on ranked item questions. (n=30)			
	Attitudes	Knowledge	Skills	STS
Attitudes	**6**	0	2	0
Knowledge	0	**1**	1	0
Skills	4	2	**8**	0
STS	1	1	0	**3**
N=	11	4	11	3

A comparison of the open response question 2 and the related ranked item questions revealed three important trends. First, “skills” and “attitudes” were ranked much higher than the other emphases in both the open response questions and the ranked item questions. This consistency suggests the four pillars framework may be a valid way of identifying teachers’ beliefs about what is most important in science education. Second, both sets of data also confirmed that teachers believed “skills” and “attitudes” were much more important than “knowledge” and “STS”. When the first and second place rankings were considered, “skills” and “attitudes” both significantly outranked the other emphases. The approximately equal emphasis placed on both “skills” and “attitudes” made it difficult to ascertain whether teachers overall believed “skills” to be most important or “attitudes” to be most important. I believe the difficulty in discriminating between the relative importance of these two categories in the data, reflected the participants’ inability to decide which is most important as well. Six respondents provided a response combination that blended “skills” and “attitudes”. When the data from all of the open response questions was combined, both “skills” and “attitudes” were mentioned together and with approximately equal frequency.

When compared to other emphases such as knowledge or STS, both of these measures suggested skills to be of greatest importance for teachers. Consistency between these results suggests this conclusion is not only potentially valid, but that teachers' conceptualization of "skills" in science education as defined by the foundational pillars is consistent.

Jackson (1988) defines reliability as, "the extent to which, on repeated measures, an indicator will yield similar readings" (p. 8). On the survey items, teachers were asked to rank what they believed to be the most important aspects of science education both generally and within their classrooms. Since, belief systems are expected to be durable and transcend situational contexts, it was expected both questions would elicit similar responses. A comparison of both sets of rankings suggests this was in fact the case, thus supporting the reliability of the ranked item questions on the survey. For a summary of comparative results for the top two ranked statements see Table 14. In addition, the written response questions also elicited a similar pattern of encoded results, suggesting the survey is a reasonably reliable measure to capture and categorize teachers' beliefs about what is most important in science education. Furthermore, the interview data also illustrates similar trends with stronger emphasis on "skills" and "attitudes".

Table 14.
Respondents' top two rankings of what is most important in the classroom and in science education

	Beliefs about what is most important in the teachers' classroom / current classes		Beliefs about what is most important in science education as a whole	
	Rank 1 (#of responses)	Rank 2 (#of responses)	Rank 1 (#of responses)	Rank 2 (#of responses)
Attitudes	12	8	10	10
Knowledge	4	7	4	7
Skills	13	5	14	6
STS(E)	1	9	2	6

The ranked item survey questions were limited in that they did not capture all of the categories identified in the written response and interview data. Response trends reflecting the four pillars framework were consistent with the other data sources, however the four pillars did not capture the added categories "everyday coping" and "habits of mind". The interview data did confirm that the addition of these other categories was potentially legitimate. Further research in this area of investigation may benefit from considering the additional categories.

Further Research

Addressing science teachers' beliefs was a worthwhile topic for investigation. Clearly, teacher beliefs are a complex matter easily influenced by changing contexts and external pressures. With this research, I feel as though I have only scratched the surface of what teachers believe to be important. Further research into the nature of teachers' beliefs, the tensions between the written curriculum and their beliefs, and teachers' enactment of their beliefs about curricula may yield a richer picture of not only what those beliefs are, but also how they potentially impact instruction.

One project that could be done to extend the findings from this investigation would be to investigate teachers' beliefs about broader range of categories or curriculum emphases using a graduated rating scale that is sensitive to the strength of their beliefs about the importance of a particular emphasis. This would allow for better comparisons between groups as well as it would help create a more detailed profile of what teachers' believe to be important.

