FACTORS AFFECTING STUDENT ACHIEVEMENT IN SCIENCE: A STUDY OF TEACHER BELIEFS

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Abstract

This study employed a mixed methods and mixed model research design to explore secondary science teachers' beliefs. Specifically, this study focused on factors that secondary science teachers believe affect student achievement in science, and the extent to which teacher beliefs transfer to teacher practice. This study is significant because the outcomes may inform professional development and policy decisions at the school, district, and provincial level.

Results from self-reporting data of 82 secondary science teachers indicate that teacher beliefs in each of the fourteen topics surveyed (Classroom Management, Learning Styles, Inclusion, Equity, Science-Technology-Society (STS), Formative Assessment, Summative Assessment, Constructivism, Thematic Approach, Hands-On/Minds-On Activities, The Nature of Science, Science Subject Matter, Electronic Learning and Cooperative Learning) are positive for most Prince Edward Island (P.E.I.) secondary science teachers. Furthermore, secondary science teachers reported having strong beliefs in their ability to affect student learning (self-efficacy beliefs). However, it is apparent from the survey and interview data that teachers believe there are other influential factors that are preventing some students from learning despite the teachers' best efforts and ability.

Regarding implementation, this study indicates that beliefs and the enactment of beliefs in classroom practice are positively correlated. The data also shows that at least seventy percent of teachers reported that they implement practices consistent with all but two topics – The Nature of Science and Electronic Learning – at least once a week.

The findings of this study are discussed in the context of the P.E.I. secondary science setting. Limitations and implications of this study are also addressed.

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Chapter 1: Introduction

Background

Our entry into the 21st century has been marked politically by an increased emphasis on accountability in the education system. "The current political climate and reform initiatives require educators to use 'scientifically based' methods" (Snider & Roehl, 2007, p. 873). In Prince Edward Island (P.E.I.), the final report of the *Task Force on Student Achievement*, a committee assembled by the provincial government, was released in December of 2005. This report entitled "Excellence in Education: A Challenge for Prince Edward Island" outlined twenty recommendations for our educational system (Kurial, 2005). The first recommendation – Curriculum – described a need for clear outcomes, standards, and benchmarks in all areas of curriculum along with adequate teacher training. The second recommendation – Student Assessment – articulated the need to administer common assessments at grades 3, 6, 9 and in select high school subjects. Furthermore, the report stated that the assessments must be used to accurately inform parents and teachers, guide professional development, and improve teaching and learning (Kurial, 2005). Consequently, province-wide assessment had its modest beginning in June 2007 in P.E.I. with the administration of the grade nine Mathematics common assessment. The common assessment in P.E.I. has been developed as a "for learning" instrument to inform practice and planning at the school, district and provincial levels. Decision-making surrounding curriculum and education policy must be based on the evaluation of sound assessment data gleaned from multiple sources. Slavin suggests (as cited in Snider and Roehl, 2007) "that the failure to base educational practice on sound research results in endless fads that wax and wane" (p. 873). Our education system must be concerned with evidence which describes achievement differences among schools, the factors that appear to affect student achievement locally, and what research states about factors affecting student achievement.

On an international scale, the 2006 Programme for International Student Assessment (PISA) had assessed students in the Organization for Economic Co-Operation and Development (OECD) countries in three domains; namely, Science, Mathematics, and writing. The 2006 PISA assessment was a first for which science was the main domain. The focus of the Science domain was on both overall (or combined) scientific literacy and three scientific sub-domains (identifying scientific issues, explaining phenomena scientifically, and using scientific evidence). In addition to the data on student performance in science, PISA also provided correlational data linking student achievement to various factors delineated from themes which include student engagement, science and the environment, and the contexts for the learning of science. Furthermore, correlations were also made between science performance and select student characteristics related to socioeconomic status, parental education, gender, and immigrant status. Although we have provincially, nationally, and internationally correlated student data on science achievement with factors delineated from PISA themes and indirect data on teacher practice from PISA, minimal data exists showing the relationship between science teacher beliefs and practice for PEI science teachers. This study explored secondary science teachers' beliefs about factors affecting student achievement and the extent to which their beliefs are enacted in classroom practice.

Rationale

Prince Edward Island invests a significant amount of public resources in the provision of K-12 education. It is the responsibility of educational leaders to determine how this funding is used to maximize student achievement and student learning in an efficient and equitable manner. Presently, minimal data exist on the general beliefs of science teachers in P.E.I. and specifically on factors that our science teachers believe affect student achievement. Gaining a deeper knowledge of teachers' beliefs about factors affecting student achievement carries considerable educational significance. Therefore, this study explored secondary science teachers' beliefs in relation to the context for teaching/learning and professional issues. The specific research questions that guided the study are:

- What factors do science teachers believe affect student achievement in science?; and
- To what extent do teacher beliefs become enacted in classroom practice?

The significance of this study is to inform decision-making regarding science-related initiatives at the school, district, and provincial levels. Knowing how well students are achieving in science, the factors that affect science achievement, and our teachers' beliefs surrounding factors affecting student achievement are crucial to the creation and implementation of policy, curriculum, professional development, and school development plans. Essentially, educational leaders must identify and understand the nature of the deep-rooted beliefs of the members of their educational community and have access to a comprehensive compilation of correlational and causal data involving factors affecting student achievement. "If the ultimate goal of research on teaching is to shape, direct, or improve the practice of teachers – then the reasons that teachers have for acting the way they do – reasons which make them more or less amenable to advice and training – must be examined" (Nespor, 1985, p. 3). As decision-making surrounding the implementation of curriculum and education policy must be informed by the evaluation of sound assessment of teacher beliefs, then the beliefs of teachers and teacher candidates should be a major focus of educational research. Attention to these beliefs can inform educational practice in ways that prevailing research agendas have not and cannot (Pajares, 1992). This research study provides such details for science educators and educational leaders.

Theoretical Perspectives

Student assessment data and research articulating factors affecting student achievement in science only provide part of the image required for the development and implementation of educational policy and prescribed curricula. In P.E.I., curriculum, which is defined by three components (outcomes, pedagogy, assessment), is developed by the Department of Education in consultation with curriculum committees comprised of subject-specific practitioners. Although the outcomes are rigidly articulated in curriculum, the pedagogical and assessment strategies provided are suggestive, thus leaving the classroom teacher with the professional autonomy for their expression. Consequently, policy and curriculum professionals can only assume that the prescribed policies and curriculum will influence what happens in the classroom. However, "whether the influence in fact takes place depends, in part, on how the policy fits with the beliefs that teachers hold about their work activities" (Eisenhart, 1988, p.137).

Jones and Carter (2007) used the *Sociocultural Model of Embedded Belief Systems* (Figure 1.1) to describe the complex, cyclical nature of the interactions between teachers' belief systems and their instructional practices. Within this model, Jones and Carter explain that "knowledge and skills, as well as motivation, are prerequisites for engaging in a particular instructional practice" (p. 1075). They describe that the motivation to engage in an instructional practice is complex because it is affected by two sets of attitudes; attitudes towards instruction, and attitudes towards implementation. Teacher motivation and both sets of attitudes are directly influenced by teacher epistemologies comprised of beliefs about science, beliefs about science teaching, and beliefs about science learning. Furthermore, attitudes towards instruction and implementation are also directly influenced by teacher efficacy (teacher beliefs about their own ability to affect student achievement), social norms (what a teacher believes is expected by others), and environmental constraints (physical factors such as time and resource availability). Environmental response is an additional variable that adds to the complex, reciprocal nature of this model. The environmental response is the students' responses to the teachers' actions. The environmental responses affect teacher beliefs just as the beliefs affect actions. For instance, positive student achievement resulting from an instructional practice may confirm beliefs while negative student achievement or responses may cause a teacher to abandon an instructional practice depending on the relative strength of the teacher's motivation to engage in the instructional practice, and their skill and knowledge of the instructional practice.

