University of Alberta

Exploring Science Curriculum Emphases in Relation to the Alberta Physics Program-of-Study

by

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To family, friends, and mentors

whose patience, support, and encouragement

made this project possible

ABSTRACT

Using Roberts' seven science curriculum emphases as a framework, an investigation into Alberta's physics program-of-study revealed pre-service, novice, and experienced teachers tended to focus on the emphasis Structure of Science. Other aspects of the program-of-study that was a high priority for teachers were the ideas of the *holistic* views of physics and *student engagement* which both fell beyond Roberts' framework. Comparing the focus of the teacher participants to the curriculum leader, interpreted by the researcher to be a representative of the Curriculum Branch of Alberta Education, it was noted that the areas of weak overlap between the teacher participants and the curriculum leader were the ideas of Structure of Science and *student engagement*. However, the curriculum leader tended to focus more on Self as Explainer and Science, Technology, and Decision.

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Introduction

The focus of this research is related to Douglas Roberts' seven science curriculum emphases: Everyday Coping, Structure of Science, Science, Technology, and Decision (STS), Scientific Skill Development, Correct Explanation, Self as Explainer, and Solid Foundation (Roberts, 1982, 1988, 1995, 1998, 2003). These science curriculum emphases each represent a specific aspect of the science program-of-study that describes the goals and objectives of science education. These will be discussed in more detail in the Seven 'Curriculum Emphases' section of the Literature Review section on page 30. When science teachers read the Alberta programs-of-study for physics each of them notices and prioritizes different aspects of the programs depending on their personal beliefs, interests, and experiences. Thus, teachers' choices to focus on particular emphases are personal choices reflecting, sometimes tacitly, what they consider are the most important aspects of the physics program-of-study. For example, teachers who focus on Everyday Coping might try to make links between the content within the program and daily activities and objects such as the use of a toaster and its daily power consumption.

Teachers' personal reflections of the program-of-study will have direct impact on students' experiences of secondary physics. It is not likely that any two teachers will prioritize the same aspects of the program-of-study to the same extent. Rather, it is more likely that each teacher will hold a different perspective of the program-of-study. Each perspective brings a different quality to the classroom, therefore providing students with potentially different views of the same course. Teachers could prioritize more than one of the seven science curriculum emphases at any given time. It is important to note there are no '*correct*' or '*right*' emphases. Each emphasis is valuable, and an overt aspect of the program-of-study. Teachers may hold substantially different, yet valid, perspectives of the program-of-study.

Since teachers perspectives are based on their personal experiences, beliefs, and contexts, the objective of this thesis is not to understand in great detail what each teacher focuses on. Rather, this thesis seeks to identify general trends in relation to teacher perspectives of the program-of-study that are evident within groups of teachers categorized according to their physics teaching experience as represented by their years of physics teaching and their level of recognition from Alberta Education, the Education Branch of the Alberta government. For the purposes of this thesis, experienced teachers are considered those with, (a) more than ten years of physics teaching experience and, (b) recognition as outstanding teachers from the Assessment Branch of Alberta Education by being identified as head markers. Novice teachers are considered those with less than ten years of teaching physics experience. Pre-service teachers were those who were in their last year of teacher education courses at the university. These numbers of years teaching physics, used to differentiate between novice and experience teachers, is chosen to provide a means of distinguishing between teachers.

A Personal Perspective: First Encounters with Programs-of-Studies

When I first started to teach, I was given a copy of the Alberta physics program-of-study. I spent my summer planning with the program-of-study and the Physics textbook I was expected to use. I looked at each of the knowledge outcomes and basically planned one lesson per outcome with an occasional laboratory activity for the students. I had the pleasure of meeting the other physics teacher I was going to work with in September at the start of the school year. When he saw my lesson plans, he bluntly told me that my planning strategy was wrong. While I had planned one lesson for each of the outcomes, he informed me some of those knowledge outcomes required more time while others could be grouped together and taught in one lesson. He also gave me several laboratory ideas that I could use with my students. After he helped me develop a new unit plan, it worked out that I had almost one laboratory activity each week. I was extremely worried as I worked through the new unit plan because I wanted to devote more time to seat work where students would solve word and number problems. In my mind, the final goal for these students was to pass the Provincial Physics Diploma Exam at the end of the year. I considered that laboratory skills were a waste of time because those skills were not going to be assessed on a paper-and-pencil final exam. When I read the physics program-of-study, laboratory skills were not a predominant aspect of the program. However, when I asked my mentor physics teacher about the abundant lab skills that my students were performing, he simply referred to the program-of-study and told me the skills and ideas the students were encountering in the laboratories not only attended to the knowledge outcomes, but also the skills outcomes. I thought the skills outcomes were suggested activities for teachers rather than mandated outcomes.

The differences between what I read from the physics program-of-study and what my mentor teacher read worried me because I was afraid I was reading the program-of-study incorrectly. I was concerned that I was not teaching the students what was mandated by the government and thus preparing them inadequately for their Provincial Physics Diploma Exam. If both my mentor teacher and I went through similar teacher education programs, then the difference in our comprehension of the program-of-study was possibly related to our teaching experiences, which included our experiences in a classroom and interactions with students and peers. This is why the different perspectives teachers have of the program-of-study is of such interest to me. I would like to understand further the perspectives of pre-service, novice, and experienced teachers and how our intentions, as teachers, might differ from the intentions of the curriculum branch which writes and publishes the program-of-study. I see this as important because teachers' emphases should, as much as possible, reflect intentions and orientations of the curriculum developers. Teachers' perspectives of the program-of-study should match those intended by the Curriculum Branch of the government. If this were not to happen, then we might begin to ask questions about how to implement curriculum in the manner that reflects the views of its creators.

Research Questions

When teachers pick up a program-of-study, each of them will interpret it differently because each teacher will read their own experiences, such as their personal and teaching experiences, into their interpretation. Researchers have speculated that the aspects of the program-of-study that teachers consider most important are also dependent on their surroundings and the social trends that influence their thinking (Roberts, 1982, 1988, 1995, 1998, 2003). The research questions that emerge from the teachers' different perspectives of the program-of-study are:

1) Is there a difference between experienced, novice, and pre-service teachers, with respect to their self-reported prioritizing of certain elements of the Alberta physics program-of-study?
2) Do the reported priorities of those physics teachers match those expressed by the Curriculum Branch, i.e., those who write and publish the physics program-of-study?

These questions are investigated using the framework of Roberts' (1982, 1988, 1995, 1998, 2003) seven science curriculum emphases to analyze and discuss the different elements of the program-of-study that teachers and a curriculum leader might prioritize.

Participants

The participants in this investigation were assigned to one of four groups: (a) pre-service teachers, who were in their final year of their Bachelor of

Education program, (b) novice teachers, who were considered those with less than ten years of physics teaching experience, (c) experienced teachers, who were those with ten of more years of physics teaching experience and who were also head markers for the provincial diploma examination in physics, and (d) curriculum leader, who works in the Curriculum Branch of Alberta Education and views will be interpreted as representative of the Alberta government. Further, the experienced physics teachers were also distinguished as outstanding teachers, the criteria for this designation will be discussed later, by the Assessment Branch of Alberta Education and were assigned the role of head marker for the diploma examinations.

Importance of Research

When students enter teacher education programs they are there to learn how to teach, and also to learn the reasoning behind their teaching. One of the first courses I took during my teacher education program taught me how to take the program-of-study and plan a class period of activities for my future students. Teacher education programs focus on reasons behind why and how we teach. An understanding of the teaching methods we choose to execute within our classroom and why we choose those particular actions allows us to gain a deeper insight of the program-of-study and explain how we animate that program into a curriculum-as-lived (Aoki, 1986/2005). When teachers read the program-of-study, the legally binding guide they are expected to teach, and begin to plan their lessons and activities they interpret the program differently. This differentiation is due to each teacher's personal experiences and preferences. For example, a teacher may focus on hands-on learning experiences because they had many positive practical laboratories in their senior high science classes or at university. Other teachers may concentrate more on daily applications because they believe examples from industries are important for students' futures and will benefit students when they join the workforce.

To date, there have been no studies conducted in Alberta and few studies conducted elsewhere that explore what teachers consider are their emphases when they implement the curriculum. This study therefore, makes a contribution to the science education literature in that it seeks to explore what teachers focus on when they teach physics. Such information is important for the purposes of evaluating the fidelity of curriculum implementation. If notable discrepancies were found between what teachers consider they emphasize and what curriculum developers intend for them to emphasize when they interpret the programs-of-studies then we might have grounds for concern. And so, this study seeks to try to understand what teachers emphasize according and to relate their emphases to those suggested by the curriculum developers.

Comparison with Previous Research

Although Roberts (1982, 1988, 1995, 1998, 2003) has written many articles regarding what he identified as seven science curriculum emphases, no research to this researcher's knowledge has been done to explore teacher's perspectives of the philosophy and rationale behind the Alberta physics program-of-study. This research is therefore unique because it tries to understand teachers' prioritizing of elements within the program-of-study, which has not been done before, using Roberts' seven science curriculum emphases as an analytic framework. It also focuses on the perspectives that senior high physics teachers report regarding the physics programs-of-studies. The investigation tries to ascertain any relationship/s between physics teaching experience and the emphases teachers may prioritize. Thus, the problem for this thesis is narrowed to explore what science curriculum emphases high school pre-service, novice, and experienced physics teachers tend to prioritize.

This problem is interwoven between disciplines within education, in particular curriculum studies and science education, and is unique in the science education literature because it intersects ideas behind interpretation of documents such as the Alberta program-of-study, the ideologies of physics education, and the differences or similarities between novice and experienced teachers. Not only does this study link the aforementioned three different areas of science education research, it also attends to teachers' perspectives of science programs-of-studies in Alberta which has not been done before in this way. This study utilizes a framework that has close parallels with the Alberta physics program-of-study. This research aims therefore to enhance the existing body of knowledge in the field of science education.

Relating Research to Audience

To allow for effective implementation of a new physics curriculum it is important to understand which aspects of the program-of-study teachers prioritize. This may help ensure consistency in the implementation of the physics programs across Alberta as intended by the curriculum developers. Novice teachers may benefit from this investigation because it provides them with more perspectives on what might be emphasized and allows them to understand what more experienced teachers report focusing on in their teaching. The same can be said of the potential benefits for pre-service teachers.

Policy makers might benefit from this research by being able to understand how teachers are interpreting the program-of-study they are charged with implementing. For example, if curriculum leaders would like teachers to prioritize *student engagement* through the guide they produce, it would be beneficial for them to look into whether teachers are actually receiving that message and reflecting it to the students. Policy makers build explicit and implicit messages into the programs-of-studies that they want Alberta students to receive. However, the vital links between policy makers and students are teachers. Thus, it is important for policy makers to send a clear and concise message to teachers so that they may be able to understand the program and be able to implement it as intended.

Further, administrators may be able to better support their teachers by understanding what the teacher tends to, as evidenced by their self reports, emphasize in their classroom. For example, if an administrator recognizes that a teacher tends to prioritize 'Science, Technology, and Decision (STS)' they may support the teacher by purchasing electronic laboratory probes for school physics labs. Many administrators are not familiar with Physics 20 and 30, thus if they understand what type of support is required by teachers it may help them understand how they can better support teachers.

In summary, through this investigation of teachers' interpretation of the Alberta physics program-of-study teachers, policy makers, and administrators might be able to better understand the reasoning behind physics teachers' views and pedagogies. To help promote a deeper understanding of the program-of-study for students, teachers may present the material using various techniques or reflecting various perspectives. This thesis employs Roberts' seven science curriculum emphases as a framework to analyze how teachers rank aspects of the program-of-study. The next section reviews the literature relevant to this study that seeks answers to the questions:

1) Is there a difference between experienced, novice, and pre-service teachers, with respect to their self-reported prioritizing of certain elements of the Alberta physics program-of-study?
2) Do the reported priorities of those physics teachers match those expressed by the Curriculum Branch, i.e. those who write and publish the physics program-of-study?

Literature Review

Introduction

This study investigates aspects of physics teachers' views of the Alberta physics program-of-study. This section starts with a comparison between *program-of-study*, the guide teachers are expected to implement, and *curriculum*, the implementation of the guide. Work done on developing physics curricula throughout North America provides insights into the developments and changes that have occurred in Alberta's physics programs-of-studies. When looking at the history of Alberta's physics program major changes are noticed. The revisions of Alberta's physics programs-of-studies reflect two major changes: the first is a decrease in the volume and depth of content knowledge, and the second is an increase in attention to developing critical thinking skills in students. These trends are most visible in the 2007 physics program-of-study within which the circuit unit was removed and an extensive list of skills outcomes was added, with a particular focus on *hands-on, minds-on* laboratories.

The physics programs-of-studies are investigated using the seven emphases developed by Roberts (1982, 1988, 1995, 1998, 2003) as a framework. Roberts' seven science emphases are, Everyday Coping, Structure of Science, Science, Technology, and Decisions, Scientific Skill Development, Correct Explanation, Self as Explainer, and Solid Foundation. These are described in depth in the section Seven 'Curriculum Emphases' later in this chapter on page 30. Further, utilizing Aoki's (1986/2005) idea of *tensionality*, which analyzes how teachers simultaneously work with two or more emphases, this thesis explores teachers' dwelling within and between these seven emphases. It is proposed that the uniqueness of each teacher is reflected in both the emphases they choose to prioritize and the depth of their focus. This section concludes with an examination of how different teaching and personal experiences may change the prioritizing of the emphases that teachers report. A review of curriculum literature specifically analyzing physics programs-of-studies suggests a need to investigate whether there is a difference between experienced and novice teachers, with respect to their prioritizing of certain elements of the Alberta physics program-of-study and the corresponding curriculum emphases they consider to be important. This investigation leads into a secondary inquiry into whether the reported priorities of the physics teachers match those intended by the program-of-study's developers is also explored for its relevance to this thesis.

What is meant by 'Curriculum' and by 'Program-of-Study'?

Roberts (2003) suggests that there are three ways to think about curriculum if one is to understand the central role that curriculum has in the work of educators: (a) *curriculum as thing*, (b) *curriculum as communication system*, and (c) *curriculum as system influence*. *Curriculum as thing* refers to the program-of-study, or the guidelines written within the document. This thesis adopts this meaning for curriculum. *Curriculum as communication system* views the program-of-study as a document that communicates curriculum policy to teachers' "rather than statements of overall goal orientation and vision, which are more abstract and further removed from the classroom" (Roberts, 2003, p. 2). In Alberta, provincial examinations also send a strong message to teachers and students regarding what the government believes is important. *Curriculum as system of influence* describes the flow of information from the government agencies and curriculum writers to teachers in the classroom. This ultimately filters down to the students who will manifest the curriculum in the classroom.

The information flows in the opposite direction as well, as teachers have their own perspectives of what is plausible in their classrooms, especially given the variety of students and teaching conditions. The teachers, and indirectly the students, provide curriculum writers with feedback regarding the development and implementation of a science-for-all curriculum because they are the end users of the curriculum (Kapuscinski, 1982; Orpwood, 1985; Roberts, 1988; Aikenhead, 1994, 2002). Education is a powerful tool in shaping societies and generations. Therefore, what and how specific topics are taught in a classroom may have rippling effects that last over an extended period of time and affect multiple areas of society. Whether students are given a fulfilling physics education experience or not is partially dependent on whether a teacher is able to bring the program-of-study to life and how it is brought to life. The valuable input of teachers is honored by allowing some teachers to be part of the curriculum writing and field testing process. This is evidence of the two way communication between the curriculum writers and teachers in the field. This thesis investigates to some extent whether teachers' experiences influence their prioritization of Roberts' seven science curriculum emphases. North America physics curricula are analyzed broadly in the next section to try to highlight some of the trends in curriculum emphases over different time periods.

Physics Programs-of-Studies

Physics is distinguished from the other sciences by its high levels of abstraction and idealization (Duit, Niedderer, & Schecker, 2007). It is generally accepted that physics is the medium for people to understand technology, transport, and energy production. Hence, to "make sensible use of technological means, to find a place in a technology-based economy, and to participate in political processes about technology-related decisions, citizens need a certain amount of physics knowledge" (Duit, Niedderer, & Schecker, p. 604). It follows that, to increase the awareness and competency of all citizens, a certain amount of physics education is required.

Globally, physics education aims to educate all citizens to make them physics competent. The European perspectives of physics education aim to fulfill three major goals: further general education, scientific thinking, and provide a foundation for learning at the post-secondary level (Fischer, Klemm, Leutner, Sumfleth, Tiemann, & Wirth, 2005). This perspective of physics puts the focus on using scientific knowledge in the formation of students' thought processes. The North American view of physics education aims to use the pragmatic and optimistic view of science for social progress (Duit, Niedderer, & Schecker, 2007). Both the European and American views of physics education seek to have their citizens integrate their scientific thinking into their world views. The following section looks at selected noteworthy physics programs-of-studies that have been used in North America over the past 100 years and how they changed over that time.

History of North America Physics Programs-of-Studies

From about 1910 to 1950 the emphasis labeled by Roberts as Everyday Coping, (described on page 30) was the fashion in physics curriculum in North America. A curriculum that related scientific concepts to the understanding of objects and events in students' everyday lives was the norm. When the Soviet Union launched Sputnik 1 in 1957 (Sputnik, n.d.), it sparked policy makers in the United States of America, where motivated, to make their science programs more internationally comparable and competitive. This was a time a great change for science education. The change to the physics curriculum was greeted with enthusiasm by some educators as a method to increase the physics interest among science students.

Two universities, Massachusetts Institute of Technology (MIT) and Harvard, answered the challenge from government to create a new high school physics course. The Physical Science Study Committee (PSSC) at MIT focused their curriculum emphasis on what Roberts would describe as Structure of Science (see page 30). This idea of scientific problem solving was compatible with the emphasis and approach taken by many schools in the 1950-1960s. Around the same time, the Harvard team was developing the Harvard Project Physics course. Their intent and overall orientation were notably different than those of the PSSC course. Harvard's course presented science essentially as akin to the humanities, focusing on the historical and philosophical perspectives of physics (Aikenhead, 2007), and directed more toward the curriculum emphasis that Roberts would describe as Self as Explainer (see page 30). This example of the two physics courses, PSSC and Harvard Project Physics, illustrates how cultural context and social influences can shift the curriculum emphasis that is predominant at a particular time. An emphasis that is highlighted in 1999 or in 2019 could be different from those considered important today (Anderson, 2007). The aim of the PSSC and Harvard Project Physics courses was to increase student enrollment in high school physics (Aikenhead, 2007). Through these courses students were to be socialized regarding the meaning of science as both a way to solve problems and a method of viewing the world.

What a teacher emphasizes and the depth to which they are willing to align their teaching practice to their emphases is dependent on their personal values (Roberts, 1988). For example, two teachers may prioritize Scientific Skill Development (see page 30) as being important. However, one teacher may choose to teach through hands-on laboratories for students, while the other may choose to talk about laboratory procedures: therefore evincing two different teaching approaches.

In the early twentieth century there was a focus on applying general methods of scientific inquiry to problems of social concern. In the 1950s and 1960s the focus "shifted away from practical and applied problem solving to rigorous intellectual treatment of the individual scientific disciplines" (DeBoer, 2007, p. 561). DeBoer (p. 561) adds that,

> … this was in part for purposes of personal intellectual development but mainly so that personnel needs could be met in technical and scientific fields and so that lay people would have sufficient understanding of science to offer their support for scientific research.

Although the physics programs-of-studies in North America have undergone several changes throughout history, physics continues to be "the domain that is greeted with the lowest interest by students among the sciences" (Duit, Niedderer, & Schecker, 2007, p. 599) despite the abundant amount of research done in physics teaching and learning. Of all the research done in science education, 64% of the studies have been carried out in the domain of physics (Duit, et. al). The attempts of the United States' education system to increase interest of students in physics did not provide enough stimuli to make much difference to students (Duit, et. al). However, the change provided several opportunities for educational researchers to investigate physics teaching and learning.

The next section narrows the focus of physics programs-of-studies to those in Alberta. The focus of the physics programs that appeared in North America influenced each other. In fact, in the 1972 Alberta physics program-of-study the PSSC physics course was offered to students in Alberta through a course named

‘Physics Alternative II Program’ (Department of Education, 1972). Hence, the programs of Alberta have had similar aims to those of PSSC and Harvard Project Physics courses of creating a society that could solve problems critically and scientifically with deep roots in history and philosophy.

Physics Program-of-Study in Alberta

The physics programs-of-studies and textbooks circulating around North America influenced the development of Alberta’s physics program from its first version to today’s. As Alberta’s physics program matured, changes were made to the program to reflect the distinctive needs of Alberta’s students and the changing society that they lived in. This section explores the major changes in Alberta’s physics programs-of-studies from its inception in 1889 (Hughes, 1964) until today.

History of Alberta Physics Programs-of-Studies

Science programs-of-studies carry both explicit and implicit messages about science and pedagogy that guide the reasons, purpose, and context within which students are to attempt to understand a science subject. The trends and changes discussed in relation to the history of the physics programs-of-studies in Alberta is a summary examination of those trends and changes. A reference list of Alberta’s physics program-of-study is shown as Appendix A. A brief summary of the history and highlights of the Alberta physics programs-of-studies of the programs from the past century is shown as Table 1.

Table 1

Alberta Physics Program-of-Study Summary

Year	Name of Course	Topics	Practical Work/Laboratories
1889-1912	General Physical Sciences	– Included topics from both chemistry and physics – Program followed required (American) textbook – Specific page numbers were given for teachers to follow	– Practical work was assigned with reference to specific pages out of textbook
1912	Physics	– Introduction of physics as its own course – Program followed required (American) textbook – Specific page numbers were given for teachers to follow	– Practical work was assigned with reference to specific pages out of textbook
1944	Physics 1 & Physics 2	– Program followed required (American) textbook – Specific page numbers were given for teachers to follow – Teachers were provided with a recommended timeline for each unit	– Practical work was listed in the program-of-study with reference to specific pages out of textbook
1961	Science 20 & Physics 30	– Program followed required (American) textbook – Specific chapters were given for teachers to follow	– Practical work was listed in the program-of-study with reference to specific pages out of textbook
1967	Physics 10, Physics 20, Physics 30, & Physics 30X (PSSC)	– Program followed required (American) textbook – Specific chapters were given for teachers to follow – PSSC is introduced as part of Alberta's physics program	– Specific experiments were listed in the program-of-study with reference to specific pages out of textbook – Each unit had specified experiments to be performed
1972	Physics 10, Physics 10 (PSSC), Physics 20, Physics 20 (PSSC), Physics 30, & Physics 30X (PSSC)	– Program followed required (American) textbook – Specific chapters were given for teachers to follow – PSSC is offered as 'Alternative II Program' to all levels of physics courses	– Specific experiments were listed in the program-of-study with reference to specific pages out of textbook – Each unit had specified experiments to be performed
1978	Physics 10, Physics 20, Physics 30, Physics 22, & Physics23	– Each course was given a list of objectives – Content was split into 'Core Topics' and 'Elective Topics' – Introduction of elective topics – No more references to specific chapters and pages out of prescribed textbook – Introduction of physics (22/32) designed for Vocational High Schools – Significant decrease in core content	– No mention of practical work in the program-of-study
1993	Physics 20-30	– Removal of elective topics – Existing topics are re-ordered into eight units – Introduction of general and specific outcomes	– Laboratory skills were recommended
2007	Physics 20-30	– Minor changes to order of topics	– Specific laboratory skills are prescribed

Prior to 1905, Alberta was part of the Northwest Territories (Government of Alberta, 2002). Even before the province of Alberta was officially named in 1905, there had been science programs-of-studies in one form or another. From approximately 1889-1912, the programs-of-studies for physics were combined with chemistry into a course called General Physical Sciences (Hughes, 1964). Biology was the last of the science disciplines to develop its independence in Alberta (F. Jenkins, personal communication, Nov. 29, 2007). It was not until 1912 when a course named Elementary Science was introduced that biology started to appear in secondary education. In 1912, physics was separated from chemistry and represented through its own program-of-study. The appearance of biology as a subject helped promote physics and chemistry as independent courses in science.