Most science teachers in the sample group taught multiple science classes at different levels. Very few of the participating teachers were truly specialists in one of the science disciplines. In addition, the participating teachers also had wide range of educational backgrounds and experiences. Using a larger sample size and asking teachers about their beliefs with respect to the individual classes they teach may reveal further significance with respect to the contextual factors that influence their beliefs. By investigating science teachers' beliefs across a broader range of teaching contexts such as individual courses taught, discrete school culture, areas of university specialization, personal experience as a student, nature or type of teacher training program and experience item writing or marking diploma examinations, perhaps other significant contextual factors influencing teachers' beliefs might emerge.

One particular area I didn't feel I was able to adequately explore in this research was the impact of teachers' beliefs on classroom practice. If we are to truly understand the tensionalities that occur between the curriculum-as-planned and the curriculum-as-lived, we must be able to observe teaching and learning in action. While I did ask teachers what they *planned to emphasize* in instruction, I had no way of knowing whether or not their plans were or would be brought to fruition. Further research into what teachers actually emphasize in their classrooms would better address the question of whether or not teachers' beliefs are enacted in the classroom. In addition, further research could also observe and account for students' experiences in their science classrooms as a critical part of the picture illustrating how curriculum as planned and curriculum as lived are mediated (or not) by teachers' beliefs.

This study was limited to teachers within a small region of the province of Alberta. Expanding this study to include a broader cross section of Alberta teachers and ultimately to include Canadian teachers whose curricula are anchored in the four foundational pillars as stated in the Pan Canadian Framework (Council of the Ministers of Canada, 1977), could reveal whether or not science teachers' beliefs about science education are anchored in local, regional, or broader contexts. Understanding what influences teachers' beliefs and how their beliefs in turn influence what is emphasized in science classrooms is a beginning step to understanding and appreciating at least some of the nuances of teaching that ultimately lead to positive student experiences.

Conclusions

For the purposes of this research, science teachers' beliefs were defined as their valuations and understandings of the relationships between the stated curricular goals of science education and how they enacted those goals in their classrooms. The results suggest that although teachers' beliefs may be guides for action, they do not alone determine what is emphasized most in science classrooms. What teachers believe to be important and what they choose to emphasize in their classes often appear to be at odds with one another. By engaging teachers in curriculum talk and investigating some of the contextual factors that contribute to this difference provides some insight into the tensionalities experienced by teachers as they navigate their way through the curriculum-as-planned, the curriculum-as-perceived, the curriculum-as-imagined and eventually, the curriculum-as-lived.

Personal Reflection and Concluding Remarks

One of my instructors from the University of Alberta, Dr. Gregory Thomas, explained in class one day, "research is always an intervention". This research has been an intervention for both my participants and me. After the data collection was completed, I had the opportunity to reflect with some of the participants. During these conversations, they expressed how the research questions I asked them caused them to pause and reflect critically upon their own teaching practices. They explained that by participating in this study they began to re-evaluate what they believed to be important in their classrooms and hoped it would help to be better teachers. I also had a similar experience. Reading the data and writing this thesis has not only made me reflect upon what I believe is most important, but it has also made me realize how wonderfully complex our jobs as science educators are. What we do in classrooms and what we believe to be worthwhile and important 'counts' for students and for their futures. I realize conversations about curriculum without teachers, are not really conversations at all. If educators, curriculum developers and teachers are to plan and implement programs that create a better future for our students, we must all be part of the conversation.

I am also reminded by doing this research how much I have yet to learn about teaching, learning and curriculum. I am grateful for the opportunities I have had to learn from my professors, colleagues and research participants. My hope is that I can share or use the knowledge I have acquired as a springboard for further thought and discussion about ‘what counts most as science education’.

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Appendix A

Information Letter for Potential Research Participants

Dear Teacher,

As you are already aware, science education can have many different objectives and goals. As a result, programs of studies are written with a variety of curriculum emphases and the Alberta science programs are no exception. Within all of the Alberta junior and senior high science programs, four key foundational statements or objectives have been identified. These are known by many educators as the four "pillars" to science education and include: knowledge, skills, STS and attitudes. As part of the requirements for my M.Ed. degree through the University of Alberta's Department of Secondary Education, I am conducting a research study investigating how Alberta science teachers prioritize the four foundational pillars and what contextual factors may influence the aspects of science education they feel are most important. I am writing this letter to invite you, a secondary science teacher in Alberta, to participate in this study investigating teacher beliefs about Alberta's curriculum emphases. The title of the study is "**What counts as science education? Investigating junior and senior secondary science teachers' beliefs about science curriculum emphases**." I, Tracey Stock, with the support of Dr. Susan Barker, Professor, and Graduate Supervisor, at the University of Alberta, am the principle investigator for this study.