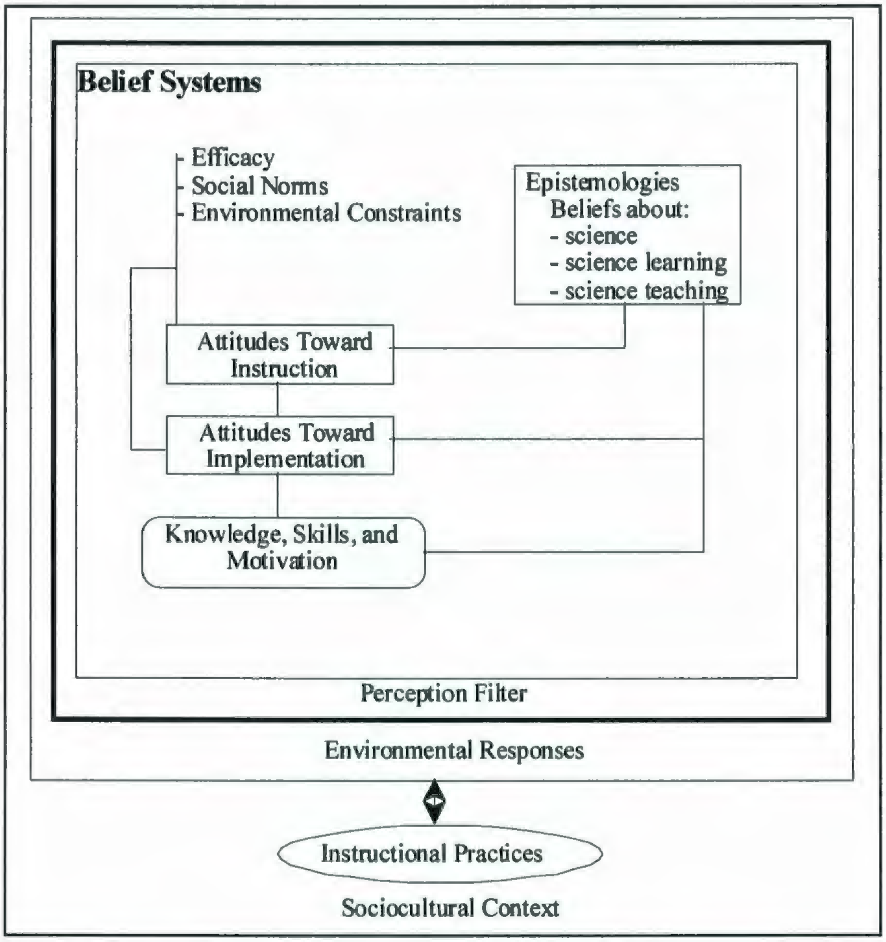

Figure 1.1: Sociocultural Model of Embedded Belief Systems
(Jones and Carter, 2007, p. 1074)

According to Jones and Carter (2007), "early interest in teacher attitudes was based on a fairly linear model that predicted that positive attitudes towards a behavior were sufficient for implementation of that behavior" (p. 1073). The sociocultural model of embedded belief systems illustrated above shows that implementation of a behavior is far more complex as it is dependent on several reciprocal interactions. By accessing the strengths of both qualitative and quantitative research techniques the use of a mixed methodology design should permit a comprehensive examination of these interactions.

Consequently, this study employed a mixed methodology research design in attempt to obtain information about teachers' beliefs, including efficacy beliefs, and the degree to which teachers' beliefs are enacted in practice.

The following chapter – Chapter 2: Literature Review – begins with a review of literature on characteristics of beliefs and teacher beliefs related to pedagogical issues. The literature review concludes with an examination of factors affecting student achievement related to professional issues which examines teacher efficacy (belief that one's teaching ability can positively affect student behavior and achievement) and outcome expectancy beliefs (belief that any teacher can positively affect student behavior and achievement in spite of all other factors), as well as teacher beliefs about other non-pedagogical issues.

Chapter 3 – Methodology – describes the study design, ethical issues, the study duration and research participants, the data collection methods, and how the data was analyzed. The methodology chapter concludes with a description of the researcher and researcher's role.

Chapter 4 – Research Findings – reports the key findings of the survey and interview data. The survey data was organized into sections related to general information (teacher demographics data), the context for teaching and learning, and professional issues.

Chapter 5 – Discussion - rationalizes the findings related to teacher beliefs, implementation of beliefs, and professional issues in the context of the P.E.I. secondary science setting. This chapter also discusses implications and limitations of this study.

Chapter 2: Literature Review

Teacher beliefs have long been, and continue to be, a focus of educational research. Although this area of research is very active, there appears to be no universally agreed upon definition of beliefs by scholars. Therefore, this review of the literature will begin with a description of the characteristics of beliefs followed by various definitions of teacher beliefs. There is potential for numerous pedagogical and non-pedagogical factors to affect student achievement. Due to the interconnectedness of these factors, the difficulty lies in identifying those factors believed to be most influential. Consequently, this review of the literature will focus on factors affecting student achievement related to the context for teaching and learning which examines teacher beliefs related to pedagogical issues. Furthermore, this review will conclude with an examination of factors affecting student achievement related to professional issues which examines teacher efficacy and outcome expectancy beliefs as well as teacher beliefs about other non-pedagogical issues.

Characteristics of Beliefs

Teacher beliefs were the subject of much research which began in the 1980s (Jones & Carter, 2007). However, the study of teacher beliefs has been difficult due, in part, to differences in definition and conceptualization (Pajares, 1992). The distinction between knowledge and beliefs has generally been a central focus. Where does knowledge end and beliefs begin? Many would agree that these two constructs do not only overlap but are interdependent. One's beliefs are influenced by one's present knowledge. The corollary being that one's knowledge, or what is known to one to be true, is informed by his or her current belief structure. In Chemistry, the L'Chatelier Principle states that when pressure is applied to a system in dynamic equilibrium, the system will shift in a direction to relieve the pressure. Therefore, an adaptation of L'Chatelier Principle can be used to describe the interconnectedness between knowledge and beliefs as being a dynamic equilibrium; a maintenance of balance between knowledge and beliefs while continuously shifting as a result of new experiences.

To distinguish between beliefs and knowledge, I draw upon the work of Nespor regarding the role of beliefs in the practice of teaching. Nespor (1985) identified four features characteristic of teacher beliefs. These include existential presumptions, alternativity, affective and evaluative loading, and episodic structure. Existential presumptions, according to Nespor, include propositions or assumptions about the existence of immutable entities. They are incontrovertible and they exist simply because they do. For instance, an existential presumption could include one's belief that when students do not learn it is because they have reached their intellectual capacity. Existential presumptions would play an important role in a teacher's actions. A teacher with the above presumption may conclude that nothing can be done to extend the learning of this student. The second feature characteristic of beliefs, identified by Nespor, is alternativity. Alternativity can be described as a teacher's attempt to create an alternative or ideal situation in which they tend not to have direct experience or knowledge of; therefore, they are conceptualizations that differ from present reality. For example, a science teacher may envision a model in which all new topics are initiated through investigation and student discourse. She then works to shape her class to this ideal even though she has never experienced it as a student nor attained it successfully as a teacher. Essentially, these situations represent a sort of utopia that is "not amenable to falsification–or even challenge – and failures to attain them in no way diminish their value" (Nespor, 1985, p. 13).