The physics program-of-study did not significantly change until 1978 when about half of the core topics, such as *cloud chambers* and *thermodynamics*, were dropped from the program and elective topics, such as *special relativity* and *optics*, were introduced. The next year of significant change was 1993, when the physics program-of-study was no longer a few pages out of the ‘Program of Studies for Senior High Schools’, but was instead a separate document entitled ‘Physics 20-30 Program of Study’ which laid out the course in more detail and gave a more in-depth rationale and philosophy regarding the course. Since 1993, physics programs-of-studies have remained relatively unchanged with minor developments, additions, and changes to the document. The next section looks at the general trends that appeared as the programs-of-studies underwent changes. Further, the next section will explain how the changes in Alberta’s physics program-of-study can be considered as a decrease in content and as representing as increase in attention to inquiry laboratories.

Trends in Alberta Physics Programs-of-Studies

A review of the history of Alberta's physics programs-of-studies reveals a general trend moving the field of physics education toward what Hodson (1988) calls "a philosophically more valid science curriculum" (p. 19). The philosophy of science is an examination of assumptions, foundations, and implications of science (Newall, 2004). Prior to 1993 the focus of Alberta's physics programs was on knowledge content and manipulative lab skills. Since then, the major shift has been to focus increasingly on critical thinking and science, technology, and society (STS) perspectives. This shift is an attempt to have physics classrooms better reflect the scientific field of physics.

Education is susceptible to trends much like the clothing industry. Trends in education are a matter of emphasizing specific methods that represents a particular "fashion at different periods in history" (Roberts, 1988, p. 38). Prior to the 1978 physics program, the programs-of-studies in Alberta would outline specific labs to be performed with references from the specified textbook. In the post-1993 programs-of-studies, an attempt was made to integrate scientific methods, technologies, and knowledge as linked to students' daily lives. The rationale was to develop scientific literacy and understand personal applications. The focus of practical lab experiences in the 2007 program-of-study lists several *skills* that students are to develop. This 2007 program allows teachers more freedom to choose appropriate laboratories for their students than the pre-1978 programs. The emphasis has shifted away from content-laden and Correct Explanation programs-of-studies to attend more Skills Development and Structure of Science (see page 30). This trend has allowed the program to focus on a more skills based and nature of science oriented science curriculum.

The Alberta physics programs-of-studies underwent several changes over the years. These changes contributed to two major differences. The first is a decrease in content required to be covered and the second was an increase in attempts to develop critical, inductive (Allchin, 2003), and hypothetico-deductive thinking (Lawson, 2002; 2005) through laboratory applications. The next sections are devoted to taking a closer look at these changes.

Decreasing content. The major change in 1912 was the establishment of physics as its own subject area with its own program-of-study. Many of the original topics and laboratory ideas from the first noted program-of-study in 1889 are still used today with minor changes. For example, the unit *Work-Power-Energy* is a topic that has appeared in all the physics programs-of-studies since 1889. As more discoveries in physics were made, such as those reflected in Atomic Theory and the ideas of quarks and fermions, simplified versions of these concepts were added to the programs-of-studies. These additions increased the volume of knowledge to be learnt by students. It also increased the burden on teachers and students as more content had to be attended to in the same amount of time. This increase in content was finally eased in 1978 when a team of curriculum writers lead by Les Tolman made drastic changes to the program. That year, many topics were removed and the remaining content was organized into broader categories (F. Jenkins, personal communication, Nov. 29, 2007). This was also the year that elective topics were introduced to the program-of-study, providing teachers with a choice of topics that hopefully interested both them and their students. This change helped personalize the programs-of-studies making them more ‘curriculum-as-lived’ (Aoki, 1986/2005) and increasingly emphasizing what Roberts would consider Everyday Coping (Roberts, 1982) (see page 30).

Teachers were to select topics that interested both them and their students. However, with the return of provincial examinations, the diploma, in 1984 the value of electives began to fade as teachers and other stakeholders focused more attention and time on the core topics that were tested on the standardized exam. It has been speculated that some teachers stopped teaching elective topics to make more time available to review core topics that would be on the provincial diploma exam.

The changes that teachers started to make in implementing the program-of-study in preparation for the diploma exam were reinforced by curriculum writers in 1993. The program-of-study published in 1993 had electives removed and had reorganized the remaining core topics into eight general units for Physics 20/30. The current physics program-of-study, published in 2007, is similar to the 1993 publication apart from the removal of the Circuits Unit that was believed to be repetitive from the grade eight and nine science courses. The reduction in content in the program-of-study is supposed to allow teachers more time to focus on the implicit, and sometimes explicit, aspects of the program-of-study teachers deem to be important. For example, developing students’ critical thinking may be important for particular teachers to varying extents. Some may explicitly teach a unit in critically thinking about science problems while others may implicitly incorporate critical thinking by having students solve scientific problems through lab activities.

These explicit and implicit aspects of the program are usually the rationale and philosophy of the curriculum. For example, there are four foundational pillars to the 2007 program-of-study: “attitudes, knowledge, science, technology, and society (STS), and skills” (Alberta, Learning, 2007, p. 4). These four pillars are to be focused on throughout the entire course. Importantly, these pillars were derived from the seven “Objectives of Secondary School Science” (Department of Education, 1972, p. 116) which mirror the seven curriculum emphases in science education as outlined by Roberts (1982) and that are described in the section Seven ‘Curriculum Emphases’ on page 30. The rationale and philosophy behind the physics program-of-study have essentially remained the same through the program changes. Hence, Roberts’ seven science curriculum emphases are still relevant today and useful for the purposes of this study.

In summary, Alberta’s physics programs-of-studies over the years evince a decrease in the number of topics to be covered. This decrease in the range of content is supposed to allow teachers and students more time to think critically about each unit, hence creating a deeper understanding of each topic. The next section focuses on the second major shift in Alberta’s physics program, the trend of increasing inquiry based laboratory applications, reflecting Roberts’ emphasis of Scientific Skills Development.

Increasing inquiry laboratories. A major shift in the programs-of-studies since its inception is the increase in the number and in the type of laboratory practices outlined. The laboratory experiences students are meant to encounter have been proposed to be more open-entry as well as more open-ended. Open-entry laboratory activities allow students to choose physics problems that interest them for their laboratory investigations. Open-ended laboratories also should enable students to use several methods to solve problems. This mimics the idea that there is no *one* scientific method, but several different methods reflecting inductive and deductive problem solving. These labs try to stimulate students to become critical thinkers when they problem solve.

The practical lab work mentioned in the curriculum prior to 1978 consisted mainly of 'cookbook' type labs where students were given step-by-step procedures to work through. These recommended labs were either listed in the 'Senior High School Curriculum Guide for Science' or the program-of-study, where teachers were given page references to the mandated textbooks. Those labs aimed to tie "together the… theory and the practical exercises" (Department of Education, 1944), with the term *practical* meaning a hands-on experience. Although students were exposed to laboratory instruments, these labs did not necessarily invoke students to think critically about their actions or their results from the labs.

The 1978 physics program-of-study did not list any required or recommended laboratories. Therefore, it was possible for students in physics classrooms between 1978 and 1993 to experience no practical laboratory activities. Not only were students not always exposed to laboratories that encouraged them to use critical thinking to scientifically solve problems, they were not always expected to be exposed to any type of practical experiences related to the theory they learned in the classroom.

The physics committee of the National Education Association's Commission on the Reorganization of Secondary Education (CRSE) defined the laboratory as a place for genuine inquiry rather than a place to verify laws (National Education Association, 1920). This definition of practical laboratory work was visible in the post-1993 programs-of-studies where the proposed lab activities aimed to promote critical thinking, meaning that students are expected to come up with their own investigations. Laboratories were no longer procedural, where students were expected to follow a list of mindless steps to achieve the *correct solution*. The laboratories described in the post-1993 programs-of-studies gave a list of skills to be performed by students, for example measuring distances. Post-1993 labs from the amended program-of-study were more open-ended, where students were asked to reflect on the procedure and expected to come up with their own analysis, discussion, and conclusions. This was a departure from the previous step-by-step guided inquiry types of labs towards more constructivist approaches to learning through open-entry lab practices.

However, this was not the end of the movement toward an emphasis on scientific inquiry within the Alberta physics programs-of-studies, an ideology that recommends that students question scientific findings and develop their own ideas to solve problems. The newly revised 2007 program-of-study requires students to “research, integrate, and synthesize information… [to] adapt or extend procedures” (Alberta Education, 2007, p. 8). Students are now expected to research and design their own lab procedures as well as “stat[ing] a conclusion, based on data obtained from investigation” (Alberta Education, 2007, p. 8). These open-entry labs provide hands-on investigations and minds-on reflections “enabl[ing] students to interact *intellectually* as well as *physically*” (Hofstein & Lunetta, 2003, p. 49, sic) and allowing freedom to design labs that have personal touches and relevance.

These types of labs might be considered to be similar to those in graduate programs, as graduate students are expected to come up with their own problem, review the literature, collect data, and state their findings. With lab experiences like these, students might be more prepared for post-secondary and graduate work in the field of science. Open entry labs generate critical thinking among students which is vital for creating scientifically literate citizens. These people should be able to use their scientific skills to problem solve with reason and to understand scientific advances presented in the media. The programs-of-studies have moved from 'recipe' labs to open-ended labs to the current implementation of open-entry labs. Although it has taken several years to bring about these changes, physics education is moving toward Roberts' emphasis of Scientific Skills Development (see page 30).

An examination of Alberta's physics programs-of-studies since 1889 have revealed two major changes in orientation, or change in emphases, of decreasing content knowledge and increasing inquiry laboratories. The next section outlines how these changes propose to have high school physics represent the newest discoveries in the scientific world of theoretical and experimental physics.

Challenges to meeting the intentions of Alberta's physics programs-of-studies. The Alberta physics programs-of-studies are constantly being revised to represent current theories and experimental data. For example, the 2007 physics program-of-study includes a section on the subatomic particles known as fermions and quarks which has never been part of previous programs, yet it has been a topic of research in the scientific world for almost two decades. Teachers are expected to teach "the ongoing development of models of the structure of matter” (Alberta Education, 2007, p. 70) which includes an analysis of particle tracks, high-energy particle accelerators, protons and neutrons as being composed of quarks, electron neutrinos, antiparticles, and fermions among other topics. Smolin (2006) suggests most of the advances in science are done by people who allow their curiosity to guide their questions about the nature of existence. These people do not allow physics principles and theories to confine their thoughts, instead they dream of the many questions that need to be investigated in the world of physics.

Students that ask questions and are bold enough to try are the leaders that will propel the field of physics forward (Smolin, 2006). However, Smolin ridicules our current education system as a place to train followers that are good at following instruction and excel at solving technical mathematical problems. Part of Smolin’s ridicule is that the current education system deems these followers as successful because they are able to read the textbook and answer the subsequent questions. According to Smolin, our education system is plaguing both the world of science education and the field of theoretical physics. He ends his argument by stating that the scientific fields of research require both leaders, who are able to dream up questions to investigate, and followers, who will carry out the research.

Smolin also suggests that the problem today is that our current system produces more followers because they are rewarded, while leaders who dream and question the world are suppressed as they do not fit the norm. Smolin has observed an abundance of students who are good at rearranging and plugging numbers into a mathematical formula, but who lack the capability of relating different ideas to one another and creating their own solution. Despite the encouragement some teachers get students to inquire about the natural world, students often misconceive inquiry labs including those mentioned in our program-of-study as single answer grade acquisition exercises rather than an opportunity to learn and explore. This idea is constantly fueled as students go through K-12 school because teachers give marks to students who are able to follow instruction and attain the *correct* answer. Students who answer the questions correctly on a test are rewarded while others are penalized with poor marks.

This idea of *one correct* truth is further reinforced by textbooks that provide one closed answer for every question. Often, even written responses have only one solution in the back of the textbook. Some teachers subject students to this type of education all through elementary and secondary school. Despite many teachers' best intentions to inspire future innovative minds, education systems often constrict such people with limited time and resources. There is a large gap between the structure of science education between secondary school and graduate school.

The four pillars that make up the rationale and philosophy of the current Alberta physics program-of-study stress understanding of nature and structure of science which will, it is proposed, help Smolin's future *leaders* be recognized and rewarded with marks that reflect their abilities to understand and apply their knowledge. It should encourage the nourishing of leaders rather than followers. The 2007 physics program-of-study has attempted to address the issue of how to make the education system relevant and by presenting real world physics and mandating more instruction that promotes critical thinking. For example, physics teachers are no longer encouraged to the same extent as previously to provide students with a procedure for laboratory activities. Instead they are expected to guide students to discover their own laboratory procedure/s that will answer the questions they have decided to investigate. This idea is encouraged through the skills outcomes of the program-of-study as well as the holistic written response of the diploma exam, where sometimes students are expected to design a laboratory to solve a particular problem. These types of open-entry and open-ended labs are more representative of the reasoning that scientists engage in.

Summary of Alberta's physics program-of-study. This section discussed the trends of decreasing content knowledge and increasing inquiry laboratories in Alberta's physics programs-of-studies. These trends are a movement towards replicating real world science (Hodson, 1998) where people are faced with problems and scientists are to design a procedure to solve the problems. The current 2007 physics program-of-study tries to address this form of scientific inquiry by giving student an opportunity to perform open-ended as well as open-entry laboratories in school settings.

The next section examines Roberts' seven science curriculum emphases, the framework used in this thesis to investigate which aspects of the program-of-study teachers propose are the most important. As previously noted these emphases are evident in the Alberta physics program-of-study. The programs-of-studies provide teachers with the freedom to decide which aspects of the program they believe are most important and how they choose to present the material in their classrooms. One aim of this thesis is to investigate which aspects of the Alberta physics program-of-study teachers rank as most important. Roberts' seven science curriculum emphases are used as the framework to analyze teachers' views.

Seven 'Curriculum Emphases'

Science curriculum emphases, as presented in Table 2, is a category system created by Roberts to explicitly describe the goals and objectives of science education. Although each of Roberts' seven science curriculum emphases is explicitly stated in the program-of-studies, teachers may choose to teach them to varying extents, both explicitly and implicitly. For example, the Structure of Science may not be explicitly discussed in class, but through problem solving or inquiry laboratory activities students may be exposed to that emphasis implicitly.

Roberts stated "it is important to recognize one curriculum emphasis is no more correct, true, or academically respectable than any other" (Roberts, 2003, p. 7). Each emphasis represents an area of educational learning that has a counterpart in human affairs and academic studies. Roberts was also very particular in stating that his "seven emphases do not necessarily constitute a set of mutually exclusive categories" (Roberts, 1982, p. 246), indicating the fuzzy boundaries and overlapping areas these emphases may have. An investigation of the of the history of the emphases reveals that these emphases were initially created to describe the different teaching approaches between two dominant physics programs in North America in the 1980's, aforementioned the Physical Sciences Study Committee (PSSC) and the Harvard Project Physics courses.

History of Emphases

In the early 1980s, Roberts inductively developed these seven science curriculum emphases by examining what had previously "been advocated in policy statements and woven into textbooks" (Roberts, 1982, p. 246) in science education practice. Roberts

Table 2

Seven Scientific Curriculum Emphases (Roberts, 1982, 1988, 1995, 1998, 2003)

Curriculum Emphasis	Explanation of Emphasis
Everyday Coping (Everyday Application)	Using science to understand both technology and everyday occurrences. For example, physics topics can be oriented to show how various common home devices, such a lamp or a television set, function and can be maintained.
Structure of Science	Understand how science functions as an intellectual enterprise in its growth and development. This emphasis stresses the importance of evidence and the role of 'scientific method' as analogy, hypothesis, experiment, characteristics of scientific concepts, and to a certain extent the historical evolution of scientific ideas. The ideas from the academic discipline, philosophy of science, is closely associated to this emphasis because it also investigates the relationship of evidence and theory, adequacy of a model to explain a phenomena, self-correcting features to promote growth of science, and matters relating to the way scientific knowledge are developed.
Science, Technology, and Decisions (STS; Science, Technology, and Society)	Brings out the interrelatedness of scientific explanation, technological planning, problem solving, and practical importance to society. For example, scientific knowledge and technical know-how should guide the decision on the route of an oil pipeline. Here socio-scientific decision making is seen as a process.
Scientific Skill Development	Developing sophisticated competence in conceptual and manipulative skills that are basic to all science, collectively labeled 'scientific process'; which are the keys to arriving at a reliable 'product', or idea in science. This emphasis concentrates on the *means* of 'science inquiry' including variations of inductive and deductive reasoning.
Correct Explanation	Concentrates on the ends of scientific inquiry versus the means. Here science is seen as reliable and valid knowledge from an authoritative group of experts developed to give students the best explanations available for natural events and objects.
Self as Explainer (Personal Explanation)	Understanding one's way of explaining events in terms of personal purpose, intellectual preoccupations, and cultural influences that form their context. Exposing the conceptual underpinnings that influence scientists when they were in the process of developing explanations; a personal animation of the history of science. A constructivist view of learning.
Solid Foundation	Science instruction should be organized to facilitate the students' understanding of future science instruction. Viewing science as an accumulation of knowledge telling students the purpose of learning this year's science is to get ready for next years, and then the following year, and so on through graduate school. Stresses science as cumulative knowledge.

developed this concept as part of a paper in honor of Dr. Fletcher Watson when he retired from Harvard in the late 1970s (Roberts, 1998). At this time Harvard was developing its Harvard Project Physics, a course that's overall intent and orientation was different from the existing Physical Sciences Study Committee (PSSC) course emanating from Massachusetts Institute of Technology (MIT). Roberts wanted to express these courses as two different purposes, or emphases, for learning science and not simply a Harvard-MIT rivalry. Hence, the historical analysis of practice led Roberts to conceptualize his seven emphases. He also investigated Gabel's (1976) eight categories of *scientific literacy* to gain support for his seven science emphases. The term *scientific literacy* is used in this document as an *umbrella* term to "represent… comprehensive, balanced and composite goal statements which cover all curriculum emphasis for science education" (Roberts, 1983, p. 19). In other words, when the term scientific literacy is used in this thesis it will encompass all science education goals.

Roberts' seven emphases are not "exhaustive in terms of what is theoretically *possible* in science education" (Roberts, 1982, p. 246), but they do seem to be exhaustive in terms of what has been *tried*. Two independent studies of science teaching objectives in American secondary schools (Ogden, 1975; Ogden & Jackson, 1978) confirmed Roberts' seven science curriculum emphases as a plausible framework for interpreting what is valued in science curricula. Of the two studies, the one that focused on biology (Ogden & Jackson) elicited seven major categories while the study that looked at chemistry (Ogden) discerned nine categories in the professional literature. Roberts', Gabel's, Ogden's, and Ogden & Jackson's emphases, dimensions, and categories as presented in Table 3 are similar and overlap in some respects. This comparison between these perspectives supports Roberts' seven science curriculum emphases as a credible framework for interpreting what is valued in science curriculum. This can be argued because Roberts, Gabel, Ogden, and Ogden & Jackson all converge on similar ideas as seen on Table 3.

The substance of Roberts' curriculum emphases in science education draws attention to the explicit and implicit messages of science education. Teachers should be aware simultaneously of "what *is* stated (about the subject matter) and what is *not* stated" (Roberts, 1982, p. 246, sic). It is important to reiterate that none of these seven curriculum emphases are more *true*, *correct*, or *right* than the others. In fact these emphases as mentioned previously are like "fashions in education (like everything else) come and go" (Hodson, 2001, p. 10). Their enactment depends on the current trends of a district, province, and/or country, which are influenced by the contemporary political, social, and economic milieu. Thus, the values of a society will directly influence the history of programs-of-studies and their implementations. An investigation of the historical trends of the Alberta physics programs-of-studies, as previously outlined, provides a backdrop to understand the content, rationale, and philosophy of the current physics program-of-study. The next section investigates the location of the emphases in Alberta's physics program-of-study.

Emphases within the 2007 Physics Program-of-Study

The Alberta physics program-of-study is structured around the rationale and philosophy of the course which is usually found in the early pages of the program. This rationale and philosophy consists of science topic components "and objectives which

Table 3

Comparison of emphases, dimensions, and categories of science education (Roberts, 1983; Gabel, 1976; Ogden, 1975; Ogden & Jackson, 1978)

Roberts: Seven science curriculum emphases for science (1982)	**Gabel:** Eight dimensions of scientific literacy (1976)	**Ogden:** Nine major categories of chemistry objectives (1975)	**Ogden & Jackson:** Seven major categories of biology objectives (1978)
• Correct Explanations	• Organization of Knowledge	• Specific Topics in Chemistry • Scientific Methods of Thinking (skill and willingness) • Scientific Habits or Attitudes	• Specific Topics in Biology • Scientific Methods of Thinking
• Solid Foundation		• Major Facts, Principles, or Fundamentals • Career Development	• Major Facts, Principles, Concepts or Fundamentals • Career Development
• Structure of Science	• Process of Inquiry	• Nature of Science and Scientists	
• Scientific Skill Development	• Intellectual Processes	• Processes, Skills and Techniques of Inquiry	• Processes, Skills and Techniques of Inquiry
• Self as Explainer	• Values and Ethics • Human Endeavour		• Interest and Hobby Development
• Everyday Coping	• Interaction of Science and Technology	• Applications of Chemistry to Daily Life	• Applications of Biology to Daily Life
• Science, Technology, and Decisions	• Interaction of Science and Society • Interaction of Science, Technology and Society	• Sociological Implications	

embody curriculum emphas[e]s" (Roberts, 1988, p. 33). These curriculum emphases are also embodied in the objectives or pillars of the program-of-study. For example, the first list of objectives made for science classes in Alberta appeared in the early 1970s. The objectives of secondary school sciences at that time are listed in Table 4 along with the corresponding curriculum emphases. These secondary school science objectives were matched up with the science curriculum emphases as interpreted by this researcher.