Your participation in this study potentially involves two phases. First, I am requesting that you participate in an online questionnaire where you will be asked to identify some general demographic information and your beliefs about the Alberta curriculum emphases as they are stated in the science programs' foundational pillars. The questionnaire is anonymous and can be completed online at your convenience. Electronic submission of your responses will be taken as your full and informed consent to participate in the questionnaire portion of this study. In addition, I am requesting your participation in a 10-20 minute, one-on-one interview, where you will be asked to elaborate on your thoughts regarding what you believe are the most important goals of science education. Interviews will be scheduled at a time and place that is convenient for you, the participant and will be audio-recorded and then transcribed by me, the researcher. You will need to provide written consent to participate in the interviews. In the final paper, your name will be replaced with a pseudonym and your identity protected. Please be aware, as the principle researcher, I am bound by University of Alberta Standards, for the Protection of Human Research Participants. This means that I will protect your confidentiality. Your questionnaire and /or interview responses will be handled in compliance with the Standards, and will be used to support and write the researcher's thesis paper for the M.Ed. Program at the University of Alberta. This paper may also be published in a peer-reviewed journal. You will be given the opportunity to review a copy of your interview data before it is used in the final thesis paper.

You have the right not to participate in this study. You may voluntarily participate in the questionnaire and not the interview, or in both. Should you choose to participate in the questionnaire portion of the study, you will be unable to withdraw your data once it is electronically submitted. You may withdraw your interview responses from the study at any time, until your interview is transcribed (within approximately 3 weeks of when the interview is conducted), and returned to you for your review, without any reasons and without any consequences. Should you choose to withdraw your data, you will be required to notify the researcher by e-mail and your interview responses would be deleted from the study. If you choose to participate in this study, a copy of your questionnaire and / or interview responses will only be seen by me, the researcher, and will be stored in a safe location for a minimum of 5 years (computer data will be password protected and printed data will be locked in a cabinet in the researcher's office). A final copy of the thesis paper will be made available to you upon request.

You may access the online questionnaire by going to the following link and entering the password provided in the attached e-mail.

http://www.surveymonkey.com/S/GRSDHHJ

Please be reminded that by submitting your questionnaire responses, you have given your full and informed consent for this data to be used in this study. Once your data is submitted, you will also be unable to withdraw it from this study.

Thank you for considering your role as a voluntary participant in this study. If you have any questions now or in the future, please contact me (information below).

Sincerely,

Tracey Stock
Graduate Student – University of Alberta
Science Teacher – Elk Island Public Schools
Ph: (780) 467-8816
Email: tracey.stock@ualberta.ca
tracey.stock@ei.educ.ab.ca

The plan for this study has been reviewed for its adherence to ethical guidelines and approved by the Faculties of Education, Extension, Augustana, Campus Saint Jean Research Ethics Board (EEASJREB) at the University of Alberta. For questions regarding participant rights and ethical conduct of research, contact the chair of the EEASJREB at (780) 492-3751.

Appendix B

Science Teacher Beliefs Regarding Curriculum Emphasis in Science - Questionnaire

By responding to and submitting the following questionnaire, you give your full and informed consent to participate in this research study, investigating teacher beliefs about science education. You are under no obligation to respond, as your participation is voluntary. The information you provide will be used solely for the purposes of this study. Your identity, as a participant in this online questionnaire, will not be known to the researcher, and therefore cannot be revealed in the final paper. Any quotes taken directly from your open-ended responses will be referenced with pseudonyms. **Once you have electronically submitted your questionnaire responses, you will not be able to withdraw them from this study.**

Thank you in advance for your co-operation.