Perhaps the most significant feature characteristic of belief articulated by Nespor is that beliefs rely more heavily on affective and evaluative components than knowledge. The affective features of beliefs typically operate independently of the cognition usually associated with knowledge. Furthermore, Nespor claimed that affect and evaluation are important regulators of the amount of energy teachers are willing to put into and expend on activities. For example, if a teacher determines that the difficulty in teaching a subject is a function of the subject's abstractness and the student's search for practical value, then this teacher would probably be willing to structure her lessons on practical associations to the subject matter. Nespor argued a fourth and final distinction between knowledge and beliefs based on method of storage. Nespor claims that knowledge is semantically stored whereas beliefs are stored in episodic memory which is contextualized with material drawn from personal or cultural experiences. For example, teacher beliefs surrounding the importance of real-time data collection for use in model problems most likely results from a reflection of past personal classroom experiences of similar nature stored in episodic memory.

Snider and Roehl (2007) stated that beliefs influence the way knowledge is viewed, and knowledge influences beliefs. Consequently, even with a concise definition these constructs are inseparable. Cross (2009) defined beliefs as "embodied conscious and unconscious ideas and thoughts about oneself, the world, and one's position in it, developed through membership in various social groups; these ideas are considered by the individual to be true" (p. 326). Kagan (1990) defined beliefs as "the highly personal ways in which a teacher understands classrooms, students, the nature of learning, the teacher's role in a classroom, and the goals of education" (p. 423). Having reviewed seminal research on teachers' beliefs, Pajaras (1992) articulated that "teachers' attitudes about education– about schooling, teaching, learning, and students – have generally been referred to as teachers' beliefs" (p. 316). For the purpose of this study, teacher beliefs will be defined as such. The challenge of this and other research involving beliefs is to have confidence that the belief inferred, as Pajaras (1992) describes, "is a reasonably accurate representation of an individual's judgment of the truth or falsity of a proposition that can only be inferred from a collective understanding of what people say, intend, and do" (p. 316).

Several studies (e.g. Ballone & Czerniak, 2001; Cross, 2009; 2001; Eberle, 2008; Nespor, 1985; Pajaras, 1992; Snider & Roehl, 2007) have indicated that teachers' beliefs have strong implications for the way they practice teaching. There is considerable evidence to suggest that deep-rooted beliefs are very difficult to change. Cross (2009) described that "beliefs develop over years of schooling and experiences in various communities, and so tend to remain intact despite educational attainment or teaching experience" (p. 326). Having reviewed decades of seminal research on teacher beliefs from prominent researchers, Pajaras (1992) had indicated that when "metaphysical and epistemological beliefs are deep and strong, an individual is more likely to assimilate new information than to accommodate it" (p.320). Elaborating on the difficulty of changing beliefs, Pajaras (1992) further described that

> [b]eliefs are unlikely to be replaced unless they prove unsatisfactory, and they are unlikely to prove unsatisfactory unless they are challenged and one is unable to assimilate them into existing conceptions. When this happens, an anomaly occurs – something that should have been assimilated is resisted. Even then, belief change is the last alternative. (p. 321)

The difficulty in changing beliefs can be problematic for curriculum implementation. Eisenhart (1988) referenced several studies which provided a significant amount of evidence suggesting that educational policies that are incompatible with teacher beliefs are not implemented as intended. This results in a gap between intended and enacted curriculum. Keys (2005), in a study of teacher beliefs and the effect of their beliefs on curriculum implementation, adds further complexity to reasons for gaps between intended and enacted curriculum. Keys (2005) found that although teachers stated that they held certain beliefs, these beliefs were not enacted in their classroom practice. Keys (2005) claimed that "time, the provision of resources and professional support are three possible factors" (p. 509) that may explain why expressed beliefs were not acted upon. Similarly, Ogan-Bekiroglu and Akkoc (2009), in a study of pre-service physics teachers' instructional beliefs, found that most pre-service Physics teachers held instructional beliefs aligned with constructivist philosophy; however, some of the pre-service teachers "presented different practices from their beliefs in different placements"

(p. 1173). Reasons described for the gap between beliefs and practice include lack of subject matter knowledge, lack of experience and skill with constructivist practices, mentor expectations, and school conditions such as inadequate laboratory equipment. Consequently, the relationship between beliefs and practice is very complex. Knowledge, skills, social environment, and environmental factors are influential in determining whether a belief is enacted in classroom practice.

Context for Teaching and Learning

This section of the literature review describes beliefs about factors affecting student achievement related to the context for teaching and learning. For the purposes of this study, the context for teaching and learning refers to teacher beliefs related to pedagogical issues such as the use of constructivism, learning styles, differentiated instruction, the nature of science and scientific inquiry, and varied learning strategies.

Snider and Roehl (2007), in a study examining teachers beliefs about teaching practices and current issues among 344 K-12 teachers, found that 75% of teachers believed that small class size was the primary factor leading to higher achievement. With regard to pedagogy, learning styles as an important factor to inform what and how to teach was a belief selected by 80% of those surveyed. Supportive of this was the belief held by 79% of those surveyed that there is no best way to teach all students and that an eclectic or balanced approach to instruction is best. Furthermore, their study data suggest that 45% of teachers believe that a prescriptive, well-designed curriculum provides the best opportunity for effective instruction and nearly half of those surveyed believed that ability grouping is necessary. A study by Ballone and Czerniak (2001), consistent with the findings of Snider and Roehl, indicated that teachers' believe that implementing a variety of instructional strategies to meet the needs of different learning styles will increase student success, motivate students, and encourage participation and interest.

Regarding constructivism, Snider and Roehl (2007) had indicated that approximately half of the teachers were neutral (balanced or undecided) in relation to constructivist versus explicit instructional practices. Snider and Roehl described constructivism as being "based on the premise that learners construct knowledge based on their own experiences and prior beliefs" (p. 874), and explicit instruction being based on "a theory of learning that posits students learn best when presented with a systematic and sequential series of skills" (p. 874). Of those who took a stance, most felt strongly about authentic (31% of total) and facilitated learning (35% of total) over systematic and direct teaching, respectively. Tsai (2002), in a study of 37 Taiwanese teachers, found that more than half of the 37 teachers interviewed subscribed to 'traditional' beliefs about teaching, learning, and the nature of science. Furthermore, Tsai found that teacher beliefs about teaching, learning, and the nature of science were interrelated or 'nested', particularly with the more experienced teachers. Tsai argued that a change in teachers' beliefs about the nature of science may then result in changing teachers' beliefs about the teaching and learning of science, and vice versa. However, changing beliefs do not necessarily translate into changing practice (Tsai, 2002; Water-Adams, 2006). This 'nested' relationship was also noted by Waters-Adams (2006) who summarized that "teachers acquire confidence in their science practice only when there existed a resonance between their ideas about how to teach science, their understanding of the nature of science, and their general beliefs about how they should be teaching children" (p. 939). Wallace and Kang (2004), in an investigation of six experienced science teachers, found that teachers held competing belief sets about inquiry. They claim that "the belief sets that constrained inquiry-based instruction were more public and culturally based, while the belief sets that promoted inquiry were more private and based on the individual teacher's notion of successful science learning" (Wallace & Kang, 2004, p. 957). Essentially, Wallace and Kang (2004) described that the culturally-based belief of exam preparation and efficiency of curriculum coverage stood in contrast to the teachers' personal learning goals related to inquiry, and that policy makers should "make explicit the value of rich and meaningful learning goals for students by supporting curriculum standards for scientific thinking" (p. 959).