These seven objectives were revised into four pillars in 1993 as the physics program-of-study was amended. The 2007 program-of-study has essentially the same four pillars of program foundations as the 1993 program shown in Table 5. Roberts' seven science curriculum emphases are related to each of the four pillars in Table 5, as interpreted by this researcher therefore it is possible to say Roberts' seven science curriculum emphases still evident in the most recent program-of-study.

The essence of the program rationales and philosophies have remained relatively unchanged throughout the years of program and policy change, indicating the importance of these objectives since the early 1970s when they were first introduced. These "objectives do not specify science topics… [they can be viewed as] *contexts in which science topics are taught*" (Roberts, 1988, p. 32, sic). Science education is not solely about the science topics that are taught in the classroom. Science education also includes the way the subject is taught, the reasons and/or purposes for students to learn, and the curricular context within which they are to understand the subject (Roberts, 1988).

For example, the students could be learning Newton's laws of Universal Gravitation. That topic is only part of the curriculum. The other part of the curriculum, or the implicit objectives behind why it is to be learned, could be to prepare "students for

Table 4

Secondary School Science Objectives (Department of Education, 1972, p. 116)

Secondary School Science Objective	Roberts' Curriculum Emphasis
1. To promote an understanding of the role that science has had in the development of societies	Everyday Coping
2. To promote an awareness of the humanistic implications of science	Self as Explainer
3. To develop a critical understanding of those current social problems which have a significant scientific component in terms of their cause and/or their solution	Scientific Skill Development
4. To promote understanding of and development of skills in the methods used by scientists	Scientific Skill Development & Science, Technology, and Decisions
5. To promote assimilation of scientific knowledge	Solid Foundation & Correct Explanation
6. To develop attitudes, interests, values, appreciation, and adjustments similar to those exhibited by scientists at work	Structure of Science
7. To contribute to the development of vocational knowledge and skill	Correct Explanation, Scientific Skill Development, & Structure of Science

Table 5

Alberta Physics Program-of-Study Rationale and Philosophy (Alberta Education, 2007, p. 3)

Foundation	Structure of Component	Roberts' Curriculum Emphasis
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 the environment	Self as Explainer and Everyday Coping
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	Correct Explanation and Solid Foundation
Science, Technology, and Society (STS)	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	Science, Technology, and Decisions
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.	Scientific Skill Development and Structure of Science

the implicit objectives behind why it is to be learned, could be to prepare “students for further study, in subsequent physics courses” (Alberta Education, 2007, p. 29), “explaining… uniform circular motion in terms of Newton’s laws of motion” (Alberta Education, p. 29), and/or “explaining the functions, applications and societal impacts of geosynchronous satellites” (Alberta Education, p. 29, italics removed).

From the implicit/explicit objectives found in the physics program-of-study Roberts distilled seven ‘curriculum emphases’ in science education to send a coherent message to science educators *about* science rather than *within* science. Curriculum emphases are used in this thesis as the framework to understand which aspects of the program-of-studies teachers and a curriculum leader rank to be most important for them. Roberts suggested “such messages constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself – objectives which can provide answers to the student question ‘Why am I learning this?’” (Roberts, 1982, p. 245).

The next section investigates how teachers can place importance on more than one aspect of the program-of-study at ant given time. It is the indwelling (Aoki, 1986/2005) between different emphases that make each teacher unique and therefore it is worth investigating how teachers prioritize each of the emphases within their own teaching.

Prioritizing Emphases (Tensionality)

No two teachers prioritize the same curriculum emphases to the same degree. Teachers can prioritize more than one aspect of the program-of-study at once and vary the degree of importance on each emphasis. This is an example of an “understand[ing towards] the nuances of the indwelling of teachers in the Zone of Between” (Aoki, 1986/2005, p. 165). As teachers prioritize the emphases, they tend to place importance on more than one emphasis to varying extents. This varying degree of importance and the overlap of emphases brings different flavors to each classroom. These different flavors are what Aoki refers to as the *aliveness* (Aoki, 1986/2005) of the program-of-study as lived by teachers and students. Educators often find themselves dwelling between different curriculum emphases, or perspectives, reflecting a tensionality that accompanies dwelling within the seven science curriculum emphases. The word “tensionality” comes from the Greek root “tens-” which means “to move in a certain direction, to stretch, to hold out” (DeForest, 2005). In a teacher’s tug-of-war between the different emphases, he/she is in constant motion between emphases. Aoki understands that finding balance between different emphases and maintaining this balance is difficult and stressful for a teacher, but in order to bring the curriculum to life teachers need to be in such a state of *healthy* pressure and anxiety. Teachers understanding of the emphases may be tacit with teachers experiencing tensionality without realizing it. It is suggested by Aoki that teachers need to be in a constant state of tension moving between different curriculum emphases as they face different classes, each with unique students and demands. Teachers need to reflect constantly upon their teaching practices and update their teaching focus to meet the needs of their changing and different students.

Curriculum is a subject where educators can “study it and think about it because it reflects a significant social practice” (Reid, 2006, p. 4). Therefore, curriculum and teachers’ perspectives of the programs guide their *practices* in the classroom. The seven science curriculum emphases act as a framework in this study to interpret the priorities teachers report regarding the different aspects of the physics program-of-study. As previously mentioned, curriculum emphases are linked to and overlap each other. For example Scientific Skill Development and Structure of Science have commonalities such as focusing on the method and process of science. Reid (2006) suggests "we need to be aware that the practice of curriculum entails a good deal of personal and collective judgment about what to pay attention to and how to treat it" (p. 5). Teachers' perspectives and attitudes in the classroom embody the world view that teachers hold. The ways we view the curriculum as practice and develop our perspectives of teaching are culture and context dependent. Hence, it is common for these perspectives to change as both teachers and the society they work in also change. Teachers seldom focus on one particular aspect of the program-of-study. Instead teachers will tend to rank a couple of aspects of the program-of-study as being fairly important to them and work between those aspects to bring the curriculum to life. The seven science curriculum emphases and dwelling between them create tension that encourages teachers to continuously update their teaching practices by reflecting on their own experiences and their students' needs. This reflection of teaching practices is an exercise all teachers should, and do to varying extents, undergo in order to maintain and update their practice.

Emphases of Novice and Experience Teachers

As previously stated, each teacher will have their own interpretation of the curriculum and therefore attend to different curriculum emphases. Hepburn and Gaskell (1998) explored the curriculum emphases of two science teachers. They made periodic visits to their classrooms while they were field testing an applied physics course in British Columbia. The two teachers in the study were given pseudonyms. Gordon, an experienced physics teacher in an urban high school in British Columbia, who was teaching applied physics for the first time, believed students who took this course would be able to write the regular physics final exam and receive academic physics credit rather than perceiving the course as an alternative to academic courses. The second teacher Bob, a technology teacher in a rural school, developed the course in his school because local industries needed students who were trained with skills required for work after high school. The credits received from Bob's course were considered to be more aligned with technology education. Each teacher taught the same course but from a very different perspective, Gordon focused on Solid Foundation and Correct Explanation whereas Bob's curriculum emphases were based on Everyday Applications and Science-Technology-Decisions. The course that was explored in the study ran the full semester with Bob making constant reference to technologies and applications found in local industries useful for work after graduation. He often "contextualized a science topic in terms of an application or job performed by a specific trade or industry position" (Hepburn & Gaskell, 1998, p. 782) and then moved to understanding the physics concepts behind the application. Gordon's more traditional perspective meant that his 'academic' physics class often left with a list of formulas, definitions, and theory leaving students with no "appreciation of how physics ideas could be used in the trades and industries" (Hepburn & Gaskell, p.782).

British Columbia did not continue with the idea of this applied physics course because no consensus could be reached as to how the course was to be taught. Gordon and Bob's perspectives in teaching reflected the emphases that they considered were best for their students and those they were most comfortable with. Each classroom had a distinct flavor as might be expected.

Jeans (1998) conducted research looking specifically at experienced and novice teachers' "'image-in-action' of what it meant to implement the [science-technology-society] STS aspect of" (p. 1) a science program-of-study. Twelve experienced and thirty-five novice secondary science teachers teaching grades 8-12 were videotaped in their classrooms. The experienced teachers were nominated by school board officials based on the success of those teachers, while the novice teachers were education students completing their teacher preparation placements. Jeans (1998) reported a difference within the groups of novice participants in their degree of utilizing and adapting STS outcomes into their lessons. A distinction was evident between secondary and elementary novice teachers' approach to STS outcomes. Jeans noted similarities in pedagogical orientation between secondary novice teachers' lessons and university science classes. He explained that this phenomenon was likely due to all of the secondary novice teachers being university science majors, and that the style of teaching they employed reflected the most recent exposure to teaching they had as students, and that they therefore tried to mimic that example. Roberts might propose that these lessons focused on the curriculum emphasis Solid Foundation. Elementary novices tended to provide students with lots of materials and an activity type of lesson to solve problems. Roberts might define this type of lesson as focusing on the emphasis Everyday Coping.

These two studies of experienced and novice teachers did not explicitly use Roberts' seven curriculum emphases as their framework. However, they do suggest that differences exist between what experienced and novice science teachers contend should be attended to in their classrooms and between subject matter knowledge. Further Hepburn and Gaskell's study shows that when there are differences between what curriculum developers intend to be emphasized and what teachers choose to do and to emphasize that curriculum implementation can be a difficult and problematic endeavor.

This study varies from the previous two studies and uses Roberts' seven curriculum emphases as a framework to investigate whether there are differences between experienced, novice, and pre-service teachers regarding what they consider important aspects of the program-of-study. In addition, it uses Roberts' framework to identify potential differences between these three groups of practitioners and the curriculum leader. This is done so that we might hypothesize further whether there is any dislocation between what is intended by the curriculum developers and what teachers view to be important. This might provide insights into the success or otherwise of the implementation of the curriculum as intended by the curriculum developers. Finally, it seeks to explore the perspectives of an under-researched group, namely pre-service science teachers, with a view to understanding what they would consider important to emphasize when implementing the physics program-of-study. Findings from this group of participants might inform science teacher education within the University of Alberta and elsewhere so that future teachers might be aware of the different perspectives of the program-of-study. Further, it might provide the basis for future study into how and why the emphases of teachers might or might not change over the course of their careers.

Conclusion

This chapter examined literature from the fields of curriculum emphases, physics education, and differences between novice and experience physics teachers as relevant to this study. Understanding the origins of the physics programs-of-studies from those used in North America provided a backdrop for considering Alberta's physics program. An analysis of past Alberta physics programs-of-studies revealed two major changes in orientation: the first being a decrease in the amount of content that was expected to be covered, and the second being an increase in *hands-on*, *minds-on* laboratories that promote critical thinking. These major changes in the Alberta physics programs-of-studies were considered using Roberts' (1982, 1988, 1995, 1998, 2003) seven science curriculum emphases as a framework for understanding the different aspects of the programs. The uniqueness of a teacher's classroom reflects a combination of emphases they choose to project and the depth they would like to focus on in relation to their selected emphases. This chapter ended with an examination of existing research that explored the emphases that novice and experience teachers reflect through their teaching practices. The areas of physics education, science curriculum emphases, and teaching experience guide this thesis in seeking to answer the questions:

1) Is there a difference between experienced, novice, and pre-service teachers, with respect to their self-reported prioritizing of certain elements of the Alberta physics program-of-study?
2) Do the reported priorities of those physics teachers match those expressed by the Curriculum Branch, i.e. those who write and publish the physics program-of-study?

These question are investigated using the framework of Roberts' (1982, 1988, 1995, 1998, 2003) seven science curriculum emphases to analyze and discuss the different elements of the program-of-study that teachers might prioritize.

Methodology

Introduction

This section focuses on the research methods used in this study. A review of the two traditional research orientations, qualitative and quantitative, sheds light on why mixed methodologies was used for this research. Previous research regarding curriculum emphases shows this study to be a point in time study. This means that the same study done with the same teachers one year from now might result in different findings and conclusions. A discussion of the methodology as well as why interviews and surveys were used are presented. The study is strengthened because of the choice to use a mixed methodology, which incorporated strengths of both qualitative and quantitative methods. Careful examination of the ethics behind data collection and data analysis shows the effort and detail that went into designing the methodology. The section ends with quality considerations that guided the design and execution of the methodology used to investigate the two research questions.

Previous Research

Previous research done in comparing novice and experienced teachers in the area of physics curriculum emphases focused on different physics topics. The Hepburn & Gaskell (1998) study investigated a pilot applied physics course where two teachers had different perspectives of the course. In this study, the experienced teacher was one deemed “a strong physics teacher” (Hepburn & Gaskell, 1998, p. 780) by the participant's school administration. While the novice teacher was a technology education teacher that taught the applied physics course.

Jeans (1998) also conducted a study on forty-seven novice and experienced teachers to understand their degree of adapting STS outcomes into their lessons. Jeans definition of novice was restricted to include only pre-service teachers, while the experienced teachers were nominated by the school board officials as successful and experienced teachers in their field.

The methods used in these studies involved the researcher interviewing the participants and videotaping their classrooms. These studies had what might be considered small samples, of two and forty-seven participants respectively. This thesis investigated the science curriculum emphases of seventy-one participants**.** Since this curriculum emphases study worked with a larger sample size, the study breaks with the previous use of videotaping and instead utilizes both a survey and interviews to explore participants' views. As in the previous studies, interviews are used to seek finer grained data from a small sample of the participant population.

From these previous studies, one can view the differences in the groupings of novice and experienced teachers. These groupings between novice and experienced teachers are arbitrarily defined based on the resources and needs of each study. Some have argued that there are no pre-set parameters to define groups of teachers using labels such as *novice* and *experienced* (Hattie, 2003). Thus, for the purposes of this curriculum emphases study, the groupings between novice and experienced teachers are set as follows. Experienced physics teachers are those with, (a) ten or more years of physics teaching experience, and (b) recognition as an outstanding teacher from the Assessment

Branch of Alberta Education by being appointed as a head marker. Novice physics teachers were those with less than ten years of experience teaching physics and not head markers. Pre-service teachers were education students who were in their final year of field experience of their teacher education program.

Mixed Methodology

Mixed methodology was the research tradition chosen for this investigation of science curriculum emphases. This research tradition "is a procedure for collecting, analyzing, and 'mixing' both quantitative and qualitative research and methods in a single study to understand a research problem" (Creswell, 2008, p552). A major strength of mixed methods is allowing the two approaches to work together to generate theories and solutions to educational problems (Gage, 1989). Each study that is guided by mixed methodology resides on the spectrum between qualitative and quantitative methodologies. Therefore, each study will vary to a different degree in its approach towards mixing the methods.

A curriculum emphases survey was developed to understand, in one way, which emphases teachers believed are most important when working with the physics program-of-study. Teachers were asked to complete a survey ranking three individual sets of statements. Within each set of statements was one that represented each one of the seven science curriculum emphases. From the qualitative side of the spectrum, this thesis utilized interviews and open-ended written responses. Participants were asked one open-ended written question at the end of the survey and several interview questions. These questions sought to understand what perspectives they tended to prioritize over others in their physics classrooms and why they did so. In the case of the curriculum developer, she completed the same survey as the teacher participants and took part in an interview. The interviews were transcribed and an analysis was made of the participants' preferences in relation to the curriculum emphases. The qualitative element of the mixed methodology, especially the interviews, was used in this study to enrich the data used to answer the research questions regarding teachers' and curriculum leader's emphases of the program-of-study. Although both research methods have strengths, they also have weaknesses. A blend of the two allows the two approaches to complement each other; the weakness of one is considered to be compensated for by the strength of the other (Erickan & Roth, 2007). The next sections provide a discussion of the qualitative and quantitative methods used in this thesis.

Quantitative

Historically, quantitative research has dominated the field of educational inquiry since the 19th century and for most of the 20th century (Creswell, 2008). Creswell suggests this type of educational research is generally used when the researcher has a specific and narrow question to study. Since the data collected is numerical and nowadays usually processed with the aid of computer software, researchers may collect data from many participants to increase the reliability of their study. Quantitative research is, (a) often considered to be based on social facts with an objective reality, (b) supposed to be able to explain causes of change through measurements, and (c) characterized by employing correlational designs to reduce error and bias (Firestone, 1987). However, the social facts of a local area may not reflect the researcher's pre-set categories (Johnson & Onwuegbuzie, 2004), or in this case the seven science curriculum emphases.

This particular study utilized the ideas of quantitative methods by developing and administering a survey for teachers to rank the seven science curriculum emphases. The survey consisted of three sets of seven statements. Each of the seven statements represented one of Roberts' seven science curriculum emphases. The first two sets of statements consisted of passages directly taken from the Rationale and Philosophy of the 2007 physics program-of-study. The difference between the first two set of statements is that the first set consisting of statements directed at student learning with all the statements starting with 'students are able to'. The second set of statements approaches the classroom from the teacher's perspectives, with all the statements beginning with 'I provide opportunities'. The third set of statements were definitions of the seven curriculum emphases derived from Roberts' literature (1982, 1988, 1995, 1998, 2003). Teachers were asked to rank them according to their preferences. From these rankings an analysis was undertaken to explore which of the aspects of the physics program-of-study teachers tended to prioritize as important. For selected teachers who were willing to provide further information regarding their preferences, a qualitative aspect involving interviews was also employed.

Qualitative

Qualitative research methodology is comparatively new in the field of educational research with a firm history of about thirty years in the field (Creswell, 2008). In this type of methodology the researcher usually starts with a general and broad question. The analysis of the data requires hermeneutics, a method used in interpretation and subjective inquiry. As the text or word data is collected, the researcher analyzes the data for recurring themes. This mode of research has standards for establishing trustworthiness. The personal nature and text-based data collection process usually requires the researcher to work with a small sample, in this case five interview participants, so that a deeper understanding of the research phenomena may be achieved. The data collected is personal to each participant and thus it may be difficult to replicate similar results in further studies. Due to the personal nature of each study it is assessed using a different set of quality considerations than quantitative research (Johnson & Onwuegbuzie, 2004).

Roberts' seven science curriculum emphases were used as a framework for the analysis. The interviews explored the topics of what teachers reported they tended to focus on in their classrooms and whether there were any clashes between the 2007 physics program-of-study and their views and practices. Interview data brought the researcher's attention to teachers prioritizing more than one emphasis at a time as well as aspects of the program-of-study that were not part of Roberts' framework of seven science curriculum emphases. For example, some teachers believed *student engagement* was the most important aspect of the program-of-study. However, that message was not explicitly portrayed through the surveys because teachers were asked to rank items representing Roberts' seven emphases, which excluded student engagement.

Research Participants

The research questions revolved around the science curriculum emphases of pre-service, novice, experienced teachers, and a curriculum leader. These groups were targeted to take the curriculum emphases survey. The teacher sample chosen can be considered a convenience sample. Participants with a variety of physics teaching experiences were approached to fill out the curriculum emphases survey in line with the aims of the research. Distinguishing between experienced teachers and less experienced teachers is not a clear cut process and the criteria for assigning teachers to groups representing different levels of experience are not necessarily consistent and agreed upon across educational research (Hattie, 2003). Further, what might be considered to be experienced in one context or locality might not be considered experienced in another. As previously discussed, different studies may define the labels of novice and experienced teachers differently. Therefore, these groups of teachers are arbitrarily defined based on the resources and needs of each particular study. The criterion used in this study to differentiate between experienced, novice, and pre-service teacher categories relates to the local context and is explained more fully in what follows.

Experienced Teachers

The experienced group for the purposes of this study consisted of teachers who had taught physics for ten or more years and were considered experts in their field as determined by the Assessment Branch of the Alberta Education government organization. These teachers had worked with the physics program-of-study on many different levels: writing the program, providing input, piloting the program, and teaching the program. Their experiences with the program make their perspectives of the program-of-study relevant to this research.

Novice Teachers

The teachers that constituted the novice group were teachers with less than ten years of experience teaching physics and not recognized as head markers by the Assessment Branch of Alberta Education. While the criterion of less than ten years experience might be seen as arbitrary it, when combined with criterion of lack of professional recognition as a head marker, meant that it was possible to delineate clearly between two groups within the participants who were already practicing teachers.

Pre-Service Teachers

Student-teachers in the pre-service program, known as Advanced Professional Term (APT) students, were approached to complete the survey. This sample of participants provided data that gave insights into their perspectives of what should be emphasized in teaching physics using the program of studies. Because their experience was substantially less then the other two categories of participants, their views add an important perspective to answering the research question.

Curriculum Leader

The curriculum leader was, at the time of this study, the program manager for secondary sciences in the curriculum branch of Alberta Education. To protect the identity and privacy of the curriculum leader, she was given the pseudonym of Lisa. The curriculum leader has played the roles of a teacher, science department head, science consultant for her district. With these experiences behind her, she stared to work as a curriculum leader with Alberta Education.

Surveys

Surveys were used as a method of collecting data for this curriculum emphases study. This section of the thesis discusses how the researcher developed the curriculum emphases survey using Roberts' seven science curriculum emphases as a framework as well as how the survey was administered to a variety of pre-service, novice, experienced physics teachers, and the curriculum leader.

Survey Construction

Surveys can accommodate a larger number of respondents than interviews. Through surveys, large amounts of data on science curriculum emphases can be collected and analyzed in a relatively short period of time. This was the main reason surveys were chosen as a method of the data collection process. A copy of the survey can be found in Appendix B. The first page of the survey allowed the researcher to gather demographic information regarding the research participants, such as the number of year teaching physics, their education background, and additional Professional Development participants may have had. The researcher was able to ascertain whether the respondents were head markers or not by recognizing their name and checking it against a list provided by the Exam Manager.

The survey constructed for this thesis consisted of three sets of statements. Each of the sets contains seven statements that each reflects/represents one of Roberts' seven curriculum emphases. The first set of seven statements has the common theme of students' learning outcomes and originates from the 2007 physics program-of-study. From the sections that pertain to student learning outcomes in the 2007 physics program different passages were chosen to represent each of the seven science curriculum emphases. For example, the statement “Students are able to use scientific vocabulary and principles in everyday discussions” was used in the first set of seven statements to represent Roberts’ Everyday Coping emphasis. The second set of seven statements encompasses the common theme of opportunities provided by teachers in their classrooms that also come from the 2007 physics program. These statements can be thought of as encouraging different teaching practices within a classroom. The second set of statements included passages such as “I provide opportunities to show science provides an ordered way of learning about the nature of things, based on observation and evidence”, in this case to represent the emphasis Structure of Science. The statements used to represent the seven science curriculum emphases in these two sets came from the first fourteen pages of the 2007 physics program-of-study where the rationale and philosophy behind the course are outlined.