Section I: Demographic / Background Information:

1. Gender:

   Male ⊗ Female ⊗

2. Years Teaching:

   0-3 ⊗ 4-6 ⊗ 7-9 ⊗ 10+⊗

3. Current School Setting:

   Junior High School (7-9) ⊗
   Senior High School (10-12) ⊗
   Junior / Senior High School (7-12) ⊗
   Elementary / Junior High (K-9) ⊗
   K-12 ⊗

4. Semesters / Full Year Program?

   Semesters ⊗
   Full Year ⊗
   Mixed ⊗

5. Grades Taught During the 2009/2010 School Year: (check all that apply)

   1 ⊗ 2 ⊗ 3 ⊗ 4 ⊗ 5 ⊗ 6 ⊗ 7 ⊗ 8 ⊗ 9 ⊗ 10 ⊗ 11 ⊗ 12 ⊗

6. Science courses Taught During the 2009/2010 School Year: (check all that apply)

General Science (Sci 7,8,9,10,20,30) ⊗
"Non-academic" Science (Sci 14,24, K&E) ⊗
Honors / IB / AP Science (any subject) ⊗
Biology (20, 30) ⊗
Chemistry (20, 30) ⊗
Physics (20,30) ⊗
Science Option (Forensics, computing science) ⊗

7. Average class size taught during the 2009/2010 school year:
0-15 ⊗ 16-25 ⊗ 26-35 ⊗ 36+ ⊗

8. Number of different courses taught during the 2009/2010 school year:
1 ⊗ 2 ⊗ 3 ⊗ 4 ⊗ 5 ⊗ 6 ⊗ 7 ⊗ 8 ⊗ 9 ⊗ 10 ⊗ 10+ ⊗

9. Academic degrees held (check all that apply):
B.Ed. ⊗ B.Sc. ⊗ B.A. ⊗ M.Ed. ⊗ M.Sc. ⊗ M.A. ⊗ PhD. ⊗ Other ⊗
Area(s) of Specialization: ____

Section II: General beliefs about the Science Education.

1. Why should students study science? Please explain.

2. Considering **Science education in general,** what aspect of science learning, do you believe, is most important for **all** students to develop? Why?

Considering your beliefs about **science education in general**, please rank the following foundational statements, from the Alberta Science programs of study, in order of importance, from the most important objective, (rank 1) to the least important (rank 5).

All science programs should:

_____a. *develop positive attitudes toward science that support the responsible acquisition and application of scientific* an technological knowledge to the mutual benefit of self, society and environment.
_____b. *construct knowledge and understandings of concepts in life sciences, physical science and Earth and space science, and apply these understandings to interpret, integrate and extend their knowledge.*
_____c. *develop the skills required for scientific and technological inquiry, for solving problems, communicating ideas and making informed decisions.*
_____d. *develop an understanding of the nature of science and technology, the relationships between science and technology, and the social and environmental contexts of science and technology.*

Section III: Your own teaching context beliefs about the importance of the foundational objectives.

1. What is the one thing do you hope every student who leaves your science classes knows or thinks about science? Please explain why you think this is important.

2. Considering **your own teaching context and your own science classes,** what aspect of science learning do you believe is most important? Why?

Considering what you believe to be important **in the science classes you have taught / are teaching this year**, please rank the following foundational statements, from the

Alberta Science programs of study, in order of importance, from the most important objective, (rank 1) to the least important (rank 5).

<u>In my science classes</u>, I believe my primary role is to:

_____a. *develop positive attitudes toward science that support the responsible acquisition and application of scientific an technological knowledge to the mutual benefit of self, society and environment.*
_____b. *construct knowledge and understandings of concepts in life sciences, physical science and Earth and space science, and apply these understandings to interpret, integrate and extend their knowledge.*
_____c. *develop the skills required for scientific and technological inquiry, for solving problems, communicating ideas and making informed decisions.*
_____d. *develop an understanding of the nature of science and technology, the relationships between science and technology, and the social and environmental contexts of science and technology.*

Section IV: Emphasis you place on the foundational objectives in your own science classes.