Teacher beliefs about the use of high critical thinking (CT) and low-CT practices have been the focus of a growing body of research. Results of seminal work by Raudenbush, Rowan, and Cheong (1993) indicated that the most prominent finding of their study was the link between CT activities and academics tracks (honors, academic, non-academic). Relative to low academic track classes, teachers were significantly more likely to focus on high-CT activities for high academics track classes, especially in Math and Science. Zohar, Degani, and Vaaknin (2001) reported similar findings where nearly half of the forty teachers interviewed in their study believe that high-CT activities to be ineffective for low-achievement learners. Torff (2006) studied the CT beliefs of expert (minimum five years experience and nominated by supervisors) and in-service teachers. The findings indicated that for both high-advantage and low-advantage learners, experts were more favorable of high-CT activities to low-CT activities relative to in-service teachers. The data also showed that the in-service teachers had strong beliefs about perceived learner advantages and the need for differentiation of the CT-level of instruction.

Professional Issues

This section of the literature review describes beliefs about factors affecting student achievement that are related to professional issues. For the purposes of this study, professional issues are non-pedagogical in nature and include issues such as those related to student and family characteristics, teacher efficacy, and outcome expectancy. "In education, self-efficacy has generally been defined as the belief that one's teaching ability is related to positive changes in students' behaviors and achievement levels, and outcome expectancy is the belief that any teacher, in spite of all other factors, can bring about positive student behavior and achievement" (Czerniak & Lumpe, 1996, p. 249).

Student and family characteristics.

In a study of the relation between teachers' beliefs about the importance of good student work habits, teacher planning, and student achievement, Fuchs, Fuchs, and Phillips (1994) found that those teachers with high standards and strong beliefs about the importance of good student work habits and classroom behavior reported that they planned their lessons with greater responsiveness to individual student performance and effected greater student achievement. Furthermore, "teachers who hold stronger beliefs about the importance of work habits and classroom behavior also appear to practice better instructional methods" (Fuchs, 1994, p. 342). Fuchs et al. also claimed that the high expectations may have more to do with teachers' commitment to having students in their classes work hard and a belief in their own capacity to obtain student achievement. The latter describes teacher self-efficacy beliefs which is elaborated on later in this section.

Harris and Goodall (2008) explored the relationship between parental engagement and student achievement among 314 respondents (parents, teachers, students) from 20 schools. Their findings indicated that there is a major difference between involving parents in schooling and engaging parents in learning. Although the involvement of parents in school activities has an important social function, Harris and Goodall (2008) claim that the evidence shows that it has little impact on subsequent learning and achievement. However, the "parental engagement in children's learning in the home makes the greatest difference to student achievement" (Harris & Goodall, 2008, p. 277). Furthermore, Harris and Goodall (2008) claim that the literature suggests that among the non-school factors affecting student achievement such as socioeconomic status, parents' educational attainment, family structure, and ethnicity, it is parental engagement that is the most strongly connected to achievement and attainment. Having made this claim is also clear that these other factors are not mutually exclusive of parental engagement as Harris and Goodall (2008) indicate that "it is clear that powerful social and economic factors still prevent many parents from fully participating in schooling" (p. 277) and "there is evidence that parental engagement increases with social status, income and parents' level of education" (p. 286). Similarly, the Snider and Roehl (2007) study reported that fifty-two percent of "teachers believed that factors (e.g., home environment, dyslexia) prevent children from learning basic skills despite the schools best efforts" (p. 882).

Snider and Roehl (2007) included additional items related to professional issues on their teacher belief survey. Nearly half of those surveyed had indicated that great teachers make learning fun as opposed to great teachers produce high achievement (11%). Furthermore, nearly half of those surveyed had indicated that teaching is more of an art than a science, and also that experience is valued over education and training in order to become an effective teacher. Only 19% of those surveyed agreed that scientifically conducted research is the best guide for determining what and how to teach. This focus on experience-driven versus theory-driven action was reiterated in the findings of the Waters-Adams (2006) study which suggest that teachers' espoused understanding of the nature of science may be formed, in part, by the influences of teachers' beliefs about education which would suggest that this influence may run from teaching to theoretical understanding, and not the reverse.

Teacher efficacy and outcome expectancy beliefs.

An alternate perspective regarding teacher beliefs and student achievement is related to teacher beliefs in their own ability to bring about positive change, or self-efficacy. Self-efficacy has generally been defined in education as "the belief that one's teaching ability is related to positive changes in students' behaviors and achievement levels, and outcome expectancy is the belief that any teacher, in spite of all other factors, can bring about positive student behavior and achievement" (Czerniak & Lumpe, 1996, p. 249).

Complementary to self-efficacy beliefs is another concept referred to as collective-efficacy. Collective teacher efficacy "refers to the perceptions of teachers that the efforts of the faculty as a whole will have a positive effect on students" (Brinson & Steiner, 2007, p. 1). Dufour, DuFour, Eaker, and Karhanek (2004) elaborated on teacher self- and collective-efficacy by claiming that "it is not the perception of a staff regarding the ability of their students that is paramount in creating a culture of high expectations. The staff members' perception of their own personal and collective ability to help all students learn is far more critical" (p. 181). In a study of 96 rural, urban, and suburban high schools from diverse geographical areas in a midwestern state, Goddard, LoGerfo, and Hoy (2004) found collective-efficacy to be a significant positive predictor of student performance in all content areas tested, even after accounting for school context factors which include minority enrollment, students' socioeconomic status, school size, and students' prior achievement. Complementary to the research correlating teacher self- and collective-efficacy to student achievement is the indirect effect of transformational leadership on student achievement. Ross and Gray (2006), in a study of 205 elementary schools, tested a model hypothesizing that principals contribute to student achievement indirectly through teacher commitment and beliefs about their collective capacity. Ross and Gray (2006) concluded that "schools with higher levels of transformational leadership had higher collective teacher efficacy, greater teacher commitment to school mission, school community, and school-community partnerships, and higher student achievement" (p. 798). Ross and Gray articulate that practices of leaders that include persuading teachers that they can become an effective organization, and setting feasible goals and interpreting achievement data as evidence of success and failure to meet these goals provide a means of increasing teacher commitment. Furthermore, they claim that principals can reduce teacher stress and also create opportunities for teacher collaboration and observation through timetabling which would provide the potential to "strengthen individual and collective teacher efficacy through vicarious experience" (Ross & Gray, 2006, p. 814).

It is evident from the review of the research on teacher beliefs that there are numerous pedagogical and non-pedagogical factors that have the potential to affect student achievement. Furthermore, it is also evident that there is a strong correlation between teacher beliefs and pedagogical practice. The following chapter describes the methodology used to obtain information on P.E.I. teachers' beliefs and the degree to which their beliefs are enacted in classroom practice.