The third sets of seven statements were passages derived from Roberts’ literature (1982, 1988, 1995, 1998, 2003). Roberts wrote about these seven science curriculum emphases in detail in his papers. From his detailed explanations of these seven curriculum emphases, a condensed version was developed and placed into this survey as the third set of statements for teachers to rank. For example, in the third set of the survey the curriculum emphasis of Science, Technology, and Decisions was represented by the statement “Students become able to understand the interrelatedness of scientific explanations, technological planning, problem solving, and the practical importance of science to society”. All statements in the survey were reviewed for face validity by Dr. Douglas Roberts. This was considered very important because the statements’ face validity was confirmed by the developer of curriculum emphases himself (D. Roberts, personal communication, May 14, 2008). Therefore it can be said that the essence of each emphasis was appropriately represented by the statements. The last part of the survey provided an opportunity for participants to respond to an open-ended question where they could express their views of the program-of-study beyond the constraints of the pre-defined items.

Survey Administration

Access was granted by the Physics Diploma Exam Manager, allowing the researcher to administer the survey to 85 diploma markers on the last day of the 2008 June marking session. Diploma marking sessions consists of a congregation of physics teachers from different areas of Alberta teaching physics through a variety of mediums such as: classroom teaching, online teaching, independent studies, etc. To be qualified to be a Physics 30 diploma marker, the teacher has to have taught Physics 30 for two years and currently be teaching Physics 30 in the year they apply for marking duty. Before the participants filled out the survey, the researcher explained the reason for the research. This was so the participants could understand what they were participating in before they consented to take part in the study by completing the survey. Surveys and consent forms were handed out to all markers to complete and return prior to lunch on the chosen day. This was after the researcher had fully explained the ethics regarding the protection of participants' identities. To ensure all surveys were accounted for, each survey was numbered before being handed out. This process of seeking informed consent was undertaken for all survey and interview participants. Of the eight-five surveys given to the teachers sixty-five were returned. Of those, nine surveys were not completed as instructed and therefore were not used as data in this study. This means that the total available from the eighty five potential respondents was less than expected and fifty-six.

A day was arranged with the physical sciences APT classes to have this project explain to the APT students and they were given the opportunity to fill out the survey. The class consisted of seventeen students. Of this group fifteen students completed and returned the survey.

The curriculum leader was approached to ask for her participation in this study as the representative from the Curriculum Branch of Alberta Education. A time was set up in her office for this researcher to go and administer the survey and conduct an interview with her regarding her views. Her views were interpreted by the researcher as a representative of the Alberta Education department, of the physics program-of-study.

Interviews

Opportunity was given for participants to leave information so they could be contacted for face-to-face interviews to allow for a more in depth analysis of their curriculum perspectives. In this particular research, face-to-face interviews were chosen over electronic mail interviews and telephone interviews. Interviews with electronic mail were discouraged because prior research showed in-depth information is not easily obtainable because electronic mail interviews do not allow for direct probing (Meho, 2006). Telephone interviews were also avoided because "the absence of visual cues via telephone is thought to result in loss of contextual and nonverbal data" (Novick, 2008, p. 391). After consideration of those previous research studies, the researcher chose face-to-face interviews as the most appropriate method of collecting the interview data for this study.

Of the seventy-one participants who participated in the survey, ten participants left contact information for a voluntary interview. Of those ten voluntary participants, five were contacted for an in-depth face-to-face interview to add to the data collected regarding physics teachers' interpretation of the program-of-study. Face-to-face interviews were specifically chosen for reasons outlined later in the paper. The five were chosen for the following reasons. Firstly, three of the five came from the same school board; therefore permission to interview those respondents was obtained through the appropriate school board, in this case Calgary Catholic Separate School Board. As this researcher resided in Calgary, this was considered convenient for the purposes of this study. Second, two of those interviewed were not affiliated with any school board at the time of the interview and agreed to make themselves available at a time convenient for all parties. The other five participants were not able to be interviewed for the purposes of this study for the following reasons: (a) two resided in remote locations making interviewing them a difficult process and one that would not be undertaken unless it was necessary to further inform the research, (b) two provided insufficient contact information, (c) one did not respond in time for an interview.

Since the interview sample was a convenience sample, the interview data are not necessarily representative of the group the participants were members of. Perspectives and ideas uncovered during each participant's interviews may only pertain to their individual experiences and views. In order to draw representative data from interviews, more interviews employing a hermeneutic cycle (Guba & Lincoln, 1989, 1997) would be necessary.

The interviews were audio taped and transcribed. The transcriptions were interpreted and analyzed for the different perspectives the interview participants reported themselves to have in their physics classrooms. Each interview started off with global questions about the physics curriculum in general and then converged on the specifics of which emphases teachers believed to be important and why. Once the interview had proceeded past the global questions, they were guided by a series of questions that changed with each interview depending on the participants' responses. For example, when Dillon (all names are pseudonyms) brought up the idea of viewing physics as an interconnected 'whole' the questions that followed were asked to enrich and expand upon that idea of interrelated concepts that link each unit. The questions that were asked during Dillon's interview were not exactly repeated in the other interviews because the other interviews did not necessarily follow the same direction as Dillon's interview. The final question to all the interviews provided the participants with the opportunity to summarize what they believed was the most important aspect of their classroom towards student learning. For example, 'Are there any concluding statements you would like to leave me with regarding our interview on curriculum focus?' This question was purposely left open for the interview participant to add additional comments that may have been missed during the interviews.

The interpretations of the transcripts are a form of qualitative methodology known as hermeneutics. Hermeneutics is a discourse of educational inquiry that focuses on "the art and science of interpretation" (Carson, 1992, p. 73). This mode of inquiry has been linked the Greek messenger god Hermes who was known for his eternal youthfulness, friendliness, prophetic powers, fertility, and as a trickster (Smith, 1991, 2003). All the qualities of the Greek god are represented in hermeneutics. In *conversations* or interviews with research participants the researcher must maintain friendliness and approachability so the participant will reveal truthful and meaningful data (Carson, 1992). As text is being considered by the researcher he/she needs to maintain openness to how the text can be interpreted and not to deny a range of interpretations. Every time a researcher interprets data they bring new experiences and thoughts to the text, therefore they might interpret something new each time they look at the text, giving the text the power of fertility of new meaning. Smith (1991, 2003) suggests using hermeneutics carefully because the text can be tricky and difficult to interpret, and if wrong meaning is given to a text, the repercussions could be detrimental to the researcher and audience of the thesis. Member checking with interview participants, which is discussed later in this chapter, was undertaken to maximize the quality of the hermeneutic process.

During interviews, constant interpretation and processing of the responses the participants provided was maintained so meaningful questions could be asked to seek information to answer the research questions. The interviews provided participants with the opportunity to state the focus of their implementation of the physics program-of-study in their classrooms. After the interview, more interpretation of the text was required. How this interpretation was undertaken is discussed in the next section.

Use of Hermeneutics in this Study

When the word interpretation is mentioned most people will think of qualitative research because hermeneutics, the art of interpretation complements text data. However, there is a much broader use for hermeneutics in research. Almost everything done in designing the methodology is laced with interpretation. Interpretation of the Alberta physics 20-30 program-of-study was done to find statements that the researcher considered represented each of the seven curriculum emphases. Those statements were organized into three sets of seven statements for participants to rank. When those participants completed the survey, they also interpreted what the statements mean to them. However, their interpretation of the statements may not be the same as the researcher's interpretation. For example, the quote "Use scientific vocabulary and principles in everyday discussions" (Alberta Education, 2007, p. 15) was interpreted by the researcher to be under the Everyday Coping curriculum emphasis meaning students use the theory learned in class to make applications to their daily lives. Since the definitions of these emphases have similar aspects, the interpretation of these emphases might overlap, depending on the individual involved. Thus each teacher's interpretation of the definitions may differ slightly. After participants had interpreted each statement they had to decide the order of the importance of each of these statements by ranking them. This decision making process also required a degree of interpretation.

Summary

In this section a review of the methodology related to surveys and interviews was discussed. It is important to stress again that all seven of the science curriculum emphases should be considered important as suggested by Roberts (2003). However, as previously discussed, it is nearly impossible for classroom teachers to place equal importance on all seven of the emphases. Therefore this investigation tries to understand where teachers stand, at that point in time, in relation to the emphases. The next section provides a detailed discussion of the ethical considerations involved in this study.

Ethics

Ethical considerations are an important aspect of this research. Normal ethical protocols as specified by the University of Alberta Research Ethics Board were undertaken. Of particular interest were the following points: informed consent letters sought participants voluntary involvement with the research, surveys were anonymous to protect the identity and privacy or participants, and pseudonyms were used during interviews and in reporting of findings to protect participants' identities and privacies. Data collection was able to begin because the Research Ethics Board at the University of Alberta reviewed and approved the application that outlined the research process.

Survey participants were asked to sign the consent letter indicating their voluntary involvement with this research project. However, due to the anonymous nature of the surveys it was essentially impossible for participants to retract their survey after they had submitted their data. This point was stressed to participants before they decided to take the survey and submit their responses. No individual names were used in the processing of the data using SPSS.

As previously mentioned, at the end of the surveys teachers were given the opportunity to volunteer for an interview for the researcher to gain a deeper understanding of their views and focus without the boundaries of the pre-determined seven science curriculum emphases. Since ethics approval is required before teachers from a particular board are allowed to participate in a research project, as previously mentioned, three of the five teachers approached were from the same school board because ethics approval was granted by that school board. The other two teachers that were interviewed were not part of any school board at the time of their interviews. Thus no additional ethical clearances were required for those teachers to participate in this research. Letters explaining the research and the ethics behind the data collection were provided for participants to sign indicating they understood the reason behind the research and their contribution to the thesis. By signing this agreement, the participants consented they were willing to participate in the research through an interview and all data collected from the interview might be used. Verbal explanations of the research project and the ethics behind the research were provided before the interviews.

To protect the identity of the interview participants, they were assigned pseudonyms during the interview process. To ensure the participants' interview data were respected and to ensure the interview was correctly transcribed member checking was done through electronic mail.

Data Analysis

Analyzing the data collected constitutes a major part of the methodology because this is one of the final steps to the method section of the research. Since three types of data were collected, the processes of analyses for each of them are explained separately.

Quantitative Analysis: Statistics

The statistical survey data were processed with SPSS Version 17.0. This program allowed for an analysis indicating the rank order of the seven emphases within the groups of teachers; pre-service, novice, and experienced. Data entry was done by the researcher and the processing was done by the program. To help with the statistical analysis and interpretation of this analysis the researcher sought assistance from consultants from CRAME (Centre for Research in Applied Measurement and Evaluation – University of Alberta), Mary Roberts and Dr. Todd Rogers. This was to allow for a better understanding and explanation of the numerical results. The advice provided by the consultants was undertaken in the quantitative analysis of the data in that they are experts in their field of statistical education research. They also provided guidance in determining the validity of the survey, and this is discussed later in this chapter.

Qualitative Analysis: Open-Ended Question

The open-ended question at the end of the curriculum survey provided participants to leave written data for the researcher in a relatively simple and quick manner. The responses were typed up and organized into the appropriate groups of pre-service, novice, experienced teachers, and curriculum leader. These responses were analyzed for each group for recurring themes that fitted within Roberts' seven curriculum emphases framework, as well as ideas that were outside the framework. Some responses were disregarded, as some participants did not answer the open-ended question as intended by the researcher. This is discussed in more detail in the 'Results and Data

Analysis' section. Each participant's open-ended responses were also compared with their survey results to test the validity and reliability of the survey.

Qualitative Analysis: Interviews

Interview questions were directed with the purpose of understanding the perspectives of physics teachers regarding the program-of-study. Prior to the interview the researcher analyzed each of the interview participant's survey and brought that data into the interviews. During the interviews, some of the questions asked were motivated by the results of the participant's curriculum emphases survey. The interviews were transcribed and then coded in relation to the seven science curriculum emphases. Sections of the transcript were coded for what the researcher considered to be related to one or more of the seven emphases. For example, when James mentioned teaching "an interest in this kind of analytical thinking in physics or at least have them build problem solving skills that are perhaps transferable to other avenues of life" this was interpreted by the researcher to represent the curriculum emphasis Scientific Skills Development. This particular emphasis requires students to use a variety of problem solving strategies in different situations to solve a variety of problems, hence the transferability aspect of their skills. Through these interviews, a link between what the participant believed was important and how this affected their implementation of physics program-of-study was developed.

The two approaches of quantitative and qualitative data analysis complement each other. The benefit of using mixed methodology allows for the strengths of one method to compensate for the weaknesses of the other (Erickan & Roth, 2007). The final section of this methodology section focuses on the quality considerations of the study with detailed discussions on credibility, transferability, dependability, and confirmability.

Quality Considerations

Rationalistic inquiry, or quantitative research, has well established standards for trustworthiness (Lincoln & Guba, 1985; Guba & Lincoln 1989). However, naturalistic inquiry, or qualitative research, including interpretive research has been attacked as being untrustworthy (Cohen & Manion, 1994). There are numerous differences between qualitative and quantitative research, therefore it would be difficult to impose the same quality considerations for both sets of research. Lincoln and Guba (1985) proposed that the trustworthiness of research is important for evaluating its worth. The trustworthiness of qualitative research involves establishing credibility, transferability, dependability, and confirmability. These considerations are considered to be equivalent to the validity, reliability, and objectivity of quantitative research. Furthermore, the authenticity criteria of fairness attempts to ensure the quality of research extend beyond the methodological focus of the previously mentioned trustworthiness criteria. This section of the study outlines the aspects of the methodology that enhanced its trustworthiness and authenticity.

Validity of Survey

Before the curriculum emphases survey was administered Dr. Douglas Roberts, the developer of the curriculum emphases, checked over the instrument. The statements from all three sets that represented the seven curriculum emphases were checked for face validity and to ensure the essence of each emphasis was correctly represented by the statements (D. Roberts, personal communication, May 14, 2008).

The validity of the survey was checked using a Mean Absolute Difference (MAD) chart, which was developed by Dr. Todd Rogers by altering the ideas behind Mean Absolute Deviation to fit specific data. Mean Absolute Difference charts use the mean of each perspective to compare and analyze the validity and reliability of the results. The mean of each statement was calculated and their means were compared in the MAD chart (M. Roberts, personal communication, Aug. 7, 2008). Since not every set of seven statements created the same ranking, the absolute difference was found between each of the three sets to establish whether a significant correlation was present between each set. The absolute difference between each of the three sets was calculated by subtracting the means between each set. These differences were made into a positive, or absolute, value for easier comparisons. Theoretically if teachers all ranked one particular emphasis the same number, then the difference between each of the sets should be zero. Lower absolute differences between sets indicate more similarities between the rankings of each emphasis and therefore the more significant the results are.

The MAD values between each emphasis were compared within the three groups of participants. The comparisons revealed different MAD values, which indicated that the three statements representing each emphasis did not correspond to one another across the three sets. Since the three sets of data could not be analyzed in one group, due to the low statistical validity, it was recommended, by Mary Roberts, that a graphical technique be used in conjunction with a descriptive statistical analysis (M. Roberts, personal communication, May 5, 2009) to explain the data collected in this study which will be explained in more detail in the analysis section.

Reliability of Survey

The reliability of this survey is not yet clear, as the results might be expected to change over time with respect to teachers' experiences and views of teaching. The ranking of the seven science curriculum perspectives the teachers provide might one day be different on another day, or change when faced with different students in different classes (D. Roberts, personal communication, May 14, 2008). Hence, this thesis only explores the general trends of curricular perspectives at a particular time and with a particular group of teachers. Since the curriculum emphases survey was administered only once, the reliability of the survey could be determined by administering the same emphases survey to other physics teachers when the opportunity arises. The validity and reliability of the surveys were further considered by having some survey participants interviewed and the two results analyzed to investigate whether the participants' survey and interview responses complemented one another.

Credibility

Credibility is associated with the confidence in the *truth* of the findings. Guba and Lincoln refer to it as "a check on the isomorphism between the enquirer's data and the multiple realities in the minds of the informants" (1997, p.89). In this curriculum emphases research, credibility was achieved through:

1. Triangulation and cross checking through corroboration of survey, open-ended question, and interviews data. Triangulation is “to use multiple methods and sources of data in the execution of a study in order to” (Mathison, 1988, p13) ensure that a rich, robust, comprehensive, and well-developed account is produced. The modest use of multiple methods to focus on curriculum emphases included using surveys and interviews which together might overcome the weaknesses and biases of each individual method. Even within the surveys, participants completed three sets of evaluations as a cross reference to their data. This allowed the researcher to draw stronger conclusions regarding the ranking of the seven science curriculum emphases.
2. Member checking. Interview participants checked the data, analytic categories, interpretations, and conclusions of the data they provided. This allowed for the opportunity to correct errors and challenge what are perceived as wrong interpretations. Member checking also allowed the opportunity to assess the adequacy of data and preliminary results as well as confirm particular aspects of the data (Cohen & Crabtree, 2006). After the interviews were transcribed, the transcriptions were electronically mailed back to the appropriate participants to check if they were exactly what they wanted to say. However, the researcher’s interpretations were not checked by interview participants. It is important to use this triangulation and member checking process as a means to work with the “data sources to enhance the validity of” (Mathison, 1988, p.13) the interviews.

Transferability

Transferability refers to the applicability of findings in other contexts. The conclusions drawn from this thesis may be applicable to other physics teachers. Due to the nature of physics itself, teachers of physics may have many commonalities that make them similar to one another in the way they interpret and view the subject. Although this study is considered a 'point in time' study, meaning the results of the study may change with time, it is still potentially transferable to a larger population. This study was conducted in Alberta, Canada but realistically it probably speaks to many teachers in different places because physics classrooms and teachers often have common characteristics (Duit, Niedderer, & Schecker, 2007). The general trend of moving away from content knowledge towards hands-on application approaches is seen in other programs-of-studies such as the International Baccalaureate physics program-of-study (International Baccalaureate Organization, 2007). The similarities between physics programs allow the results of this study to potentially speak to many educators.

The survey is composed of statements taken from the 2007 Alberta Physics 20-30 program-of-study, but the statements are general enough that they could be found in many different science programs-of-studies. For example, statements such as "I provide opportunities for students to explore their personal perspectives, attitudes and beliefs regarding scientific and technological advancements" (Alberta Education, 2007, p.15) are general enough to fit the rationale and philosophy of science courses other than physics.

Dependability

Dependability is associated to whether the findings are consistent. This particular quality consideration parallels the reliability criterion of quantitative research. Dependability was addressed by having the interview participants fill out a curriculum survey rank order and an open-ended response question. The results were analyzed to investigate whether the survey and open-ended responses complemented one another for all survey participants. The results of the five interviews were checked against the surveys those participants filled out. In fact, the researcher had the analyzed data from the interview participants' surveys during their interviews. Some of the interview questions were sparked by the results of their curriculum surveys.

Confirmability

Confirmability describes a degree of neutrality, or the extent to which the findings of the study are shaped by the respondents and not the researcher's bias (Cohen & Crabtree, 2006). The processes of inquiry and confirmability audit trials to ensure dependability and confirmability, respectively, follow the descriptions provided by Lincoln and Guba (1985). "The purpose is to evaluate the accuracy and evaluate whether or not the findings, interpretations, and conclusions are supported by the data" (Cohen & Crabtree, 2006). In this particular study the quantitative data was processed by a computer program. The qualitative data was member checked, so the interview participants were able to look over the transcripts of the conversations to ensure the essence and detail of the interview was appropriately interpreted by the researcher.

Conclusion

In this research a design using mixed methods was used to understand physics teachers' curricular perspectives. This study utilized surveys to collect data from 119 physics teacher and potential physics teacher participants regarding their emphases of the program-of-study. Pre-service, novice, experienced, physics teachers, and a curriculum leader were among the participants who completed the curriculum emphases surveys. The survey participants were also given the chance to participate in an interview where their views could be studied in-depth without the pre-set boundaries of Roberts' seven science curriculum emphases. The statistical data from the surveys were analyzed using SPSS version 17.0 to decipher how teachers ranked the emphases. The open-ended responses were typed up and analyzed in the appropriate groups for repeating themes. The interview data were transcribed and analyzed for recurring themes. The interviews provided teachers and the curriculum leader with a platform to express their perspectives and how they prioritize them. Using interviews as a data collection method enriched the data collected with only the surveys.

The ethics associated with the research undertaken for this thesis was also discussed. The main concern for this research project was to protect the identities of individual teacher participants. Extra precautions, such as analyzing results as a larger, novice or experienced, group and using pseudonyms with interview participants was done to protect the voluntary participants. This was particularly important in the case with the curriculum leader as there are not many people in her position in Alberta. Each participant was given both a verbal and written explanation of the research project before they completed the surveys and interviews. Participants also signed an agreement stating they are willing to participate in this research and all relevant data collected might be published.

This methodology section of the thesis ended with considering the quality considerations associated with qualitative and quantitative methods utilized in this mixed methods research design. The next section explores the data and its analysis to answer the research questions.

Results and Data Analysis

Introduction

Using mixed methods, data was collected to investigate the perspectives of pre-service, novice, and experienced physics teachers and also a curriculum leader. Surveys were administered to different participants to gain an understanding of their perspectives. Participants were also given a chance, at the end of the survey, to provide the researcher with more information about their perspectives of the physics program-of-study through an open-ended question and an interview asking them to report on what they focused on in regards to the program-of-study. The population was split into four groups for data analysis: pre-service, novice, experienced teachers and the curriculum leader.

Experienced physics teachers were classified as those with, (a) ten or more years of physics teaching experience and, (b) recognition as an outstanding teacher from the Assessment Branch of Alberta Education by being a head marker. Novice physics teachers were those with less than ten years of experience teaching physics. Pre-service teachers were education students who were in their final year of teacher education program. The curriculum leader was a representative of the Curriculum Branch of Alberta Education who was substantially involved in the creation of the new 2007 physics program-of-study. The interview and survey data regarding curriculum prioritizing were analyzed separately.

A ranking of the seven science curriculum emphases was created by calculating the means of each emphasis using SPSS Version 17.0. From those means graphical representations were used to describe the data. The interviews were transcribed and analyzed to identify the themes teachers prioritized.

The three sets of data, survey ranking, open-ended comments, and interview were compared for validity. “Validity is the extent to which a test measures what it claims to measure” (About.com: Psychology, 2009). This can be done by comparing the ranking order provided by the participants and matching those priorities to those mentioned in the open-ended survey question in each survey. When the highest priorities from the ranking match those mentioned in the open-ended survey question then the survey might be considered to have reasonable validity. For example, Participant 65 ranked the emphasis Scientific Skill Development as their top priority in all three sets and gave an open-ended survey response of focusing on “lab skills and extensions to theory”. This statement describes Roberts’ emphasis of Scientific Skill Development, thus the ranking and the open-ended response provided by Participant 65 match and support the validity of the survey. In the following section the results of the surveys and interviews are presented as four groups, pre-service, novice, experienced, and curriculum leader participants.