1. Reflecting upon what you *do* in your own science classes, what aspect of science do believe you emphasize most in your teaching? Why?

2. What factors **most** influence what you choose to emphasize while teaching science? Why?

Considering what aspects **you consciously emphasize in your science classes**, please rank the following foundational science objectives in order of emphasis, from the most emphasized**,** (rank 1) to the least emphasized (rank 8).

In my science classes, I plan instruction with the goal of:

_____a. *develop positive attitudes toward science that support the responsible acquisition and application of scientific an technological knowledge to the mutual benefit of self, society and environment.*
_____b. *construct knowledge and understandings of concepts in life sciences, physical science and Earth and space science, and apply these understandings to interpret, integrate and extend their knowledge.*
_____c. *develop the skills required for scientific and technological inquiry, for solving problems, communicating ideas and making informed decisions.*
_____d. *develop an understanding of the nature of science and technology, the relationships between science and technology, and the social and environmental contexts of science and technology.*

Section V: Additional Comments

1. What would like to add regarding your beliefs about what is most important in teaching science or about the foundational objectives in science education?

If you are willing to participate in a one on one interview, please e-mail your contact information and a brief description of your teaching assignment for 2009/2010 to the address below. If you are selected for an interview you will be contacted.

tstock@ualberta.ca

Thank you for participating in this survey. Your commitment to science education is appreciated!

Appendix C

Science Teachers' Beliefs – Interview questions

1. Do you give your full and informed consent to participate in this interview and to have the information you provide included in this study? Do you have any questions before we begin?

2. Please briefly describe your teaching assignment for this year.

3. What do you think is the most important purpose of science education? Why?

4. What most influences what you believe is most important?

5. How does this compare with what is written in the program of studies?

6. How does this compare with what you *do* in your science classes?

7. What most influences what perspectives you emphasize in your science classes?

8. Can you identify any barriers that prevent you from teaching science the way you believe it ought to be taught?

9. Do you perceive the goals of science differently in different contexts? Please explain.

10. What would you say to a new teacher if you were asked to give them some guidance as to what the purpose of science education is? What would you tell them they should be emphasizing in your classroom?

Appendix D

Summary of Participant Demographics and Sample Sub-Groupings

Sex:

- Male – 17 (56.7%)
- Female – 13 (43.3%

Years of Teaching Experience:

- 0-10 years – 15
- 10+ years – 15

Years Teaching Science:

- 0-10 years – 15
- 10+ years – 15

Academic Degrees Held:

- B.Ed – 28
- B.Sc. – 20
- Graduate degree – 8

Major area of specialization in B.Ed. program

- Biological Sciences – 19
- Physical Sciences – 7
- General Sciences – 2
- Mathematics – 2

School Grade Setting:

- Junior High School – 9
- Senior High School – 15
- Junior-Senior High School – 6

Semesters / Full Year Programming:

- Semesters – 13
- Full Year – 10
- Mixed – 7

Grades Taught During 2009/2010 School Year:

- 6 - 1
- 7 - 11
- 8 - 13
- 9 - 11
- 10 - 17
- 11 - 18
- 12 – 18

Science Courses Taught During the 2009/2010 School Year:

- General Science (Sci 7,8,9,10,20,30) – 26
- Non-Academic Science (Sci 14, 24, K&E) – 7
- Honors Science (IB, AP, honors) – 8
- Biology 20,30 –8
- Chemistry 20,30 – 8
- Physics 20,30 – 7
- Science Options – 4

Number of Different Science Courses Taught During the 2009/2010 School Year:

- 1 - 2
- 2 - 6
- 3 - 8
- 4 - 4
- 5 - 2
- 6 - 4
- 7 – 4

Average Class Size:

- 0-15 - 3
- 16-25 - 8
- 26-35 - 19
- 36+ - 0

School Size:

- 0-300 - 4
- 301-600 - 6
- 601-900 - 9
- 900+ - 12