Chapter 3: Methodology

Study Design

According to Johnson and Onwuegbuzie (2004), mixed methods research is defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p.17). A mixed method design does not restrict the researcher to the methods used by quantitative or qualitative purists, but rather allows the flexibility to select a combination of data collection methods that best fits the research question. Essentially, the use of both quantitative and qualitative data may enrich results in ways that one form of data does not allow (Hansen, Creswell, Clark, Petska, & Creswell, 2005). The use of both forms of data should "[allow] researchers to simultaneously generalize results from a sample to a population and to gain a deeper understanding of the phenomenon of interest" (Hansen et al., 2005, p. 224). Green, Caracelli, and Graham (1989) identified five purposes for conducting mixed methodology research, including triangulation (convergence, corroboration), complementarity (elaboration, clarification), initiation (uncovering contradictions or new perspectives), development (one method informs the other), and expansion (increasing the breadth of the research).

The primary rationale for the use of mixed methodology research in this study was to access the strengths of two opposing paradigms of research which permitted a more accurate examination of the research questions, and identified further areas of potential research. Specifically, this study contains evidence of the purposes for using mixed methodology as articulated by Green, Caracelli, and Graham. The qualitative data assisted in providing a context which elaborated (complementarity) and increased the breadth (expansion) of the quantitative data. Furthermore, data from the first stage (survey) of this study was analyzed prior to the second stage which provided new perspectives (initiation) that were used to inform (development) the method used in the second stage (teacher interviews).

This study followed a mixed methods research process model devised by Johnson and Onwuegbuzie (2004) which comprised the following eight steps:

> (1) determine the research question; (2) determine whether a mixed design is appropriate; (3) select the mixed method or mixed-model research design; (4) collect the data; (5) analyze the data; (6) interpret the data; (7) legitimate the data; and (8) draw conclusions (if warranted) and write the final report. (p. 21)

This research design (mixed-model and mixed methods) was employed in two sequential stages with a primary emphasis placed on the quantitative approach and secondary emphasis placed on qualitative. The first stage entailed a *within-stage mixed model design* (QUAN + qual) using a survey which primarily contained scaled response items (quantitative) and three open-response questions (qualitative). The second stage involved interviews (qualitative) with a purposeful sample of participants who had completed the questionnaire.

For several reasons, survey was selected as the data collection method to obtain the necessary information to assist in exploring the two primary research questions. Questionnaire type surveys are conducive to collecting data from large populations in a short time period. Furthermore, survey data can be quickly compiled and analyzed for quantitative predictions. According to Cohen, Manion, and Morrison (2003), the advantages of survey over other data collection techniques, such as interview, include greater reliability and honesty in responses due to participant anonymity, and surveys are more economical in terms of time and money. According to Fink (2003), a survey is a "system of collecting information from or about people to describe, compare, or explain their knowledge, attitudes, and behavior" (p. 1).

In the context of this study, a previously established survey, conducive to exploring the primary research questions, was used to collect data on teacher beliefs. Permission was granted from Charlene M. Czerniak to use/adapt the survey instrument from her study published in the *Journal of Science Teacher Education* entitled "Relationship between Teacher Beliefs and Science Education Reform" (Czerniak & Lumpe, 1996). A consensus panel and a pilot group were used in this study to adapt and validate the existing survey instrument and pilot test survey procedures, respectively. More specifically, the consensus panel, consisting of a school district curriculum consultant, two university science education researchers (thesis supervisors), and a secondary science curriculum specialist (primary researcher), analyzed the adapted survey instrument for content validity through the following two lenses: the importance of the survey items, and the feasibility of getting honest answers to questions. Furthermore, the panelists provided suggestions for question addition, adaptation, and removal, such that the adapted instrument would be more conducive to finding answers to the research questions.

Qualitative methods, as a secondary emphasis, were employed in both stages of the study design. In consideration of the nature of the research questions, discrepancies may exist between teacher beliefs and how their beliefs are enacted in practice. The quantitative survey data served to identify similarities and differences among respondents; however, this quantitative research method has limitations such as its ability to place potential discrepancies in context. As an example, the quantitative data may suggest differences in responses between minor groups of the survey population; however, the quantitative data does not provide a context as to why these differences do exist. Furthermore, "if only closed items are used, the survey may lack coverage or authenticity" (Cohen, Manion, & Morrison, 2003, p. 129). According to Johnson and Onwuegbuzie (2004), the strength of the qualitative component is that it can describe phenomena with rich detail using local contextual and setting factors.

The first qualitative component occurred in stage 1 of the study design. This qualitative component was incorporated in the *within-stage mixed model design* which utilized open-response items. The open-response questions were included to assist in providing a context to survey responses, identify new perspectives, contribute to triangulation, and to aid in identifying areas of further research. The results from open-response questions, as Cohen et al. (2003) stated, may "contain the 'gems' of information that otherwise might not have been caught in the questionnaire" (p. 255). Furthermore, Cohen et al. (2003) articulated that open-response questions can provide participants with ownership of the data and also catch the authenticity, richness, depth, and candor which are the hallmarks of qualitative data.

The second qualitative component occurred in stage 2 of the study design. This component involved teacher interviews with a purposeful sample of six educators who completed the survey and agreed to be questioned. The questions included in the interviews were informed by the analysis of the results of the stage 1 survey data.

Ethics

The proposal for this research was reviewed by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) and found to be in compliance with Memorial University's Ethics policy. A letter (see appendix A) requesting permission to survey and interview the secondary science teacher population was send to both English language school districts – Western School Board and Eastern School District – of Prince Edward Island on June 11th, 2009. Permission was granted from both districts.

Stage 1- Survey.

A letter (see appendix B) containing all necessary information about the survey (study rationale, anonymity, confidentiality, consent), as well as the survey location (web address) and incentive (explained in a following subsection) was sent via electronic mail to the entire secondary science teaching population (N = 159) of both school districts on June 17th, 2009. Two reminders were sent to each secondary science teacher prior to closing the survey on Friday, June 26th at 5 pm (EST). Specifics regarding anonymity, confidentiality, and consent are further described as follows: (a) participation in the survey was completely voluntary; (b) confidentiality and anonymity was guaranteed as the survey did not ask for teacher identification or contact information; (c) teachers were not asked for information that identified their school or school board/district; and (d) teacher consent to participate in this survey study was given by submission of a completed survey. Furthermore, as a small incentive to participate in the survey, participants had an opportunity to win one of ten $50 gift certificates at a local restaurant.

Upon completion of the survey, participants were asked if they would like a chance to enter a draw for a gift certificate. Participants who chose to engage in the survey incentive were redirected to a separate website which requested their name and contact information. As a result, the personal information provided by participants was collected completely independent of, and thus is not linked to, their survey data. Furthermore, the participation incentive was administrated entirely by an independent third party.

Stage 2 – Teacher interview.

A letter (see appendix C) containing all necessary information about the interview (study rationale, anonymity, confidentiality, consent) was provided to participants. Participation in the interview process was voluntary. Participants signed a statement of informed consent prior to participating, were free to withdraw from the study at any time and also to withdraw any data that pertained to them. Pseudonyms were used as identifiers on all data collected from the interview. The interpretations of the interview data (research summaries) were shared with participants to obtain their feedback prior to the publication of results. Furthermore, participants were informed that the interview data would be stored in a locked cabinet in the office of the principal investigator (myself) and that a research assistant (transcriber) and I would be the only individuals who would have access to the data. Furthermore, data transcription was performed confidentially and all data will be destroyed within five years of completing the research.