Results of Curriculum Emphases Surveys

The final ranking of the seven science perspectives are determined from the data collected through the surveys. The means for each curriculum emphasis was calculated using SPSS Version 17.0 and the results are presented in Table 6, Table 7, and Table 8. Each table has a column for each emphasis, the results that correspond to that particular emphasis is located below its title. The survey consisted of three sets of seven statements each representing the seven curriculum emphases. The means of each statement, in the

Table 6

Means, Ranks, and Mean Absolute Difference for Pre-Service Teachers

n=15

	Scientific Skill Development	**Structure of Science**	**Science, Technology, and Decision**	**Everyday Coping**	**Correct Explanation**	**Self as Explainer**	**Solid Foundation**
Emphasis Set 1	4.7333	1.6667	3.6000	3.4000	4.7333	3.4667	6.4000
Emphasis Set 1 Rank	5.5	1	3	2	5.5	4	7
Emphasis Set 2	4.9333	3.6667	3.4667	2.6667	3.5333	4.5333	5.2000
Emphasis Set 2 Rank	6	4	2	1	3	5	7
Emphasis Set 3	3.1333	4.0667	2.4000	3.0000	4.6000	5.1333	5.4000
Emphasis Set 3 Rank	3	4	1	2	5	6	7
Mean Absolute Difference │Set 1 – Set 2│	0.2000	2.0000	0.1333	0.7333	1.2000	1.0666	1.2000
Mean Absolute Difference │Set 2 – Set 3│	1.8000	0.4000	1.0667	0.3333	1.0667	0.6000	0.2000
Mean Absolute Difference │Set 1 – Set 3│	1.6000	2.4000	1.2000	0.4000	0.1333	1.6666	1.0000
Final Rank of Emphases	4.5	1	3	2	4.5	6	7

Table 7

Means, Ranks, and Mean Absolute Difference for Novice Teachers

n=25

	Scientific Skill Development	**Structure of Science**	**Science, Technology, and Decision**	**Everyday Coping**	**Correct Explanation**	**Self as Explainer**	**Solid Foundation**
Emphasis Set 1	4.2917	2.7083	4.5000	2.8750	4.5000	3.5833	5.5417
Emphasis Set 1 Rank	4	1	5.5	2	5.5	3	7
Emphasis Set 2	5.6800	2.9600	3.9200	2.0800	3.4000	5.5600	4.4000
Emphasis Set 2 Rank	7	2	4	1	3	6	5
Emphasis Set 3	3.1600	3.5600	2.8800	3.1600	4.6400	5.3600	5.2400
Emphasis Set 3 Rank	2.5	4	1	2.5	5	7	6
Mean Absolute Difference │Set 1 – Set 2│	1.3883	0.2517	0.5800	0.7950	1.1000	1.9767	1.1417
Mean Absolute Difference │Set 2 – Set 3│	2.5200	0.6000	1.0400	1.0800	1.2400	0.2000	0.8400
Mean Absolute Difference │Set 1 – Set 3│	1.1317	0.8517	1.6200	0.2850	0.1400	1.7767	1.0576
Final Rank of Emphases	4.5	2	3	1	4.5	6	7

Table 8

Means, Ranks, and Mean Absolute Difference for Experienced Teachers

n=30 participants

	Scientific Skill Development	**Structure of Science**	**Science, Technology, and Decision**	**Everyday Coping**	**Correct Explanation**	**Self as Explainer**	**Solid Foundation**
Emphasis Set 1	4.9667	2.7333	4.3333	2.8333	3.7333	3.5667	5.8333
Emphasis Set 1 Rank	6	1	5	2	4	3	7
Emphasis Set 2	6.3103	2.6207	3.2759	2.6897	4.3103	4.9655	3.8276
Emphasis Set 2 Rank	7	1	3	2	5	6	4
Emphasis Set 3	2.8214	3.2500	3.6071	3.7500	4.4286	5.2857	4.9643
Emphasis Set 3 Rank	1	2	3	4	5	7	6
Mean Absolute Difference │Set 1 – Set 2│	1.3436	0.1126	1.0574	0.1436	0.5770	1.3988	2.0057
Mean Absolute Difference │Set 2 – Set 3│	3.4889	0.6293	0.3312	1.0603	0.1183	0.3202	1.1367
Mean Absolute Difference │Set 1 – Set 3│	2.1453	0.5167	0.7262	0.9167	0.6953	1.7190	0.8690
Final Rank of Emphases	4.5	1	3	2	4.5	6	7

three sets presented in the curriculum emphasis survey, were calculated using the ranking numbers each participant gave that particular statement. Means, or averages, were chosen for this analysis because it is a "measure of central tendency" (Russo, 2003, p. 23) and may be used "as a balance point for a distribution" (Gravetter & Wallnau, 2007, p. 75). Although the correlation between the three sets of emphases is low, a final ranking was created using the three sets of emphases from each group of teachers to help readers better understand the statistical data. The method of quantitative analysis was decided after consultation with the University of Alberta CRAME department.

Survey Analysis: Mean, Rank, and Mean Absolute Difference

A thorough analysis was done for each group to gain a better understanding of the perspectives for pre-service, novice, experienced teachers, and the curriculum leader. The means of each set are presented in the rows named 'Emphasis Set 1', 'Emphasis Set 2', and 'Emphasis Set 3'. From the means for each emphasis a ranking was created within each set to understand which emphases, or aspects of the program-of-study, participants prioritized as most important. In the ranking system, '1' represented the highest priority, thus a low mean would represent that particular emphasis was held in high priority by teachers. The ranking of each set of emphases is presented in the rows named 'Emphasis Set 1 Rank', 'Emphasis Set 2 Rank', and 'Emphasis Set 3 Rank'.

The correlations between the MAD values were explored. As the name of this analysis suggests, the means of each set of statements are subtracted from one another and made into an absolute value. The differences between each set of means are presented in the rows 'Mean Absolute Difference │Set 1 – Set 2│', 'Mean Absolute

Difference |Set 2 – Set 3| ', and 'Mean Absolute Difference |Set 1 – Set 3| '. These MAD values were compared for correlation between the three sets of statements. If teachers ranked each emphasis the same in all three sets then the absolute difference should be zero. Therefore, if there is a strong correlation between data from the three sets of statements the MAD should be very low (M. Roberts, personal communication, Aug. 7, 2008).

The MAD values were compared within each emphasis for similarly low values. However, the MAD values obtained were varied and in some cases relatively high, with values exceeding three. The ideal values for MAD should be close to zero to represent high correlation between the items corresponding to each curriculum emphases between the sets of responses. Since the MAD values indicated a low correlation between the three sets of statements for each emphasis, the data from each of the three sets are analyzed separately as well as together as one set of data for each of the groups. Hence, a final average for each group of experiences, novice, and pre-service teachers should not be compared relative to one another. Instead, graphical analysis and descriptive statistics was used to analyze and "extract useful information from unorganized data" (Russo, 2003, p. 9).

Descriptive statistics, as the name suggests, are used to describe a set of statistical data using words. This form of statistical analysis is easy for readers to interpret as the mathematics involved are generally simple calculations such as using the mean, median, mode, range, and/or standard deviation (Gravetter & Wallnau, 2007). However, a disadvantage of used descriptive statistics is that it provides *static* results, which only pertain to the participants in the current study (Russo, 2003). This means, the results obtained in this research may not necessarily represent the views and perspectives of other physics teachers and pre-service science teachers. If calculated statistics were to represent the entire population of physics teachers and pre-service science teachers, *inferential statistics* would need to be used. Inferential statistics “provides those techniques that allow us to infer the characteristics of a population from sample data” (Russo, p. 10).

Pre-Service Teachers’ Curriculum Emphases Surveys

The statistical data collected from the curriculum emphases surveys are tabulated and presented in Table 6. Pre-service teachers ranked, respectively, Everyday Coping, Science, Technology, and Decision, and Structure of Science as their top three emphases to focus on in a classroom. Another interesting finding from this data was the low priority given to the emphasis Solid Foundation.

Novice Teachers’ Curriculum Emphases Surveys

The statistical data collected from the novice teachers are calculated and presented in Table 7. Novice teachers ranked, respectively, Everyday Coping, Structure of Science, and Science, Technology, and Decision as their top three emphases to focus on in a classroom. The emphasis that got ranked with the lowest priority by novice teachers is Solid Foundation.

Experienced Teachers' Curriculum Emphases Surveys

Experienced teachers' quantitative data was computed and shown in Table 8. Experienced teachers ranked Structure of Science, Everyday Coping, and Science, Technology, and Decision as their top three emphases, respectively, to focus on in a classroom. The emphasis Solid Foundation was ranked the lowest by experienced teachers.

Curriculum Leader's Curriculum Emphases Survey

The rankings of the curriculum leader are shown in Table 9. The final ranking showed a tie between the emphases Self as Explainer and Science, Technology, and Decision as being her top priorities. However, a closer look at the data revealed she ranked Structure of Science as her top priority in Set 1, while she ranked Self as Explainer as most important in Set 2 and Set 3. Interestingly, the emphasis Science, Technology, and Decision was ranked second, third, and third in all three sets of data respectively. The Science, Technology, and Decision emphasis was consistently ranked with high priority by the curriculum leader in all three sets. On the other end of the ranking was the emphasis Solid Foundation. This emphasis was consistently ranked with the lowest priority in all three sets by the curriculum leader.

Summary of Pre-Service, Novice, Experienced, and Curriculum Leader's Surveys

The general trend between the three groups of teachers revealed a tendency to prioritize Structure of Science, Science, Technology, and Decision, and Everyday Coping, in no particular order, as the emphases with high importance. In the final

Table 9

Ranks and Mean Absolute Difference for Curriculum Leader

n=1 participant

	Scientific Skill Development	**Structure of Science**	**Science, Technology, and Decision**	**Everyday Coping**	**Correct Explanation**	**Self as Explainer**	**Solid Foundation**
Emphasis Set 1 Rank	5	1	2	3	4	6	7
Emphasis Set 2 Rank	2	6	3	4	5	1	7
Emphasis Set 3 Rank	2	5	3	6	4	1	7
Mean Absolute Difference │Set 1 – Set 2│	3	5	1	1	1	5	0
Mean Absolute Difference │Set 2 – Set 3│	0	1	0	2	1	0	0
Mean Absolute Difference │Set 1 – Set 3│	3	4	1	3	0	5	0
Final Rank of Emphases	3	4	1.5	5.5	5.5	1.5	7

rankings, these three emphases were consistently ranked first, second, and third by all three groups of teachers. The three groups of teachers also consistently ranked Solid Foundation as their lowest priority when looking at the final ranking of each group

Since, the correlation between the three sets of data was not high. The final ranking of the three sets of data for each group of teachers does not represent a strong picture of the overall ranking of the emphases. Thus, it is more appropriate to look at data from each set and compare between the groups. The rankings of each set of data are presented in Table 10.

Survey data analyzed by sets. By looking at the data collected from each set, one can note some general trends. In Set 1, the emphasis Structure of Science was ranked as the highest priority by all three groups of teachers and the curriculum leader. On the other end of the spectrum, the emphasis Solid Foundation was ranked consistently low by all three groups of teachers and the curriculum leader in all three sets. The only exception to this low ranking was by the experienced teachers in Emphasis Set 2. The experienced teachers ranked the Solid Foundation statement in Set 2 as their fourth priority. However, the same emphases were ranked seventh and sixth by the experienced teachers in Set 1 and Set 3 respectively. The emphases Everyday Coping, Science, Technology, and Decision, Scientific Skill Development, and Self as Explainer were each ranked top priority by at least one group of participants in one of the sets of emphases.

A general trend emerges from the data presented in Table 10. The participants tend to prioritize the emphasis Structure of Science and place less importance on the emphasis Solid Foundation when compared to the other emphases. To help the reader

Table 10

Rankings of Set 1, Set 2, and Set 3 by Pre-Service, Novice, Experienced, and Curriculum Leader

n=71 (Total number of survey participants)

Groups of Participants	Number of Participant (n)	Everyday Coping	Structure of Science	Science, Technology, and Decision	Scientific Skill Development	Correct Explanation	Self as Explainer	Solid Foundation
Emphasis Set 1 Ranking								
Pre-service	15	5.5	1	3	2	5.5	4	7
Novice	25	4	1	5.5	2	5.5	3	7
Experienced	30	6	1	5	2	4	3	7
Curriculum Leader	1	5	1	2	3	4	6	7
Emphasis Set 2 Ranking								
Pre-service	15	6	4	2	1	3	5	7
Novice	25	7	2	4	1	3	6	5
Experience	30	7	1	3	2	5	6	4
Curriculum Leader	1	2	6	3	4	5	1	7
Emphasis Set 3 Ranking								
Pre-service	15	3	4	1	2	5	6	7
Novice	25	2.5	4	1	2.5	5	7	6
Experience	30	1	2	3	4	5	7	6
Curriculum Leader	1	2	5	3	6	4	1	7

better understand the statistical data presented in Table 10, a graphical analysis is presented in the next section to provide readers with a visual representation of the quantitative data.

Graphical analysis. Graphical analysis is a statistical method that is used to organize data with visual aids to help readers understand the data as presented in Figure 1, Figure 2, and Figure 3. As previously mentioned, the low correlation between the statements that were under the same emphasis required the researcher to analyze each set of statements individually. The three figures represent the trends of how curriculum emphases were ranked by the three groups of teachers in each emphasis set.

Each group of teachers ranked the emphases in different order for each of the three sets of statements. For example, the pre-service, novice, experienced teachers, and curriculum leader ranked the emphasis Everyday Coping 5.5, 4, 6, and 5 respectively in Set 1 which indicate this emphasis is ranked near the middle. However, in Set 2 the same group of teachers ranked the Everyday Coping emphasis 6, 7, 7, and 2 respectively suggest this emphasis is low by the teachers, but high by the curriculum leader. The statements in Set 3 yielded a ranking of 3, 2.5, 1, and 2 respectively showing high importance on the ranking order for the emphasis Everyday Coping. Differences such as these indicate the statements do not correlate strongly, meaning the statements were not interpreted as the same emphasis by the teachers. This is supported numerically by the MAD values, as previously discussed.

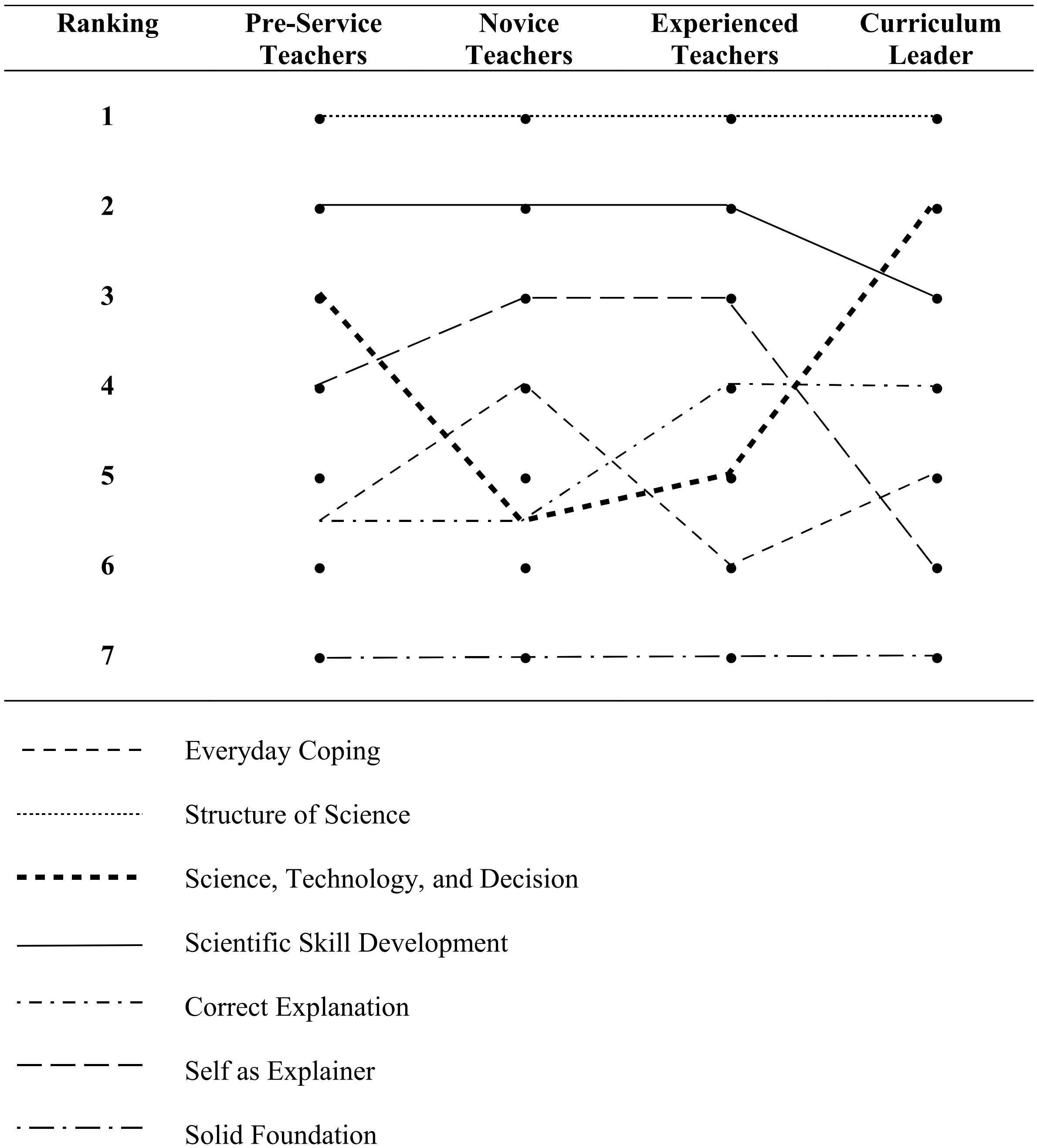

Figure 1. Graphical Analysis of Curriculum Emphases Set 1 of Pre-Service, Novice, Experienced Teachers, and Curriculum Leader

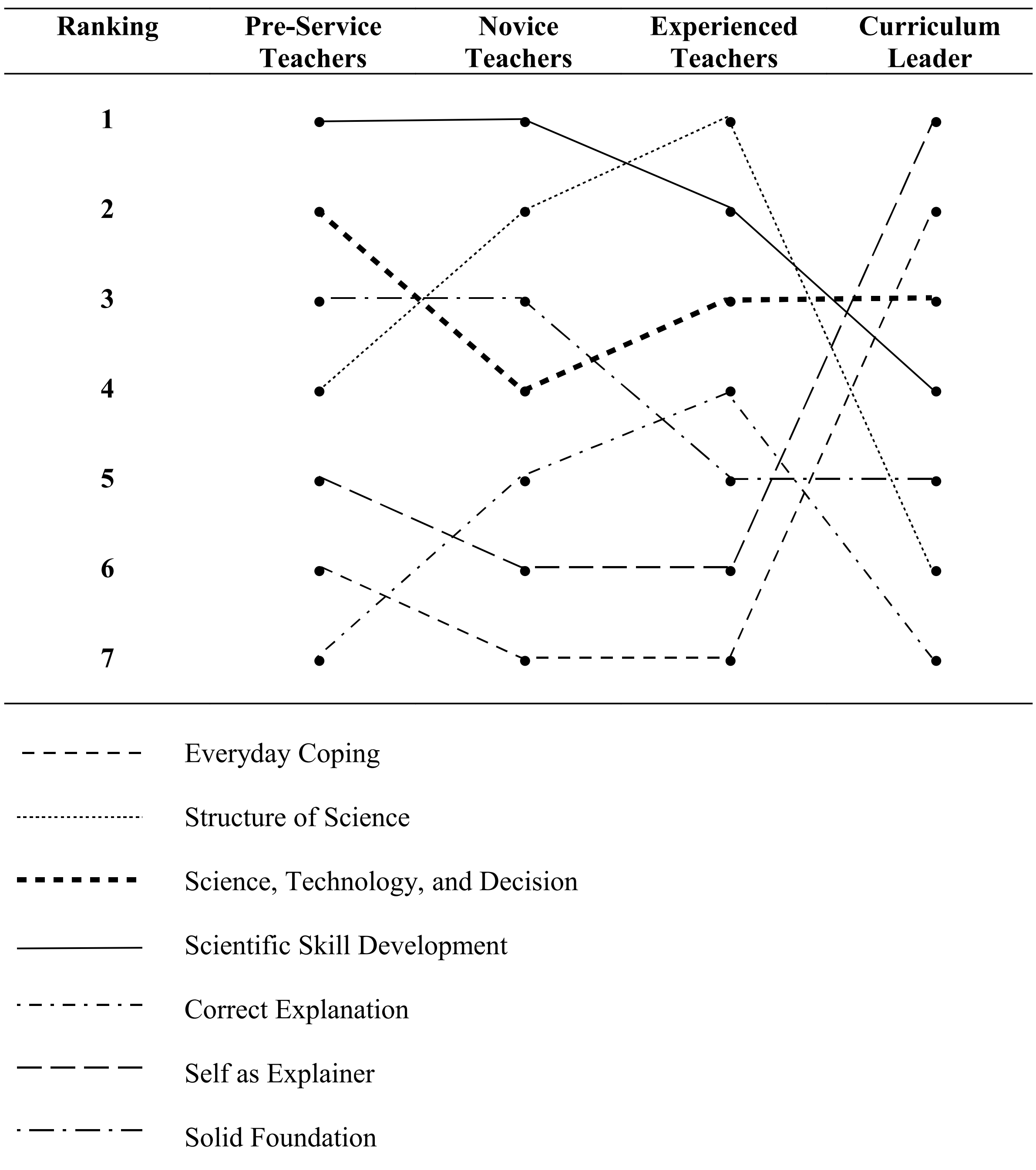

Figure 2. Graphical Analysis of Curriculum Emphases Set 2 of Pre-Service, Novice, Experienced Teachers, and Curriculum Leader