Study Duration and Research Participants

This study began in June 2009. Survey data collection was completed on June 26th of the same month. Teacher interviews were completed in October and November of

2009. Participants in this study included the entire secondary science teacher population (N = 159) of both English language school districts – Eastern School District and Western School Board – of P.E.I. For the purpose of this study, to be considered as a member of the secondary science teacher population, participants must have taught at least one science course during the year that the survey was administered (2008-2009 school year). The decision to survey the entire secondary science teacher population was based on obtaining the best possible representation of the population, and eliminated the need for probability samples. A sample size of thirty is frequently referenced to be the minimum number of cases required if researchers plan to use statistical analysis on their data (Cohen et al., 2003); therefore, by surveying the entire population there existed a greater opportunity to perform statistical analysis on the population, as well as comparing categories within the population to identify similarities and statistically significant differences in their responses to survey items. Categories within the population were created based on teaching experience (1-5 years, > 5 years), level taught (intermediate – senior high), gender (male, female), undergraduate major (science, non-science), and education degree (Bachelor of Education, Master of Education).

Data Collection Methods

The data collection methods employed in this study were survey (stage 1) and interview (stage 2). The following sections describe the details of these data collection methods.

Stage 1 - Survey.

The form of survey used was an online, self-administered questionnaire. This survey was computer-assisted to allow the participants to select from available options which minimized coding on the researcher's part, and reduced the time required for participants to complete the survey. Furthermore, the survey was web-based to minimize cost and to allow respondents to respond with greater flexibility of time and location. The survey instrument (see appendix D) was divided into the following three distinct components: Part I (General Information); Part II (Context for Teaching and Learning); and Part III (Professional Issues). Each component, and the details of its construction, is described subsequently.

Part I: General information.

This component of the survey instrument contained five items which collected participant information using nominal (e.g., male or female) and numerical response choices (e.g., years of teaching experience). Participant information collected included: possession of an undergraduate major in science, highest level of degree in education, number of years of teaching experience, courses presently teaching, and gender.

Part II: Context for teaching and learning.

The instrument used in the second part of the survey was developed by adapting the *Reform Instrument* (Czerniak & Lumpe, 1996) to measure teacher beliefs about various ideas reflected by topics regarding science education and the degree to which these ideas are transferred to teachers' classroom practice. The authors, Charlene M. Czerniak and Andrew T. Lumpe, created their 12-topic reform instrument by adding three topics – nature of science, hand-on/minds-on activities, and science content knowledge – to the Biological Sciences Curriculum Study (1994) survey instrument. These three additional topics were gleaned from influential policy reports on science education from professional organizations – The *National Science Education Standards (NSES)* developed by the National Research Council (NRC) and Academy of Sciences (NRC, 1996); *Project 2061: Benchmarks for Science Literacy* developed by the American Association for the Advancement of Sciences (AAAS, 1993); and *Science for All Americans: Project 2061* (Rutherford & Ahlgren, 1989) developed by the American Association for the Advancement of Sciences. *"Benchmarks for Science Literacy"* is the Project 2061 statement of what all students should know and be able to do in science, mathematics, and technology by the end of grades 2, 5, 8, and 12. The recommendations at each grade level suggest reasonable progress toward the adult science literacy goals laid out in the project's 1989 report "*Science for All Americans*" (AAAS, 1993). *Benchmarks for Scientific Literacy* was used, in part, in the development of the National Research Council's NSES. The NSES presents a vision of scientific literacy for all members of the population and outlines what students need to "know, understand, and be able to do to be scientifically literate at different grade levels" (NRC, 1996, p.2).

The general changes to the Czerniak and Lumpe *Reform Instrument,* based on the recommendations of the consensus panel, resulted in an adapted survey instrument containing 14 topics which included: constructivism, learning styles, inclusion, thematic approach, classroom management, formative assessment and evaluation, summative assessment and evaluation, equity, science/technology/society, electronic learning, science subject matter, cooperative learning, hands-on/minds-on activities, and the nature of science (see appendix D). The topic *Assessment and Evaluation* from the original reform instrument was divided into two topics, namely, *Summative Assessment and Evaluation* and *Formative Assessment and Evaluation*. The topic *Inclusion* was added to the adapted survey. Furthermore, the topic *Educational Technology* was replaced with *Electronic Learning*. Most topic definitions from the original reform instrument were maintained; however, new definitions were added for the three additional topics identified above and minor modifications were made to the definitions of three existing topics (*Constructivism*, *Equity*, *and Cooperative Learning*).

The adapted survey instrument, like the original reform instrument, defined each topic. Each topic definition was followed by two scaled items: a) belief about the degree of necessity to be an effective science teacher, and b) degree of implementation in your classroom during the year. A four-point, forced-choice scale was used for participants to identify the degree in which their beliefs aligned with a given topic. Options made available in the adapted survey instrument included: Unnecessary, Not Very Necessary, Necessary, and Very Necessary. The adapted survey instrument did not include the "Undecided" response option that was available in the original *Reform Instrument*. The "undecided" option in the adapted survey was removed, thus forcing participants to take a stance about their beliefs and to provide a more thoughtful response about their beliefs, instead of selecting a neutral option. No changes were made to the five-point, Likert scale from the original *Reform Instrument* which was used to permit respondents to identify the degree to which they incorporate their belief of a given topic into their teaching practice. The response options available for the scale related to the degree of implementation of a topic in classroom practice during the year included: Never, Less

Than Once a Week, About Once a Week, Several Times a Week, Almost Every Day. The original *Reform Instrument* did not include any qualitative items. However, the adapted survey instrument included the following open-response item:

Explain why differences exist (if they exist) between topics that you believe are necessary to be an effective science teacher and the degree of implementation of these topics in your teaching practice.

Part III: Professional issues.

The *Science Teacher Efficacy Belief Instrument,* STEBI (Czerniak & Lumpe, 1996), was adapted in the third part of the survey to measure science teacher beliefs about teaching science. This 25-item instrument, originally developed by Riggs and Enochs (1990), consists of two scales: self-efficacy and outcome expectancy. Self-efficacy items measured teacher beliefs in their own ability to affect student achievement in science, while outcome expectancy measured teacher beliefs about an educator's ability to affect student achievement in science.

The adapted instrument used an ordinal four-point forced choice scale in which the degree that participant beliefs aligned with a given item description could be described by selecting one of the following four available options: Strongly Disagree, Disagree, Agree, and Strongly Agree. The response options on the adapted instrument deviated from the original by removing the "Uncertain" option from the five-point Likert scale used in the STEBI. Furthermore, the following two open-response questions were added to the STEBI, for a total of 27 items included in the adapted instrument:

- What is the primary factor(s) that enhances your ability to be an effective teacher of science?
- What primary factor(s) presents challenges to your ability to be an effective science teacher?

The open-response questions added to the *Reform Instrument* and STEBI in the creation of the adapted instrument for Part I and Part II, respectively, serve to address all five purposes identified by Green et al. (1989) for conducting mixed methodology research; namely, triangulation, complementarity, initiation, development, and expansion.

Prior to administering the survey to the entire population, a pilot group consisting of two in-service science teachers (1 intermediate teacher; 1 high school teacher) pilot tested the self-administered, web-based survey instrument to assess the functioning of the online survey procedures. The pilot teachers both indicated that the online survey functioned well; however, the redirect function which sent participants to the survey incentive Internet page required further programming to function properly.

Stage 2 - Teacher interviews.

Teacher interviews, conducted after the survey data had been collected and analyzed, were performed for the purpose of collecting rich contextual data and to assist in corroborating the survey results through the use of interview technique. The interview process began on October 16th and was completed on November 11th. The interviews involved a purposeful sample of six teachers whose demographic distribution was similar to that of the survey participants. Candidates interviewed were those who had completed the survey and who had indicated (on the survey) their willingness to participate in a post-survey interview. The demographic distribution among those interviewed was as follows: males (3), female (3); M.Ed. (3), B.Ed (3); B.Sc. (4), no B.Sc. (2); greater than 5 years experience (4), 1-5 years experience (2); intermediate level (2), senior high level(4).

Each teacher interview was approximately 45 minutes in duration and they were digitally recorded and later transcribed. To guide the interview process, a set of standard interview questions were created (see appendix E). The interview questions were informed, in part, by the results of the survey data analysis. This method of using one data collection process to inform the other, as Green et al. (1989) describe as development, allowed for the necessary elaboration on the quantitative data. For example, the survey data indicated that the frequency of implementation of beliefs into classroom practice was high for select topics and low for others. Consequently, the interview data was able to provide insight into reasons for the observed trend.

Reliability & Validity

The following briefly describes the procedures, followed by Czerniak and Lumpe (1996), which were used to address reliability and validity in the creation and testing of the *Reform Instrument* and STEBI instrument used in their study. Furthermore, this section describes the procedures employed to address reliability and validity of the adapted reform instrument and adapted STEBI instrument used in Part 1 "Context for Teaching and Learning" and Part II "Professional Issues" sections of this study, respectively.

Context for teaching and learning.

Reliability indices for both scales, beliefs and implementation, of the original *Reform Instrument* used by Czerniak and Lumpe (1996) were established using stability (Pearson correlation test-retest) and internal consistency (Cronbach's alpha analysis). In the Czerniak and Lumpe study, "reliability scores using test-retest procedure yielded coefficients of 0.82 for the belief and 0.73 for the implementation scales indicating a moderate to strong correlations between the two testings" (Czerniak & Lumpe, 1996, p.253). Regarding internal consistency, Cronbach's alpha coefficient resulted in 0.62 for the belief scale and 0.61 for implementation scale (Czerniak & Lumpe, 1996).

Czerniak and Lumpe (1996) argued that content validity existed for their reform instrument for two reasons. The first stems from the fact that the twelve items on the *Reform Instrument* pervade the science education reform literature and were extracted from various reports such as the *National Science Education Standards* (NRC, 1996), *Benchmarks for Science Literacy* (AAAS, 1993), and *Project 2061* (Rutherford & Ahlgren, 1989). Secondly, they argue that content validity exists because the Biological Sciences Curriculum Study (1994) survey instrument, which formed the foundation of their reform instrument, was based on a needs assessment which identified the topics that were later sent to reputable organizations for evaluation such as the Council of State Science Supervisors, the National Science Educational Leadership Association, and the Association for the Education of Teachers in Science.

Select topics - *Assessment and Evaluation, Educational Technology, Constructivism, Equity, and Cooperative Learning* - (see Data Collection Methods) on the reform instrument were amended in the creation of the adapted survey used in this study in order to provide clarity resulting from present understandings of these topics that have evolved since the original survey was administered. Consequently, content validity has been maintained as the individuals on the consensus panel who analyzed the amended survey items have expertise in science education research and/or curriculum development and implementation.

Professional issues.

Reliability indices for the two scales, self-efficacy and outcome expectancy, on the STEBI instrument used by Czerniak and Lumpe (1996) were established using stability (Pearson correlation test-retest) and internal consistency (Cronbach's alpha analysis). In the Czerniak and Lumpe study "Cronbach's alpha reliability coefficients were 0.85 for self-efficacy and 0.81 for outcome expectancy. Pearson correlations on a test-retest procedure yielded reliability coefficients of 0.87 and 0.77 for self-efficacy and outcome expectancy, respectively" (Czerniak & Lumpe, 1996, p. 253).

The response options from the STEBI used by Czerniak and Lumpe (1996) were amended in the creation of the adapted survey instrument used in this study. The change involved converting the five-point Likert scale to a four-point forced choice scale (see Data Collection Methods). Consequently, the adapted instrument used in this study reported the same Cronbach's alpha reliability coefficient of 0.85 for the self-efficacy scale and a lower Cronbach's alpha reliability coefficient of 0.67 for outcome expectancy.

Analysis of Data

A variety of quantitative and qualitative techniques were used to aid in analyzing the data. Descriptive statistics (response frequencies, means, and standard deviations) were provided for all survey items. Non-parametric tests (chi squared, Spearman's rho) were chosen to analyze the survey data for two reasons. Firstly, the response options to the survey items were ordinal (e.g., Never, Less Than Once a Week, About Once a Week, Several Times a Week, Almost Every Day). Secondly, only one survey item was provided on the survey for each topic assessed. Consequently, Pearson's chi squared analyses were performed to identify if statistically significant differences existed between responses gathered from minor groups of the population. Spearman's rho was performed to identify if correlations existed between beliefs about particular science education topics and the degree of implementation of these topics in classroom practice. Furthermore, qualitative methods were used to code the data resulting from the open-response questions. Descriptive statistics were then gathered to describe the frequency of the categories that were identified in the teacher responses. The following subsections further describe the specifics of the data analysis used on the data obtained from Part II (*Context for Teaching and Learning*) and Part III (*Professional Issues*) of the survey, and the teacher interviews.

Context for teaching and learning.

The descriptive statistics described the percentages of teachers responding to the necessity of each of the 14 topics to be an effective science teacher and the degree of implementation of these topics in their classroom during the year. Mean response and standard deviations were provided for both of these scales by assigning a numeric value to the response options. Pearson's chi squared analyses were performed on responses to teacher beliefs about the necessity of each of the 14 topics to be an effective science teacher in order to identify if statistically significant differences existed between subgroups of the six categories (undergraduate major in science, highest level of degree in education, number of years of teaching experience, courses presently teaching, participation on a science curriculum committee, and gender) of teacher demographic data obtained. For each of the fourteen topics in Part II of the adapted survey, Spearman's rho were performed between teacher beliefs about the necessity of a topic to be an effective science teacher and the degree of implementation of the topic in their classroom. Qualitative methods were used to analyze data from the open-response items by coding responses into categories (e.g., time) and sub-categories (e.g., curriculum, preparation) that emerged from the data (see Research Findings, Table 4-6). Descriptive statistics were then gathered to describe the frequency of the sub-categories that were identified in teacher responses to the open-response question items.

Professional issues.

The descriptive statistics described the percentages of teachers responding to the 25 items related to self-efficacy and outcome expectancy. Mean response and standard deviations were provided for both of these scales by assigning a numeric value to the response options. Pearson's chi squared analyses were performed on responses to the 25 professional issues items to identify if statistically significant differences existed between subgroups of the five categories (undergraduate major in science, highest level of degree in education, number of years of teaching experience, courses presently teaching, and gender) of teacher demographic data obtained.