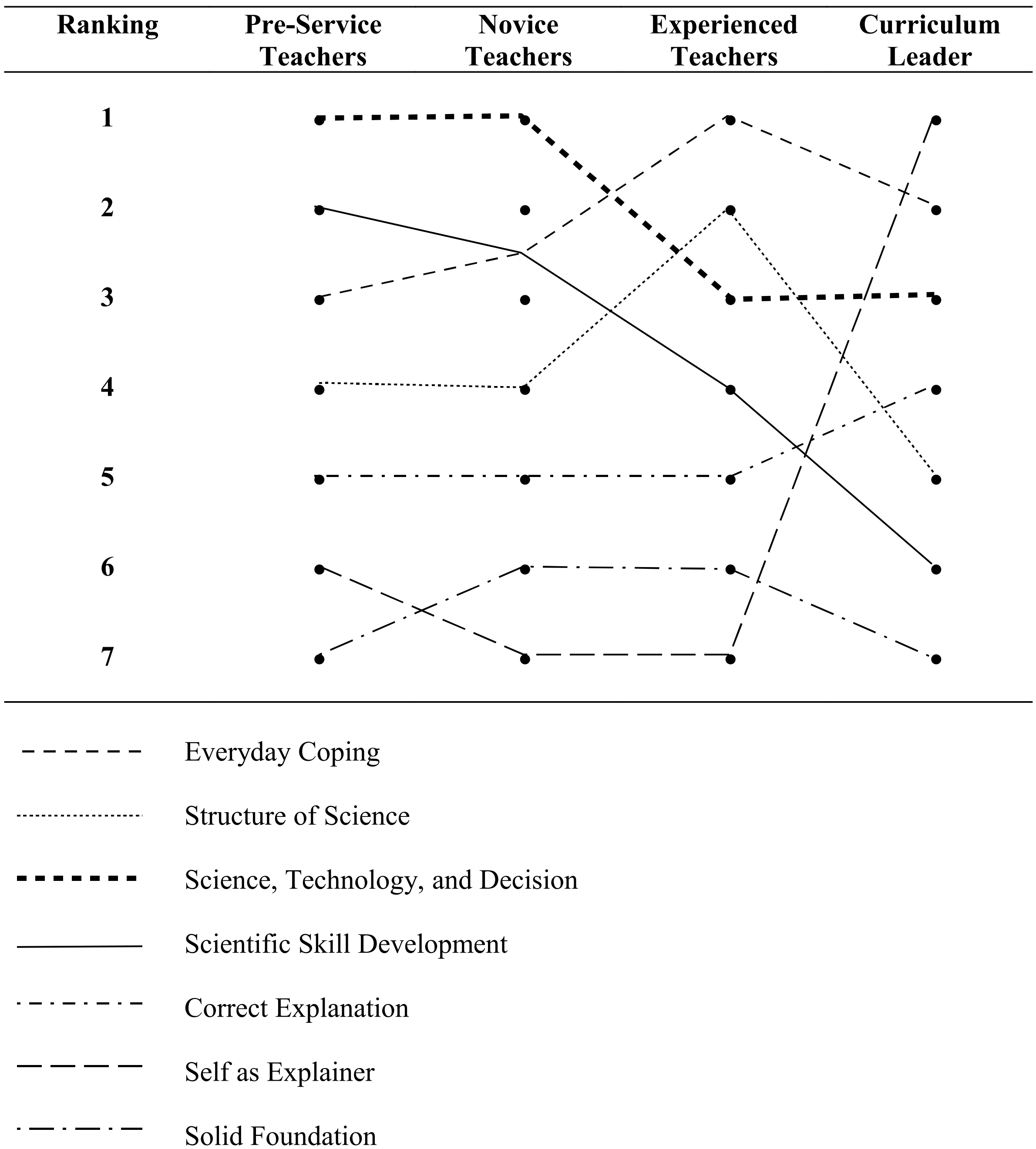

Figure 3. Graphical Analysis of Curriculum Emphases Set 3 of Pre-Service, Novice, Experienced Teachers, and Curriculum Leader

Since the emphases lines cross quite frequently in the each of the three sets of statements, no conclusive statements could be made regarding the exact rank order of the emphases by the participants. However, general trends can be noted regarding how specific emphases were ranked.

The emphases Structure of Science, Science, Technology, and Decision, Scientific Skill Development, and Self as Explainer were consistently ranked higher by the groups in all three sets indicating the participants believed these emphases are relatively important when compared to the other emphases. Interestingly, in Set 1 the participants ranked Structure of Science with high importance meaning they believe there is a need to focus on the *methods* used to scientifically solve problems more than the other emphases listed. Examples of the *methods* used in a science classroom may include problem solving, analytical, and laboratory skills needed to solve scientific problems.

On the other hand, the emphasis Solid Foundation was consistently ranked lowly on all three sets by all the participants. In fact, the four groups of participants all ranked this emphasis with the lowest importance in Set 1. To the participants of this study, having a vast amount of pre-knowledge and ideas about physics before they enter a physics classroom is not as important as having the ability to solve problems scientifically when compared to the other emphases presented.

Although the statements do not correlate *across* each set, the rankings *within* each set of statements do correlate relatively well. For example, in all three sets the participants ranked Scientific Skill Development similarly. In Set 1 Scientific Skill Development was ranked quite high, in Set 2 the ranking proved this emphasis was in the middle, and in Set 3 the ranking showed the emphasis was also in the middle. Of course there are anomalies in these results. For example, in Set 3 the emphasis Self as Explainer was ranked 6, 7, 7, and 1 by the pre-service, novice, experienced teachers, and curriculum leader respectively. The top ranking in the emphases Self as Explainer provided by the curriculum leader contrasts with the low priority given to this emphasis by the teachers. This finding is attended to in the discussion section.

The teacher participants tended to have similar rank orders of the seven curriculum emphases when the data was compared between each set of statements. This indicated the three groups of teacher participants: pre-service, novice, and experienced teachers ranked the seven emphases relatively similarly within sets.

This section of the data analysis described the quantitative data gathered with the curriculum emphasis survey using a graphical analysis. The next section explores the comparisons between each group of teacher participants and the curriculum leader's rankings obtained through the surveys.

Pre-service teachers' compared to curriculum leader's surveys. The pre-service teachers ranked Structure of Science, Scientific Skill Development, and Science, Technology, and Decision as most important in Set 1, Set 2, and Set 3 respectively. The curriculum leader only ranked two emphases as top priority across the three sets of statements. Her top priorities were Structure of Science, in Set 1, and Self as Explainer, in Set 2 and Set 3. The common emphasis that was ranked with high importance between the pre-service and curriculum leader was the Structure of Science. On the other end of the ranking, pre-service teachers and the curriculum leader ranked Solid Foundation as their lowest priority in all three sets of statements. Although pre-service teachers and the curriculum leader were not identical in the emphases they considered most important, they were identical in prioritizing Solid Foundation as their least important emphasis.

Novice teachers' compared to curriculum leader's surveys. Novice teachers ranked their top priorities as Structure of Science, Scientific Skill Development, and Science, Technology, and Decision in Set 1, Set 2, and Set 3. This prioritizing is identical to the rankings provided by pre-service teachers. The curriculum leader ranked Structure of Science, in Set 1, and Self as Explainer, in Set 2 and Set 3, as her top priorities. Although the curriculum leader ranked Solid Foundation as the lowest priority for her, this perspective was not the same as novice teachers. Novice teachers ranked Solid Foundation, Everyday Coping, and Self as Explainer as their lowest priority in each set respectively.

Worth mentioning is the direct clash of perspectives between the novice teachers and the curriculum leader in Set 2 and Set 3. In Set 2, novice teachers ranked Everyday Coping with a seven, while the curriculum leader ranked it with a two. Within the same set of statements the emphasis Self as Explainer was ranked by novice teachers to be six, while the curriculum leader ranked it number one. Thus, within Set 2, novice teachers prioritized Everyday Coping and Self as Explainer with low importance, while the curriculum leader ranked these emphases with high importance. The most contrary ranking between the novice teachers and the curriculum leader was in Set 3, where novice teachers ranked Self as Explainer with a seven and the curriculum leader ranked this emphasis with a one.

Although there are discrepancies between which emphases the novice teachers and curriculum leader ranked as important, both groups ranked Solid Foundations relatively low.

Experienced teachers' compared to curriculum leader's surveys. Experienced teachers ranked, as their top prioritizes, Structure of Science, in Set 1 and Set 2, and Everyday Coping, in Set 3. The curriculum leader ranked the Structure of Science, in Set 1, and Self as Explainer, in Set 2 and Set 3, as her top priorities. The emphasis Solid Foundation was ranked quite low by both groups in all three sets.

Although the top, Structure of Science, and lowest, Solid Foundation, rankings between experienced teachers and the curriculum leader are identical in Set 1, this varied in Set 2 and Set 3. In Set 2, experienced teachers ranked Everyday Coping and Self as Explainer as their lowest two emphases while the curriculum leader ranked these emphases her top two. On the flip side, in the same set, experienced teachers ranked Structure of Science as their top priority, while the curriculum leader ranked that emphasis with a six, indicating the low priority of that emphasis for the curriculum leader. Interestingly, in Set 3, the same discrepancy seen with the novice teachers were also seen with the experienced teachers, in that experienced teachers ranked Self and Explainer as their lowest priority, while the curriculum leader ranked this emphasis her top priority.

Even though experienced teachers ranked Solid Foundation with a four in Set 2, it is possible to see a general trend that there are similarities between experienced teachers and the curriculum leader in terms of ranking Solid Foundation with low priority.

Results of Open-Ended Survey Question

The open ended question at the end of the survey provided teachers with a place to write about what aspects of the program-of-study they believed to be the most important. In this section of the survey, teachers could provide information regarding aspects of the program-of-study they believed to be important in their own words without the constraints of the pre-determined seven curriculum emphases framework.

Although many participants left open-ended comments at the end of their survey, some participants choose to not leave any responses. Some participants who left responses in the open-ended survey question also seemed to misinterpret the intent of the question. Their statements such as those, for example, focusing on "kinematics [and] dynamics" (Participant 51) were not relevant to answer the research questions of this study. The focus of this study was to determine the *aspects* of the program-of-study that teachers emphasize and not the *units* of emphasis. Hence, less data that was relevant was collected from the open-ended response section of the survey than expected.

The data collected from this section of the survey were organized into the pre-service, novice, experienced teachers, and curriculum leader. Once the comments were separated into their respective groups, they were categorized using Roberts' seven curriculum emphases as a framework. From there, an analysis of which emphasis had the most comments was undertaken to determine which of the seven emphases teachers believed were most important. It should be noted that an eighth category was created for comments that did not fit into the framework of Roberts' seven science curriculum emphases.

Pre-Service Teachers' Open-Ended Survey Question

Some of the comments pre-service teachers provided at the end of the curriculum emphases survey included descriptions of *student engagement,* Structure of Science, and Correct Explanation. The focus of *student engagement* is an aspect that pre-service teachers mentioned, but not part of the emphases framework, while the emphases Structure of Science and Correct Explanation comes from the framework of Roberts' science curriculum emphases. The idea Structure of Science which fits into Roberts' framework was also heard through the survey rankings by the pre-service teachers. For example, Participant 107 ranked Structure of Science as a top priority during the curriculum emphases survey and also stated it was important "for students to go through the scientific process". Although the participant did not explain what they meant by *scientific process*, it was interpreted by the researcher to mean problem solving skills.

The idea of *student engagement* was present in comments highlighting the importance of teaching "fun and interesting topics that can be demonstrated" (Participant 106) and in performing "physics labs to help engage students" (Participant 112). The comments from pre-service teachers also showed they placed priority in "producing critical student[s] who will have interest in learning about current investigations in science" (Participant 103). In other words, a major focus of the pre-service teachers was to provide students with hands-on activities that "related to attitude and interest outcomes and enhances understanding of knowledge" (Participant 109).

Some pre-service teachers made specific mention of focusing on Correct Explanations. Some pre-service teachers focused on "knowledge outcomes [because they] feel the pressure to cover it" (Participant 104) as there is a demand from parents and students to prepare them for different assessments and post-secondary education. The comments from pre-service teachers included technical terms, such as "nature of science" (Participant 115) or "scientific inquiry" (Participant 109), terms that are not used regularly in a science classroom. The fact that these pre-service teachers were taking teacher education courses at the University may have played a role with their ideologies and choice of phrases.

This section discussed the open-ended survey question results from the pre-service teachers showing a focus on *student engagement*, Structure of Science, and Correct Explanation. The idea of *student engagement* was mentioned in five out of nine open-ended survey responses. The importance of Structure of Science was confirmed using the survey rank order as this emphasis was ranked first overall by the pre-service teachers. However, the emphasis on Correct Explanation was not strongly supported by the rank order because this emphasis was ranked fourth by these teachers. The next section outlines the results provided by the novice teachers.

Novice Teachers' Open-Ended Survey Question

The comments left by novice teachers did not specifically use the terminology of Roberts' science curriculum emphases framework. Their comments were interpreted hermeneutically by the researcher to represent those emphases. Many comments from novice teachers suggested they focused on the emphasis Structure of Science and Correct Explanation. These emphases were supported by the novice teacher's survey rankings. For example, Participant 40 ranked Structure of Science as their top priority and their open-ended comments revealed a need to "critically evaluate situations based on scientific principles" used to solve real life problems. The ideas of "questioning skills, inquiry, and problem solving skills" were also listed as areas of focus on by Participant 57, who also ranked Structure of Science as their most important emphasis. However, there were comments that exceeded the framework of the seven science curriculum emphases, such as those related to a *holistic* view of physics. The idea of viewing physics as a whole includes being able to recognize the many links between units and understand the unifying concepts to view physics as one big idea. For example, most of the units covered in Physics 20 , kinematics, dynamics, circular motion and gravitation, and waves, are linked with the concept of conservation of energy. Many of the comments from the novice teachers also circled around the ideas of "demos, real life examples, technological applications, labs" (Participant 5) to help "problem solve" (Participant 7) and improve "conceptual understanding of theories" (Participant 9). One participant talked about a focus on "inquiry approach" as a method "to attach a problem with scientific thought and process" (Participant 30), which is interpreted as reflecting the emphasis Structure of Science. Some novice teachers talked about viewing physics *holistically* by focusing on "linking concepts studie[d] in one unit to the next so that students 'see' that there is a relationship between info[rmation] studie[d] in one unit to the next and begin to develop 'big picture' thinking" (Participant 39, sic). A few novice teachers such as Participant 67 comments reflected their priority of Correct Explanation by focusing on "knowledge outcomes of the program-of-study… to prepare [students] for the diploma exam". Participant 67 also ranked Correct Explanation as one of their top priorities, hence indicating a certain level of validity in the survey.

The open-ended survey question allowed novice teachers to voice their focus on understanding theory, problem solving, and real life applications. However, there were a few teachers who also expressed the Physics Diploma Examination as a focus that drives the physics courses they teach. As previously mentioned, the Diploma Examination sends a strong signal about what is to be taught in physics courses across Alberta.

Experienced Teachers' Open-Ended Survey Question

The emphasis Structure of Science was found to be quite pronounced in the open-ended comments provided by the experienced teachers. This emphasis was also ranked as a top priority by the experienced teachers in their survey rankings. For example, Participants, 9, 11, and 29 all ranked the emphasis Structure of Science as their highest priority. In fact, participant 29 ranked the Structure of Science as their top priority in all three sets. The comments left in the open-ended survey question supported the top ranking of Structure of Science with statements that focus on "conceptual understanding of theories" (Participant 9) that help students "better understand the scientific process" (Participant 29). Participant 11 stated they "focus on understanding of concepts. Why something works is more important than how it works". Statements like these support the emphasis Structure of Science, which these experienced teachers ranked as their top priority.

Experienced teachers also left comments that showed the researcher, these teachers focus on viewing physics *holistically*. Although teachers did not specifically use the language Roberts' seven science curriculum emphases in their responses, their comments were hermeneutically interpreted by the researcher to reflect the emphasis

Structure of Science. Many experienced teachers talked about this emphasis as being a high priority in their classrooms because they believed they focused their students on "application, [and] problem solving" (Participant 63) and an "investigation, planning/designing" (Participant 29). As part of the definition of Structure of Science, as defined by Roberts, students have to be able to see the "relationships and interrelationships between different concepts" (Participant 6) and to form different "applications of knowledge" (Participant 38) gained from their investigations.

The open-ended comments left by the group of experienced teachers tended to, "focus most on understanding of concepts. Why something works is more important than how it works. Students can learn knowledge by themselves but connecting the big picture is what they need help with, *linking ideas*" (Participant 11). An experienced physics teacher stated they do not "place a lot of value on memorized, rote learning [instead, they] emphasize the importance of applying knowledge to new situations, understanding science as a human construct that is a useful way of viewing/understanding the world" (Participant 73). Comments like the ones provided by Participant 11 and Participant 73, suggested experienced teachers focus on a *holistic* view of physics. The open-ended survey questions provided experienced teachers a chance to further explain the data they provided regarding their prioritization of the Structure of Science and relationships within the physics program-of-study as aspects they value. The open-ended survey question response of the curriculum leader is presented in the next section.

Curriculum Leader's Open-Ended Survey Question

The open-ended question at the end of the survey allowed the curriculum leader, Lisa, to elaborate on her focus without the constraints of the seven science curriculum emphases framework. Although her response was short and provided minimal insight into her focus of the program, it was direct and to the point. In her answer she revealed her focus as being on "STS → relevance to science, technology, and society are vital for all learners". This idea of focusing on STS, science, technology, and society, is further supported by her rankings of the three sets of statements because the emphasis Science, Technology, and Decisions was ranked two, three, and three, i.e. relatively high, in each set of statements respectively. These ranking indicated and confirmed relatively high importance of this emphasis by the curriculum leader.

Summary of Pre-Service, Novice, Experienced, and Curriculum Leader's Open-Ended Survey Question

Using an open-ended questions at the end of the survey allowed participants to express their focus of the program-of-study without the constraints of Roberts' curriculum emphases framework. This section of the survey allowed teachers to bring the researcher's attention to aspects such as *holistic* views of physics, which were mentioned as a focus of novice and experienced teachers that lie outside the pre-determined emphases framework. The idea of *student engagement* was also mentioned as a priority from pre-service teachers in their open-ended comments.

Using Roberts' framework pre-service, novice, and experienced teachers mentioned the emphasis Structure of Science as being of high priority. The ideas behind the emphasis Correct Explanation were also highlighted as being important by pre-service and novice teachers. Interestingly, the curriculum leader only mentioned the emphasis Science, Technology, and Decisions in her open-ended survey question as being an aspect of focus in the program-of-study. The next sections compare the open-ended survey responses between pre-service, novice, and experienced teachers to those of the curriculum leader.

Pre-service teachers' compared to curriculum leader's open-ended survey question. Through the open-ended survey question pre-service teachers left comments that suggested they focused on the emphases Structure of Science and Correct Explanation. The comments left by the pre-service teachers also spoke of a focus on *student engagement* which was not part of Roberts' framework. These priorities were different than the focus of the curriculum leader in the open-ended questions section of the survey where she only spoke of focusing on Science, Technology, and Decision.

Novice teachers' compared to curriculum leader's open-ended survey question. Similar to the pre-service teachers, novice teachers also focused on the emphases Structure of Science and Correct Explanation. Outside of Roberts' framework, novice teachers' comments suggested they also focus on a *holistic* view of physics. The view of the curriculum leader was of a focus on Science, Technology, and Decision. Thus, the priorities of the novice teachers and curriculum leaders' in the open-ended survey question did not match.

Experienced teachers' compared to curriculum leader's open-ended survey question. Experienced teachers tended to focus their comments towards the emphasis Structure of Science. They also mentioned the importance of viewing physics *holistically*, which is a view that lies outside of Roberts' framework. However, these comments did not match those provided by the curriculum leader who focused her comments towards the emphasis Science, Technology, and Decision.

Summary of Open-Ended Survey Question

Since the curriculum leader only spoke of the emphasis Science, Technology, and Decision as being an important focus, her results from the open-ended survey question did not match those from the pre-service, novice, and experienced teachers. The teacher participants spoke of focusing on a variety of emphases and aspects such as Structure of Science, Correct Explanation, *student engagement*, and *holistic* views of physics.

Results of Interviews

Of the physics teachers that filled out the survey, ten participants volunteered contact information and five of them were interviewed to further understand their focus on the physics program-of-study. Of the five interview participants: two represented the novice group, two represented the experienced group of physics teachers, and one represented a curriculum leader from the Curriculum Branch from Alberta Education. Unfortunately no participants from the pre-service group were available for an interview. Thus, data collected in this section of the research only pertain to the two novice and two experienced teachers and the curriculum leader who were interviewed. It is important to note these interviews are a convenience sample and are not necessarily representative of the group they were members of. Therefore, the perspectives and emphases the interview participants voice may only be relevant to their experiences and views. More interviews employing a hermeneutic cycle (Guba & Lincoln, 1989, 1997) would be necessary to gain representative data from interviews. Triangulation between the survey and interview responses will be attended to later in the discussion section.

Novice Teachers' Interviews

James and Fred were the pseudonyms given to the two novice teachers who volunteered for interviews. James and Fred provided more in-depth responses regarding their preferences of the aspects of the physics program-of-study they believed is important. An analysis of the interviews with the two novice teachers showed a tendency for them to prioritize Scientific Skills Development and Structure of Science by focusing on *transferability* through skills and improving *student engagement* through interesting examples and making content relevant to students' lives. James and Fred suggested the ideas of Scientific Skills Development is the preface for making physics *fun* for students. These predominant emphases of those two participants are now discussed.

Scientific skills development: Transferability through skills. Both the novice teachers, James and Fred, spoke of focusing on skills that are transferable to other areas of students' lives. In fact, Fred ranked Scientific Skill Development as his top priority in the survey rankings. When James and Fred were asked to elaborate on the type of skills they were referring to, a variety of explanations surfaced. Fred referred to the basic skills students should have in physics as “setting up proper investigation and [knowing] what kind of question you need to ask, and what variables you should be manipulating to get… [to the answer] right”. An elaboration of the Fred’s priorities in a classroom revealed he might “spend a quarter of the time to teach [students] the basic” skills “like significant digits, like the basic trigonometry, so skills like, formula manipulation and basic math skills [students] need for physics class”

An elaboration of the focus teachers should have in their classroom revealed Fred’s definition as mandatory math skills required for physics. Fred also reported a focus on explanations and communication skills as important, suggesting that students need “the explanation part, because if they don’t have the explanation part then it doesn’t make sense if you’re just putting in numbers in a calculator”. James referred to skills as including analytical problem solving and laboratory skills that students would be able to use outside of the physics classroom in addition to Fred’s definition. According to Fred and James, the types of skills students learn in physics should also be applicable to other courses and used in different situation in students’ lives. Although each novice teachers’ definition of skills differed slightly, they both agreed one of the main goals of a physics teacher is to provide opportunities to increase student engagement by making the course fun and approachable.

Scientific skills development: Transferability through student engagement. Both James and Fred agreed that students need to be engaged with the course and be able to take certain aspects of the course out of the classroom. James and Fred mentioned they tried to focus on a variety of methods to keep students engaged on the course. James tried to engage students through “something they’ve heard about, whether it’s a helicopter, or a spaceship, or whatever”. An underlying theme between the novice teachers was to make the course fun for students because, as James says, “anytime you have a practical problem instead of a theoretical one, there’s a lot more room for engaging students”. James also explained the reason behind his idea of transferability. He suggested as students are interested and engaged in a course, they will remember what they learned from the program and “perhaps transfer… [that knowledge] to other avenues of life”. This idea of transferability of knowledge through skills and student engagement supplements the idea of focusing less on knowledge content. According to James and Fred, putting a high priority on skills and other methods of acquiring knowledge, such as laboratory applications, helps to engage students so they may find the course fun and applicable to their lives. The next section will discuss the idea of novice teachers focusing less on knowledge outcomes of a program-of-study.

Less focus on correct explanation. James and Fred made it extremely clear that content knowledge was important for students to learn because of summative course assessments. According to Roberts’ seven curriculum emphases framework, this aspect of the program-of-study corresponds to the Correct Explanation emphasis. Correct Explanation does not direct the course to be solely based on knowledge and content. James and Fred recognized the importance of teaching transferable skills that students can apply to their lives. As Fred pointed out, “in science… there’s a ton of material” that needs to be understood. James furthered this idea by referring to content knowledge as “stuff the kids… a year later wouldn’t remember from the program or rather not remember" because it is associated with impersonal memorized content according. According to James, this impersonal nature of content makes it difficult to grasp and remember for applicable situations outside of the classroom and tough to help keep students engaged in the subject. Although the interviews revealed an importance for James and Fred to focus less on Correct Explanations, their survey rankings painted a slightly different picture. While James ranked Correct Explanations sixth on the survey, Fred ranked this emphasis second. In the open-ended comment section, both Fred and James mentioned focusing on topics such as "kinematics" (James) and "Newton's Laws" (Fred). Their open-ended comments missed the intentions of the question, and hence do not provide reliable data to help answer the research questions.

Experienced Teachers' Interviews

The two experienced teachers were given pseudonyms Dillon and Brad. Both Dillon and Brad had been physics for more than ten years and had experience teaching both Physics 20 and 30, extensive experience working on the planning and writing stages of the physics program-of-study, work on the Physics 30 Diploma assessments, as well as being recognized as outstanding teachers by the Assessment Branch of Alberta Education by being appointed as head markers. The recurring themes that emerged from their interviews were the ideas of Structure of Science and *holistic* views of physics. The emphasis Structure of Science was ranked as Dillon's top priority and Brad's second priority in their survey rankings. Indicating the high importance these two teachers placed on this emphasis. In fact, Brad's open-ended comments stressed the importance of focusing on "problem solving [that] can be used later in life".

Structure of science: Transferability of higher level processes. Transferability of higher level processes refers to being able to apply, or transfer, physics skills learned in the classroom to situations to the world outside of the classroom. Using Roberts' seven science curriculum emphases as a framework and in the classroom, this is interpreted as falling under the emphasis of Structure of Science which refers to developing general problem solving skills that can be applied to many different situations. The definition of Structure of Science is considered to be a contested ground. For example, Hodson promotes this idea as talking *about* science instead of imitating "a real scientific experiment in the activity of *doing science*" (1993, p. 50). Roberts, however, defines this emphasis as an understanding of how the world of science works, promoting the idea of problem solving and adding to the existing body of knowledge. This idea of transferring scientific problem solving methods, Structure of Science, was one of the main foci in the interviews with Dillon and Brad as well as open ended comments from experienced group of teachers at the end of the surveys. The interviews revealed when students are able to apply the knowledge and skills they learned in the classroom that was considered by this group to be a sign of the students truly learning the material. This idea was supported by the Dillon's open-ended comments of needing students to "understand science as a human construct that is a useful way of viewing/understanding the world". Brad further clarified this idea of transferability by defining the skills associated with higher level processes as:

> … organizational skills, the skill to be able to look at stuff, the skill to be able to take a problem and break it down and think about what's going to occur and run it through a logical and correct process.

This definition of skill from Brad falls under Roberts' emphasis Structure of Science because it involves higher mental activities such as logically breaking down and solving a problem. The emphasis Scientific Skill Development would focus on student being able to perform manual tasks such as performing the laboratory or data collection. Brad referred to the biggest concept in teaching as providing students with "strategies they can use throughout their lives… teaching content is something that we do to teach those skills". When students leave the safety and comfort of their high school physics classroom and into a business opportunity or post-secondary institution, very seldom are people going to ask them about Newton's 3rd law. They are usually more interested in whether this student is able to solve a problem, hence being able to apply their skills. The focus of *transferability* supports the experienced teachers' survey rankings as well as the open-ended questions which focused on the emphasis Structure of Science. The next section discusses the ideas of *connectivity* between units in physics.

Connectivity between units. From the interviews, a recurring theme was a move away from memorized facts and towards looking at physics as a big picture. This idea of viewing physics as a large interconnected piece of science is one of the main motivations behind making connections between units. As Dillon claimed,

> We [a]re not here to memorize facts. We [a]re here to make connections, so we see this knowledge and skills and attitude, that we [a]re developing a course as an interconnected whole, so that we [a]re not putting all this information into little pigeon holes that are independent of each other, it [i]s one big mass and we [a]re trying to make it as many connections as we can.

Dillon and Brad both agreed that content knowledge was not a priority for them when teaching physics because the subject itself requires students to have a handful of ideas that they can connect together and apply them appropriately. This application of physics knowledge focuses on more than just knowing the content itself. Dillon stated "in physics in particular we can't ignore the science process, rather than straight memorization" to support his claim that the *holistic* view of physics is more important than content knowledge. He elaborated on this idea by drawing on his familiarity of other physics teachers by saying "most physics teachers that I know like the subject because you need a handful of ideas and then you apply them every which way, it's more about the application than the straight recall". Dillon recalled courses where students had memorized straight content, and that there was a tendency for them to forget all the knowledge they memorized when they finished writing the final exam. In those cases, the students did not benefit from taking those courses. Dillon believed courses where students tried to make the subject matter personal and made the "connections… to understand what [i]s going on in a broader way [rather] than to memorize the atomic mass of carbon" had more impact on students. The idea of viewing physics as a big picture lends itself to the idea of applications of classroom content to other skills outside of the classroom.

Curriculum Leader's Interview

The main focus that arose from the interview was the idea of *student engagement* through Scientific Skills Development. Making problems personal to students would help keep students engaged in their physics courses, thus making them want to learn about the subject. Lisa believed education is to

> open the doors for students to have experiences which then allow[s] them to make *decisions* so they can go further with their learning because it [i]s a life-long process so it should be about turning kids on to ideas and places they may want to pursue (italics added)

According to Lisa a skillful teacher is one that is:

> able to organize a classroom where students will have different opportunities for engagement. In other words, in different levels of learning or in different application of the learning; so not everything will fit for all the students, but there will be a big enough buffet for them to give them those opportunities to really learn and engage in ways that are most meaningful for them

Lisa's perspective of the program-of-study was one where *student engagement* is the key to developing problem solving skills that are applicable to issues outside of the classroom and retention of material learned in class. Teachers, according to Lisa, are essential to the success of the program-of-study and they need to be willing to accept the idea of change to improve their practice and be able to keep up with the different needs of students. When asked about the curriculum and program-of-studies, Lisa made it very clear that the program-of-study is “a document that outlines the particular outcomes that would be taught and learned in classrooms in Alberta”. She stressed the importance for teachers to bring the curriculum-as-lived to the classroom through interactive lessons which students are able to find engaging.

Although, the term Scientific Skills Development was not used explicitly during the interview, Lisa mentioned the focus to “figure out” problems and take a “hands on and outdoors [approach], and being able to experience living things in their natural environment” as being important for not only herself, but also for students and teachers. These intimations were interpreted as being what Roberts refers to as Scientific Skills Development within the framework of curriculum emphases. However, when the curriculum leader’s interview was compared to her survey ranking and open-ended comments, the responses did not complement each other. For example, Lisa ranked Structure of Science and Self as Explainer as her top priorities in her survey ranking. She mentioned a need to focus on Science, Technology, and Decision in her open-ended comments. In her interview, it was interpreted by this researcher that her focus was on Scientific Skills Development. For the curriculum leader, there was no overlap between the survey rankings, open-ended comments, and the interview data. This was quite surprising and unexpected as it was expected that there would be some consistency between the three types of data. However, in all three sets of the curriculum emphases survey ranking, Lisa ranked Solid Foundation as her lowest priority. This was, to some extent, the only consistency in the data provided by the curriculum leader.

It is important to be reminded that the process of curriculum development is collaboration between teachers, government officials, university professors, and other stakeholders. For the purpose of this study, only one curriculum leader was interviewed, therefore her comments are, perhaps not the best, representation of the Curriculum Branch of the Alberta Education. However, the researcher refers to her comments as representative of the Alberta Education as this is where she is currently employed. Further, Lisa was the key member of science curriculum development team with respect to the Physics programs of study, and the only person from Alberta Education who could provide the type of information and data that was relevant for this study. This is an area of the research that could have been improved if it was possible to have the whole curriculum development team as representatives of the government instead of a single curriculum leader, as was the case for this study. However, this was not possible because there is not a whole team employed by Alebrta Education to oversea the Physics Program of Study. The next section compares the differences and similarities between novice and experienced physics teachers' perspectives with those of the curriculum leader.

Summary of Novice, Experienced, and Curriculum Leader's Interviews

An analysis of novice physics teachers', James and Fred, priority of the program-of-study revealed the emphasis Scientific Skills Development was an important focus for them. The novice teachers interviewed defined the Scientific Skills Development emphasis as the *transferability* through skills and *student engagement*. The two novice participants also mentioned placing less priority on the emphasis Correct Explanations.

Experienced teachers, Dillon and Brad, prioritized the emphasis Structure of Science as the most important aspect of the program-of-study. This emphasis was defined by the two teachers to be the *transferability* of skills as well as the *connectivity* of physics ideas.

The curriculum leader, Lisa, made it clear that a main focus for her and the Curriculum Branch of Alberta Education was Scientific Skills Development. She described this emphasis as depending heavily on, or perhaps a way of, *student engagement*. In her mind, when students are engaged with a problem, they are more inclined to learn the scientific methods required to solve the problem as well as retain the information long after they have left the classroom. Lisa made several mentions of the importance of *student engagement* in the classroom, hence indicating this aspect of the program-of-study was particularly important to her. Lisa's views from her interview tended to be more similar to those of Fred and James, both groups agreed on focusing on Scientific Skill Development and *student engagement*. However, Lisa did not have similar perspectives of the program as Dillon and Brad.

Novice teachers' compared to curriculum leader's interview findings. There are similarities between novice teachers and the curriculum leader in their priorities of emphases and aspects of the program-of-study. Both groups agreed on the high importance of the emphasis Scientific Skills Development through *student engagement*. On top of this agreement between the two groups, novice teachers also spoke about the need to focus on the transferability of skills. The skills that the novice teachers referred to ranged from problem solving skills to basic mathematical skills. Novice teachers also made explicit mention of focusing less on the emphasis Correct Explanation. The novice teachers and the curriculum leader agreed on focusing on the emphasis Scientific Skills Development through *student engagement*.

Experienced teachers' compared to curriculum leader's interview findings. Experienced teachers focused on the emphasis Structure of Science through the *transferability* of skills and *connectivity* of physics concepts. The curriculum leader focused on the emphasis Scientific Skills Development through *student engagement*. Although there were no noticeable overlaps between the experienced teachers and the curriculum leader's priorities of emphases, interviews with both suggested that it was important to create a learner who can take personal classroom lessons and transfer them to other aspects of their life.

Conclusion

The results of experienced, novice, and pre-service teachers' perspectives were analyzed and compared. Surveys were compared using MAD tables and each set of data was compared individually. From the quantitative data obtained from the surveys, it was concluded that all three groups of participants prioritized the emphases Structure of Science as being more important than the other emphases. This conclusion was further supported by the open-ended survey data as many teachers disclosed the importance of scientific problem solving skills that are transferrable to other aspects of a student's life, which is consistent with Roberts' emphasis Structure of Science.

Through the curriculum emphases survey rank order and the open-ended survey question all three groups agreed that one of the more important aspects of the program-of-study that should be prioritized is the Structure of Science. The interview data supported the quantitative survey data in suggesting that teachers place a high priority on the Structure of Science emphasis because of its transferability to other aspects of students' lives. However, the interview data revealed subtle differences between the different groups of participants as the definitions of the type of skills to be transferred. Experienced teachers like Dillon and Brad defined skills to be high process analytical problem solving skills. James and Fred's, the novice teachers, description encompassed mathematical skills and technical laboratory skills as well as analytical problem solving skills. James and Fred both made the point that students need to find physics fun and engaging for them to be successful in the course.

There was consensus between the three groups of teachers that the emphasis Solid Foundation should have less priority over the other science curriculum perspectives. However, all seven perspectives can be viewed as important and teachers' preferences might be subject to change depending on their experiences and mind set at a particular time. If the same survey were given to the same teachers, different rankings might arise because each teacher may have changed.

The overall ideologies and perspectives between the three groups of teacher participants, experienced, novice, and pre-service teachers, are quite similar. The differences between the groups are minor and could be due to each teacher's different interpretation of the statements and terms, such as the definition of *transferable skills*. The differences between Dillon and Brad, the experienced teachers, and James and Fred, the novice teachers, are that Dillon and Brad prioritized on the ideas of connectivity between units and transferability of higher level processes while James and Fred preferred the ideas of transferability through skills and student engagement. The curriculum emphases surveys, open-ended survey questions, and interviews converged on the importance of the Structure of Science as a key curriculum emphasis.

When the results from the three groups of teacher participants were compared to the curriculum leader, several differences were noticed. In the survey rankings Lisa ranked Self as Explainer as her top priority in two of the three sets, while no teacher groups ranked or mentioned this emphasis as a priority in the three forms of data collected. Some similarities between the teacher groups and Lisa appeared in her open-ended response she stated a focus on the emphasis Science, Technology, and Decision, which was ranked as a top priority by the pre-service and novice teachers. Through Lisa's interview data, it was interpreted by this researcher that she tended to focus on Scientific Skills Development and *student engagement*, which were similar to the foci of Fred and James, the novice teachers. Overall, Lisa tended to agree more with the pre-service and novice teachers than the experienced teachers.

Discussion

An investigation of the new Physics 20/30 Program-of-Study reveals that it houses all of Roberts' seven curriculum emphases through the rationale and philosophy located at the front of the document. The curriculum emphases survey ranks, open-ended responses, and interview data suggested that, the teachers prioritize Scientific Skills Development and Structure of Science as major goals of the 2007 Physics 20/30 program-of-study. Another priority of the 2007 Physics 20/30 program-of-study for the teachers is the development of a way of looking at the world, a view of the world from a physics perspective. These relate to the idea of transferring and applying knowledge from the classroom to everyday activities.

Research Problem

The main purpose of this research was to seek differences and similarities between pre-service, novice, experienced teachers and a curriculum leader's interpretations of the physics program-of-study using Roberts' seven science curriculum emphases: Everyday Coping, Structure of Science, Science, Technology, and Decision (STS), Scientific Skill Development, Correct Explanation, Self as Explainer, and Solid Foundation (Roberts, 1982, 1988, 1995, 1998, 2003) as a framework. Teachers generally focus on specific emphases that match their experiences and personalities. This uniqueness of each teacher brings different interpretations of the program-of-study to life. For example, a teacher who focuses on Science, Technology, and Decision (STS) may raise more issues related to science and technology into the classroom. The focus of a teacher will directly impact students' experience of senior high physics. Although a teacher's preference of which aspects of the program-of-study to prioritize is their personal, and possibly subconscious, choice there could also be general perspectives all teachers might focus on.

When a teacher picks up a program-of-study, different interpretations of the guide are present as each teacher reads their own experiences into the program. There are no wrong emphases or perspectives because all science curricular emphases can be considered equally important. In fact, over the course of a teacher's career they may focus on each of the seven emphases at different times. Since each teacher may focus on different perspectives depending on their experiences, the focus of this thesis was to try linking teaching experience, in particular the number of years teaching physics, to specific curriculum perspectives. Thus, this investigation was undertaken to find whether there is a difference between pre-service, novice, and experienced teachers, with respect to their self-reported prioritizing of certain elements of the Alberta physics program-of-study. A secondary question for this investigation was whether the reported priorities of the physics teachers matched those expressed by a prominent curriculum leader within Alberta Education, i.e. a representative of those who write and publish the physics program-of-study.

Reviewing Major Findings

The benefit of using mixed methodology in this study was that it allowed for dual data collection processes in an attempt to overcome the weaknesses and biases of each individual method. The results collected through the surveys and the interviews were presented in Table 11.

Pre-Service Teachers

The survey rankings indicate the pre-service teachers value using real life examples and problems to stimulate students to develop scientific skills used in problem solving. Analyzing the survey rankings and the open-ended questions from pre-service teachers the emphasis Structure of Science was highlighted in both sets of data. Pre-service teachers also ranked Solid Foundation last, indicating they believe the other emphases are more important than focusing on ensuring students have pre-knowledge before they enter a course and building a strong base of knowledge to prepare students for future physics courses.

Pre-service teachers suggested that they prioritized the engagement of students by using real life examples to inspire students to develop scientific skills required to solve the problems that are personally interesting to students. Although the premise for pre-service teachers' focus is to encourage students by making the subject *fun*, they also made mention of the importance of content knowledge required to be successful in physics, especially when faced with a summative provincial assessment of the Physics 30 Diploma Exam.

Novice Teachers

The commonalities between the three modes of data for novice teachers are the emphases Structure of Science, common between the survey rankings and the open-ended

Table 11

Summary of Emphases and Focuses of Participants.

Participants	**Top Rankings in the Three Sets of Statements**	**Lowest Rankings in the Three Sets of Statements**	**Focus of Open-ended Comments**	**Focus from Interview Data**
Pre-Service	Structure of Science Scientific Skill Development Science, Technology, and Decision	Solid Foundation Solid Foundation Solid Foundation	Structure of Science Correct Explanation *Student Engagement*	Did not participate in interview process
Novice	Structure of Science Scientific Skill Development Science, Technology, and Decision	Solid Foundation Everyday Coping Self as Explainer	Structure of Science Correct Explanation *Holistic Views of Physics*	Scientific Skill Development through: *transferability* and *student engagement*
Experienced	Structure of Science Structure of Science Everyday Coping	Solid Foundation Everyday Coping Self as Explainer	Structure of Science *Holistic Views of Physics*	Structure of Science through: *transferability* and *holistic views of physics (connectivity)*
Curriculum Leader	Structure of Science Self as Explainer Self as Explainer	Solid Foundation Solid Foundation Solid Foundation	Science, Technology, and Decision	Scientific Skill Development through: *student engagement*

Note. Italicized words do not fit into the framework of Roberts' seven science curriculum emphases.

comments, and Scientific Skill Development, common between the survey rankings and the interviews. Interestingly, contrary results were collected between the open-ended survey question and the interviews. Novice teachers mentioned a need to focus on Correct Explanations during the open-ended survey questions, but during interviews Fred and James made specific mention to focus less on this emphasis.

Novice teachers reported valuing the use of technology and real life examples to stimulate students to learn scientific skills needed to problem solve personal and interesting questions. Some novice teachers viewed physics holistically, meaning they considered it important to build as many connections between the units as possible, to help students gain skills that are transferable to other avenues of their lives as well as keep them engaged on the subject.

Experienced Teachers

Experienced teachers gave results that were similar across the three methods of data collection. This group of participants, in all three methods of data collection, showed a strong focus on methods used to scientifically solve problems that may be transferred to students' daily lives, which is referred to as Structure of Science by Roberts' framework. This idea of transferable scientific problem solving method was viewed *holistically* by these teachers indicating they viewed the skills and concepts of physics as part of a larger picture that may be transferred to other aspects of life. This idea of viewing physics as a whole, finding *connections* between each unit to form a *holistic* view of physics, was a common theme between the open-ended question and the interviews.

Curriculum Leader

In Lisa's interview, she mentioned that she considered that the most important aspect of the program-of-study is *student engagement*. This view was shared with the novice interview participants, Fred and James. This idea of keeping students engaged could be related to the emphasis Self as Explainer, which she ranked as her top priority in two of the three sets of statements. The results of Lisa's data were not consistent throughout the three modes of data collection: survey ranks, open-ended question, and interview data. The discrepancy could be due to the different interpretations of the statements participants were asked to rank. Lisa's results were not very similar to those of the teacher participants. However, there were a few points of general similarities between her and the other groups of participants. For example, she agreed with all the teacher participants in ranking Structure of Science as one of their top priorities and her focus of Science, Technology, and Decision was agreed upon by the pre-service and novice teacher's rankings.

Significance of Findings

The results of the survey showed similarities between the pre-service, novice, and experienced teachers. Their results were different than those provided by the curriculum leader. This suggests that the teachers focus on different aspects of the program-of-study compared to some extent with those intended by the Curriculum Branch of Alberta Education. The similarities between the teacher participants could be attributed to all the teachers being educated through similar teacher education programs, with similar ideologies being developed within each teacher. "Many teacher education programs emphasiz[e] different traditions of practice, [but] use the… same strategies and program structures" (Zeichner, 1993). According to Zeichner (1993) there are four traditions that describe teacher education programs: an academic tradition, a social efficiency tradition, a developmentalist tradition, and a social reconstructionist tradition. These four traditions constitute the backbone of many teacher education programs in North America.

Another reason for these similarities in perspectives between the teacher participants could be the fact that many of the novice and pre-service teachers were once students of experienced teachers, as the experienced teachers have been teaching for many years. As students, these now novice and pre-service teachers, portray the ideologies they were taught and influenced by as students. Thus, as these novice and pre-service physics teachers teach, they pass on similar philosophies of physics education to the next generation of students, and future teachers especially during field experiences and early years of teaching. As experienced teachers 'pass on' their ideologies to their students, the novice teachers, they also pass on similar ideologies to their students, the pre-service teachers. Hence the cycle of passing on similar ideologies gets perpetuated through many generations. However, these perspectives are interpreted by each person differently, thus the emphases may change with time. A review of the literature by Wang, Odell, and Schwille (2008) found that what beginning teachers "thought and did were shaped by the curriculum and teaching organization where mentoring relationships were situated" (pp. 148). They suggest there is a certain level of enculturation of these beginning teachers into *school science* by their experienced mentors.

Although there are many similarities between the teacher participants, the pre-service and novice teachers tended to have more in common with each other than with the experienced teachers. This, in part, could be due to experienced teachers creating a routine and becoming ingrown to the ways of their school and their environment. For example, if specific labs and lessons have been *successful* and well received by students, teachers may continue to use the same activities for several years.

Although the differences in each group of teachers, as well as each individual teacher, allow the students of Alberta to be exposed to a variety of perspectives of physics education, there is a community expectation for all teachers to follow the program-of-study. To a certain extent, teachers at expected to be somewhat similar in their delivery of physics education so students may *succeed* at their course.

In Alberta the measure of *success* for both teachers and students is not necessarily how well the program-of-study was taught, but how well students perform on the *hidden* or *exam* curriculum. This summative provincial Diploma exam can dictate students' futures, e.g. whether or not they go to university or college. The exams are written to represent the program-of-study and test whether students learned the program. However, some teachers focus more on "the components of diploma exam preparation" (Participant 31) than they do trying to focus on covering all the content in the program-of-study. For some teachers, the message of the diploma exam is heard much louder than that of the program-of-study even though the exam is made to support the program. This researcher speculates that all physics teachers try follow the program-of-study. However, the common thread between all physics classrooms in Alberta is the Diploma exam which assesses the level of achievement gained by a student at the end of the course. It is also due to this common exam that students, parents, and administrators expect a level of consistency in the physics education taught in the province. For example, the first of the three written responses on the diploma exam is a skills-based question. If a teacher does not value the emphasis Scientific Skill Development and tends to not focus on this emphasis then it would be difficult for students in that classroom to develop the skills needed to be successful on this question of the exam. Hence, it might be speculated that the Diploma exam tends to be a stronger driving force in bringing consistency between physics teachers and classroom across Alberta than the program-of-study.

Similarities and Differences between Pre-Service, Novice, and Experienced Teachers

The emphasis that was predominantly reported as focused on by the teacher participants was Structure of Science. This emphasis was ranked as the top priority by all the teacher participants in at least one of the three sets. This emphasis was also revealed to be an important focus of all the teacher participants through the open-ended survey question. On the other end of the spectrum, all the teacher participants agreed on ranking the emphasis Solid Foundation as least important. They suggested that having pre-knowledge for secondary and tertiary physics courses was less important than the outcomes of attending to other emphases.

Other aspects of the program-of-study that were common between two of the three groups are themes such as *transferability* and *holistic* views of physics, common between novice and experienced teachers, and *student engagement*, common between pre-service and novice teachers. Although novice and experienced teachers suggested that *transferability* is important to physics classrooms, their definition of transferable skills differed slightly. Experienced teachers', Dillon and Brad, definition of these transferable skills involved scientific reasoning and analytical skills that are used to solve problems. These problems may be physics related or general life issues a student may encounter. Higher level analytical skills useful in problem solving are what experience teachers believe should be a focus in physics education. Novice teachers', Fred and James, definition of these skills was much boarder than that of experienced teachers. They believed that skills included all types of skills from manipulative mathematics and laboratory skills to practical problem solving skills that could be applied to situations out of the classroom. The focus that some novice teachers had on manipulative math and laboratory skills was generally confined to a mathematics or science classroom setting. This idea of *transferability* suggested that physics teachers hold a general ideology regarding the direction of Alberta's physics program. With teaching experience, each teacher's definition of the skills that should be transferred maybe refined towards the idea of the Structure of Science, an emphasis which was agreed upon by all three groups of teacher participants as a top priority.

These findings suggests majority of the physics teachers and pre-service science teachers in Alberta hold similar philosophies towards teaching physics. The minor differences between the groups could be attributed to personal differences and experiences that bring life into each classroom. This could be attended to in future studies.

Similarities and Differences between Teacher Participants and Curriculum Leader

The teacher participants focused on similar aspects of the program-of-study. Their general trend was to focus on aspects and emphases such as: Structure of Science, Correct Explanation, *holistic* views of physics, *transferability*, and *student engagement*.

They also agreed on ranking Solid Foundation as their lowest priority when compared with the other six emphases. The curriculum leader, Lisa, differed from the teacher participants in that she focused on the emphases Self as Explainer and Science, Technology, and Decision, which are different than the other teacher participants. The points of commonalities between Lisa and the teacher participants were of ranking Solid Foundation low on the survey and focusing on Scientific Skill Development and *student engagement*, as revealed during her interview.

Although the curriculum leader focused on different emphases than the teacher participants, the teachers tended to focus on similar aspects of the program-of-study. As professionals, teachers teach the program-of-study, but the rationale and philosophy of the program may be interpreted differently by each teacher. Perhaps more guidance from the Curriculum Branch of Alberta Education is required in order for teachers to live out the program as intended by its developers. The province holds consortiums where Lisa's Curriculum Branch of Alberta Education provides funding to organize professional development in the forms of workshops and in-services to support new program. According to Lisa, teachers and speakers are chosen to work with teachers to enhance their understanding of the new program-of-studies. However, it is important to note again that there are no *wrong* emphases. The fact that the curriculum leader tended to focus on other emphases may act as a reminder to all teachers that the *popular* emphases are not the only aspects that can be focused on. Instead of focusing on *popular* emphases teachers should explore emphases that appeal to them and develop those aspects of the curriculum. Teachers many be living out the curriculum differently as intended by the curriculum leader. The next section compared the results of this study to previous studies in this area of research.

This Study Compared with Previous Studies

The results of this study show minor differences between the views of pre-service, novice, and experience physics teachers. This is contrary to past studies such as the Hepburn and Gaskell (1998) study where a novice and an experienced physics teacher were piloting a new applied physics course. The different emphases each teacher held represented their personal experiences and beliefs of what the applied physics course should be. Whether it was a prequel to academic physics or a preparatory training course of skills required in the industry.

A second study involving novice and experienced teachers' implementation of the ideas behind Science-Technology-Society (STS) by Jeans (1998) also showed similar ideologies between the two groups of teachers, novice and experienced teachers. The difference Jeans noted was between the elementary and secondary novice teachers. The novice elementary teachers focused on the curriculum emphasis Everyday Coping while novice secondary teachers focused on the emphasis Solid Foundation. The similarities between the novice and experienced teachers from Jeans' study are similar to the results from this thesis in that there is not a big difference between the groups of participants. This thesis regarding Roberts' (1982, 1988, 1995, 1998, 2003) seven science curriculum emphasis suggests no substantial difference in many ways between the pre-service, novice, and experienced teacher participants as well.

Review of Methodology

Reviewing the methodology used in this study, several areas of possible improvement might be suggested. One of the major issues with this study is that this is considered a *point in time* study were this research gives a snap shot of part of the physics education scene in Alberta at the time of the research. Despite the views that were passed down by previous generations of teachers, the views and perspectives of each participant may change as they experience different events in their lives. Further a different sample of teachers meeting the same criteria as those sampled in this study might also provide different insights. This means that a similar study conducted in a year's time, for example, may provide different results that might cast doubt on the veracity of this study's finding. Of course, it would be reasonable for such a study to be undertaken regularly so that trends might be identified. In fact, this would seem to be a reasonable undertaking.

Another issue with the methodology was the time restraints on the researcher to complete this Masters thesis. More time for this research could have allowed for a pilot study to be done to test and improve the curriculum emphasis survey. This might have improved the validity of the curriculum emphases survey. Since no survey using Roberts' seven curriculum emphases as a framework had existed prior to this study, it was an ambitious attempt on the researcher to create the survey used in this study. The pilot study would have also given the researcher evidence than an explanation or re-wording of the open-ended response was required, as some participants misunderstood the questions and provided the researcher with invalid responses for this study. As previously discussed, some participants such as Participant 26 who, in their open-ended response, mention their focus on “electricity + magnetism, [and] momentum” which are *units* in the program they believe are important. However, this study seeks to find *aspects that reflect emaphses* of the program participants believe are important.

Another issue identified during this research was the difficulty in getting a group of physics teachers together at the same place and time to administer the survey. If more time and resources were available to the researcher, the surveys could have been administered to teachers by shipping the surveys to teachers in their schools instead of waiting for participants to come together for the administration of this survey, which was the method used in this study. Additional resources and time could have also helped to improve the number of interview participants in this study so that a representative sample may be achieved in the future.

Further, after talking with several professors in both curriculum studies and education psychology I now see not only the intricate aspects of qualitative curriculum research. I now see there is an extremely interesting side to quantitative education research as well. For example, after a short conversation with Dr. Todd Rogers at CRAME I learned many things I could have done to construct a better survey for my research. For example, he suggested that I had several *double barrel* statements in my survey such as the last statement in emphasis set 2, where I asked whether participants:

> …provide opportunities for students with a foundation in science to create opportunities for them to pursue progressively higher levels of study, prepare them for science-related occupations, and engage them in science-related hobbies.

Although many participants may rank “provide opportunities for students with a foundation in science to create opportunities for them to pursue progressively higher levels of study” fairly high on the scale of importance, they may rank “prepare [students] for science-related occupations” lower on the scale. The same participant may have no interest in “engage [students] in science-related hobbies”, thus ranking this portion of the statement fairly low on the scale. Since this one statement encompassed three different ideas it may have caused for different interpretations of the statement and thus a misleading ranking of this statement. Another suggestion was to have teachers rank only the top and bottom statements so teachers would not have to retain and process all seven statements at once. Three sets of seven statements is very difficult for people’s short term memories to process, thus different font and different colored paper could have been used to help participants memory retain and process the seven statements they were trying to rank.

Future Studies

The fact that curriculum emphases change with time and personal experiences make it an on going research concern as each time this topic is investigated different answers might arise. If different teachers are used for each of the investigations there will possibly be differences in the results because each teacher encounters different experiences. Even if the same teachers are used, the results may vary according to time because teachers will experience more incidences as teachers change in life in general. Thus, an ongoing investigation into the emphases teachers take would provide a more in-depth look at the trends of curriculum over several years and perhaps be able to pin point particularly large events, such as Les Tolman removing a significant amount of content knowledge from the program-of-study in 1978 (F. Jenkins, personal communication, Nov. 29, 2007), that contribute to the changes in the trends. Perhaps the introduction of the new Physics (Ackroyd, et. al, 2007) textbook written specifically for the Alberta physics program-of-study, which attempts to strength students' scientific inquiry through open-ended laboratories, might be basis for change in the future.

As suggested by Brad, an experienced teacher, although some novice teachers claim they place very little emphasis on content knowledge this may not be the case. Thus, to truly find an answer to where content knowledge is ranked on each teacher's priority list an in-depth exploration of teachers' lessons should be studied. Instead of passing out surveys and performing interviews with teachers, video taping and observing teacher's lessons and classroom interactions would provide more in-depth results to what teachers emphasize even though this suggestion raises a new list of methodological and ethical issues.

Another project that could be undertaken from this investigation of the seven science curriculum emphasis is the focuses on a new applied physics course that is to be piloted in Alberta. An investigation into the perspectives teachers have when teaching the applied physics course will allow for more insight into how the course is written, interpreted, and enacted. This project might be similar to the Hepburn and Gaskell (1998) study of the applied physics course that was introduced in British Columbia. Although the path of the applied physics course in British Columbia was ultimately unsuccessful, perhaps much can learned from past experiences and with an understanding of science curriculum emphases a new path might be paved for the applied physics course in Alberta.

The ideologies and emphases teachers have of the physics program-of-study is a direct reflection of teachers' personalities and experiences. There are no correct or right emphases for teachers to have in any classroom. They believe the emphases they attend to are the best emphases for their classroom. Ultimately, teachers want what is best for their students so they will attend to particular emphases they deem best for their students given their own comfort level with the emphases.

Lastly, this thesis has created a platform for the researcher, me, to be exposed to a world of knowledge that I would otherwise not be able to encounter. After doing research for this topic I have discovered how little I know regarding the many aspects of science curriculum research. The more research I did into my topic, the more interesting ideas I learned about that I had never even previously thought of. Reading the literature for this thesis has opened my eyes to many other opportunities that could be pursued in the future, perhaps not for the purposes of a Doctoral paper, but for my own interests. Topics of research, as I have found, are endless. However, the art of research methodology is also vast and intricate.

Regardless of the results of this study, this thesis has already increased my knowledge of the new physics program-of-study. This in-depth understanding and collaboration of views with other teachers would not have been gained if I did not pursuing specific research questions. This Masters Degree provided a place for me to learn so much more than I could have ever imagined. Now that I has been exposed to a world of new knowledge a Doctoral Degree is in my future plans as I research and pursue the many different areas of knowledge.

Conclusion

The focus of this research was to explore teacher's perspectives of which aspects of the physics program-of-study they tended to prioritize. To investigate this problem, a framework was adopted from Douglas Roberts' seven science curriculum emphases: Everyday Coping, Structure of Science, Science, Technology, and Decision (STS), Scientific Skill Development, Correct Explanation, Self as Explainer, and Solid Foundation (Roberts, 1982, 1988, 1995, 1998, 2003). Teachers' choices to focus on particular emphases are personal choices reflecting, sometimes tacitly, what they consider are the most important aspects of the physics program-of-study depending on their personal beliefs, interests, and experiences. Teachers' personal reflections of the program-of-study influence students' experiences of secondary physics because each perspective brings a different quality to the classroom providing students with different experiences of the course. There are no *correct* or *right* emphases. Teachers may hold substantially different, yet valid, perspectives of the program-of-study.

Literature Review

As the physics curricula changed matured throughout North America, those changes affected the physics programs-of-studies in Alberta. An investigation of Alberta's physics program revealed two major changes over the years: the first is a decrease in the volume and depth of content knowledge, and the second is an increase in attention to the development of critical thinking skills in students. These trends have influenced the development of Alberta's 2007 physics program-of-study where content was removed from its predecessor and an extensive list of skills outcomes were added to promote the idea of *hands-on, minds-on* laboratories. This physics program was investigated using Roberts' seven science curriculum emphases as a framework to analyze which aspects of the program teachers tended to prioritize as most important. However, some teachers tend to enact more than one emphasis at once. Hence Aoki's (1986/2005) idea of *tensionality*, which analyzes how teachers simultaneously dwell within and between these seven emphases is salient. Since the uniqueness of each teacher is reflected in both the emphases they choose to prioritize and the depth of their focus. An investigation of whether teaching experience influences the prioritization of certain elements and emphases of the Alberta physics program-of-study to be more important than others was seen as important. This analysis of teaching experience and prioritization of emphases led to a secondary question of whether the reported priorities of physics teachers match those intended by the program developers represented by, the curriculum leader.

Methodology

A mixed methodology was utilized to understand physics teachers' curricular perspectives. Using Roberts' seven curriculum emphases as a framework, a curriculum emphases survey was created to collect data regarding teacher's rankings of the emphases. At the end of the survey participants were given the opportunity to leave an open-ended response regarding the aspects of the program-of-study they considered most important. These survey participants could also volunteer to participate in an interview where they could provide the researcher with in-depth responses to which elements of the program they believe is most important without the pre-set boundaries of Roberts' seven science curriculum emphases. To interpret the rankings provided from the survey SPSS version 17.0 was used. The open-ended survey responses and interview data was recorded, transcribed, and analyzed for recurring themes. Interviews provided teachers with a platform to enrich the data they provided through their surveys regarding their perspectives and how they prioritize them. Ethics associated with this research was considered thoroughly to protect the identities of all the participants. Verbal and written explanations of the research were given to each participant before they decided to partake in this project. Written consent obtained to indicate voluntary participation. The quality considerations associated with both qualitative and quantitative methods were considered throughout the design and execution of the study.

Data Analysis and Interpretation

Results of the teacher participants' perspectives were analyzed and compared. Analysis of the quantitative data from the surveys suggested that all three teacher participant groups ranked the emphasis Structure of Science as being more important than the other emphases. This conclusion was further supported by the responses to the open-ended survey question as many teachers in all three groups identified developing transferable scientific problem solving skills that might be used in other aspects of a student's life as an important element of the program. The interview data also tended to be consistent with the survey data in that teachers reported placing a high priority on the Structure of Science emphasis because of its transferability to problems outside of the classroom. The rich nature of the interview data revealed subtle differences between the different groups of participants as the definitions of the type of skills to be transferred. Experienced teachers, Dillon and Brad, defined skills as analytic problem solving skills, whereas novice teachers defined skills to encompass mathematical skills and technical laboratory skills as well as analytical problem solving skills. Novice teachers, Fred and James, also made the point that physics needs to be fun in order for students to be *engaged* and find success in the course. It is important to note that the interview sample was small and not considered a representation of the groups they belongs to. Another agreement between the three groups of teacher participants was their low ranking of the emphasis Solid Foundation. The teacher participants agreed that having strong pre-knowledge of physics before students enter a course is not as important as the other emphases.

Although the teacher participants revealed similar ideologies and perspectives, they differed from the curriculum leader who tended to prioritize emphases such as Self as Explainer and Science, Technology, and Decision. The differences between the teacher participants and the curriculum leader were particularly noticeable in the survey ranking and the open-ended responses. However, interview results revealed the curriculum leader focused on *student engagement* the most, which is also prioritized as important by pre-service and novice teachers. The similarities between the teachers indicate the physics teachers are working towards a common program goal in physics education in Alberta. However, this goal may be different from those of the curriculum branch, which may indicate the need for more professional development put on by the curriculum branch to convey their views and perspectives of the program.

Discussion and Implications of Curriculum Emphases Study

These results show a trend in physics teachers' perspectives of the program-of-study. The trend is for teachers focus on the emphasis Structure of Science. This was described by teachers as transferable problem solving skills that can be applied to situations out of the classroom. Not only do the findings represent the current trend in reported classroom emphasis, they also provide teachers with an understanding of the curriculum they delivery to their students. The tendency of putting less focus on content knowledge was reported by novice teachers through their interviews. However, this view was contradicted in the open-ended responses provided by pre-service and novice teachers. Perhaps teachers, particularly pre-service and novice teachers are dwelling between these two contradicting states, as suggested by Aoki (1986/2005).

The findings of this survey are not stagnant, as the focus of each teacher might shift as times change and each teacher's live through different experiences. Thus, the results of this thesis act as only a general guide for how pre-service, novice, and experienced teachers differ from the curriculum leader. Hopefully, the findings presented here might act as a stimulus for pre-service novice, and experienced teachers to reflect upon their teaching practices. The differences between the teacher participants and the curriculum leader suggest that the program-of-study is being lived out differently to what was intended by the curriculum leader. Perhaps, more direction is required from the Curriculum Branch of Alberta Education before teachers are able to deliver the program as it was intended. Perhaps, the intended program is to cover a little bit of each emphases, hence it was possible to find passages out of the physics program-of-study to represent each of Roberts' seven curriculum emphases. It is important to note each emphasis is equally important, there are no *wrong* emphases. Since the results of science curriculum emphases are dynamic and able to change to fit each teacher and their classroom there are many studies that could be done in the future.

Appendix A

Historical Curriculum Resources

Alberta Education. (1993). *Physics 20-30*. Alberta: Alberta Education.

Curriculum Branch of Department of Education. (1951). *Program of studies of the senior high school.* Alberta: Curriculum Branch of the Department of Education

Department of Education. (1961). *Program of studies for senior high schools of Alberta.* Edmonton: Department of Education.

Department of Education. (1967). *Program of studies for senior high schools of Alberta.* Edmonton: Department of Education.

Department of Education. (1972). *Program of studies for senior high school.* Edmonton: Department of Education.

Department of Education. (1974). *Program of studies for senior high schools of Alberta.* Edmonton: Department of Education.

Department of Education. (1975). *Program of studies for senior high schools.* Edmonton: Department of Education.

Department of Education. (1978). *Program of studies for senior high schools.* Edmonton: Department of Education.

Department of Education. (1982). *Program of studies for senior high schools.* Edmonton: Department of Education.

Appendix B

Curriculum Emphasis Survey

1. Please provide the following demographic questions:

a) Number of years teaching: _________
b) Number of years teaching physics: _________
c) Age: _________
d) Gender (Please circle): Male / Female
e) Type of Education Degree (Please circle):

Two year after degree / Four year degree / Five year combined degree / Other: __________

Major: _________ Minor: _________

f) Have you participated in any type of curriculum course or professional development? If yes, please specify.

____
____
__

2. Please rank from 1(most important) to 7 (least important) the following statements regarding students' proposed learning outcomes from their physics course, in terms of their importance to you as a teacher.

a) Students are able to use scientific vocabulary and principles in everyday discussions. __________

b) Students are able to explore their environment, gather knowledge and develop ideas that help them interpret and explain what they see. __________

c) Students are able to use and recognize that science and technology are developed to meet societal needs and expand human capability. __________

d) Students are able to use the skills developed at each level of physics with increasing scope and complexity of application: initiating and planning, performing and recording, analyzing and interpreting, & communication and teamwork. __________

e) Students are able to recognize the subject matter of science, including the laws, theories, models, concepts, and principles that are essential to an understanding of each science area. __________

f) Students are able to show interest in science-related questions and issues and confidently pursue personal interests and career possibilities within science-related fields. __________

g) Students are able to recognize that their physics course prepares them for further study in subsequent physics courses. __________

3. Please rank from 1(most important) to 7 (least important) the following statements about your classroom teaching practice, in terms of the importance of each practice to you as a teacher.

a) I provide opportunities to show how cultural and intellectual traditions have influenced the focus and methodologies of science, and that science has influenced the wider world of ideas. __________

b) I provide opportunities to show science provides an ordered way of learning about the nature of things, based on observation and evidence. __________

c) I provide opportunities for students to investigate how technological solutions have emerged from previous research, and how many of the new technologies have given rise to complex social and environmental issues. __________

d) I provide opportunities for students to develop skills that involve answering questions, solving problems and making decisions. __________

e) I provide opportunities so that students recognize that the goal of science education is to construct knowledge about the natural world. __________

f) I provide opportunities for students to explore their personal perspectives, attitudes and beliefs regarding scientific and technological advancements. __________

g) I provide opportunities for students with a foundation in science to create opportunities for them to pursue progressively higher levels of study, prepare them for science-related occupations, and engage them in science-related hobbies. __________

4. Please rank from 1(most important) to 7 (least important) the following objectives for students in terms of their importance to you as a teacher.

a) Students become able to use science to understand both technology and everyday occurrences. __________

b) Students become able to understand science as a growing intellectual enterprise, stressing the importance of 'scientific method' using hypotheses, experiments, scientific concepts, and historical evolution of scientific ideas. __________

c) Students become able to understand the interrelatedness of scientific explanations, technological planning, problem solving, and the practical importance of science to society. __________

d) Students become able to develop competence in conceptual and manipulative skills that are basic to science, collectively labeled 'scientific process'; which are the keys to arriving at a reliable 'product', or idea in science. __________

e) Students become able to concentrate on the ends of scientific inquiry, science is reliable and valid knowledge from an authoritative group of experts developed to provide explanations to justify natural events and objects. __________

f) Students become able to explain events in terms of their personal purpose, their intellectual preoccupations, and their cultural influences that form their context. __________

g) Students become able to view science as an accumulation of knowledge, a development in preparation for subsequent science courses. __________

5. What part of the curriculum do you focus most on in your classroom and why?

6. (OPTIONAL) If you are willing to provide more in-depth answers, through an interview, e-mails, etc., please leave your name and contact information.

THANK-YOU FOR YOUR PARTICIPATION, YOUR INPUT IS EXTREMELY VALUABLE TO THIS RESEARCH

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