As the 25 items used in this part of the survey assessed two scales (Self-Efficacy, Outcome Expectancy), a more relevant statistical analysis was employed by creating a Combined Self-Efficacy and a Combine Outcome Expectancy scale. These scales were created by combining the 13 items related to self-efficacy and the 12 items related to outcome expectancy, respectively (see Research Findings; Table 4.7 – *Professional Issues Survey Items*). To combine the items into the new scales those items that were negatively coded were recoded: negatively coded items were re-coded by assigning the values 1 through 4 to the response options "strongly agree" through "strongly disagree", respectively. The original coding for all items had assigned the values 1 through 4 to the response options "strongly disagree" through "strongly agree", respectively. Descriptive statistics were performed on the combined self-efficacy and outcome expectancy scales to identify the mean, median, and skewness statistic of each scale in order to determine if the data was normally distributed. Furthermore, the value of Cronbach's alpha was obtained to analyze the internal validity of the combined scales. Finally, independent sample t-tests were performed on each combined scale in order to identify if statistically significant differences existed between subgroups of the five categories (undergraduate major in science, highest level of degree in education, number of years of teaching experience, courses presently teaching, and gender) of teacher demographic data obtained.

Qualitative methods were used to analyze the data from the open-response items by coding responses into categories (e.g., passion) and sub-categories (e.g., content, pedagogy) that emerged from the data (see Research Findings, Table 4-11, Table 4-12). Descriptive statistics were then administered to this data to describe the frequency of the sub-categories that were identified in teacher responses to the open-response question items.

Teacher interviews.

An interview protocol (see appendix E) was administered in which interview participants were asked questions pertaining to (a) general beliefs, (b) the context for teaching and learning, and (c) professional issues. The interviews were recorded and later transcribed. The data from each interview were analyzed by first clustering interviewee responses to questions from the interview protocol. Patterns or themes that emerged from the interview responses were recorded and frequencies of occurrence of these common themes were reported. Furthermore, excerpts from interviewee responses containing rich contextual data were provided (see Research Findings; Interview data section) in support of summaries or interpretations made.

Researcher and Researcher's Role

I have twelve years of experience in the field of education. During this time I have taught in a variety of school settings – private, public, adult education – and at various grade levels (1-12). The majority of my professional career teaching occurred at the high school level teaching physical sciences. During the past four years, I have worked in the capacity of Secondary Science Program Specialist for the P.E.I. Department of Education and Early Childhood Learning. In this role, I developed, resourced, and facilitated in-service workshops for a variety of new high school science programs. Consequently, it was very important that participant confidentiality and anonymity was guaranteed as I am known by most secondary science teachers. Having recently renewed all the 'traditional' academic high school science courses (Chemistry, Biology, Physics), the study of science teacher beliefs is of particular interest to me in my role as secondary science program specialist as it has a huge potential to inform decision-making and professional development surrounding the supports required for the teachers engaged in these programs.

My role in this study was to perform the teacher interviews, and to create and deliver (via electronic mail) the adapted online survey instrument. Furthermore, I collected, coded and analyzed all resulting data. Those participants who chose to also participate in the survey incentive were redirected to a web site that was independent of their survey data. The redirected website requested personal information from participants and, consequently, was managed by a third party in order maintain participant anonymity.

Chapter 4: Research Findings

The following is a report on the findings obtained from the teacher beliefs survey that was administered to the secondary science teaching population of P.E.I.'s English language school boards and the teacher interviews that were conducted after the survey data was analyzed. The sections include (a) General Information (teacher demographics), (b) Context for Teaching and Learning, (c) Professional Issues, and (d) Interview Data.

The General Information section reports frequency data regarding the demographics of the survey participants. The second section – Context for Teaching and Learning – is subdivided into the subsections: Beliefs, Degree of Implementation, and Qualitative Survey Question. The Beliefs section reports descriptive statistics (frequency, mean, standard deviation) on the items assessed, statistically significant differences (chi squared) between teacher beliefs and teacher demographic data, and bivariate correlations (Spearman's rho) between teacher beliefs and the degree of implementation of these beliefs in classroom practice. The Degree of Implementation subsection reports descriptive statistics (frequency, mean, standard deviation) on the items assessed. The final subsection – Qualitative Survey Question – reports descriptive statistics used to describe the frequency of the sub-categories that were identified in teacher responses to the open-response question item. The third section – Professional Issues – reports descriptive statistics (frequency, mean, standard deviation) on the items assessed (efficacy beliefs, outcome expectancy beliefs), and statistically significant differences (Pearson's chi squared) between the items assessed and teacher demographic data.

Furthermore, two new scales were created by combining all items related to self-efficacy beliefs into one scale (self-efficacy) and all items related to outcome expectancy beliefs into another scale (outcome expectancy). The combined scales were then assessed for skewness (skewness statistic, mean, median), reliability (Cronbach's alpha), and statistically significant differences (independent sample t-test) between teacher demographic groups. Finally, descriptive statistics were used to describe the frequency of the sub-categories that were identified in teacher responses to the open-response question items. The final section – Interview Data – reports on the key findings obtained from the teacher interviews.

Teacher Demographics

Research participant demographic data is listed in Table 4.1. Eighty-two surveys (52%) were completed from the total population of 159 secondary science teachers. From the completed surveys, 34 (41%) were male and 48 (59%) female. This participation by gender was similar to the gender distribution among the total secondary science population which contains 69 (43%) males and 90 (57%) females. Thirty-two (39%) of the participants taught at the intermediate level while 50 (61%) taught at the high school level. This statistic was significantly different from the total science teacher population ratio which consist of 81 (51%) intermediate and 78 (49%) senior high teachers. It should be noted that two participants who taught at both the intermediate and senior levels were included in the intermediate group. Sixty-five (79%) teachers had an undergraduate degree in science, while 17 (21%) did not. Twenty-three teachers (28%) held a Master's degree in education, and 59 (72%) held a Bachelor's degree. With regard to teaching experience, three teachers (4%) had two years experience or less, 12 teachers (15%) had 3-5 years experience, and 67 teachers (82%) had more than five years experience.

Table 4.1 - *Demographic Data*

Category	---------------------------- Frequency (Percent)	----------------------------		Total
Gender	34 (41%) Male	48 (59%) Female		82
Teaching Experience	3 (4%) 1-2 years	12 (15%) 3-5 years	67 (82%) >5years	82
Undergraduate Science	65 (79%) Yes	17 (21%) No		82
Education Degree (Level)	59 (72%) Undergraduate	23 (28%) Masters	0 PhD	82
Level Taught*	32 (39%) Intermediate	50 (61%) Senior High		

*Note: 2 teachers of the 32 intermediate teachers listed also teach 1 section of a high school science course

Contexts for Teaching and Learning

Teacher beliefs.

Percentages of teachers responding to each of the fourteen topics measuring their belief of the degree of how necessary these are to be an effective science teacher are listed in Table 4.2. This table also provides the mean response and associated standard deviation for each topic surveyed. The mean values shown in Table 4.2 were obtained by assigning the values 1 through 4 to the response options "unnecessary" through "very necessary", respectively.

The results show that teachers hold strong beliefs for each of the fourteen topics surveyed. The strong beliefs were indicated by the high combined frequency of "Necessary" and "Very Necessary" responses. Over 90% of teachers believed that all but three topics surveyed were necessary or very necessary to be an effective science teacher. It should also be noted that "Unnecessary" was never selected by participants for any of the fourteen topics surveyed. Teachers reserved their strongest beliefs for four topics with a mean score above 3.5 and a percentage of combined frequency of "Necessary" and "Very Necessary" responses greater than 98%. These topics include Science Subject Matter (*M* = 3.65; *SD* = 0.51), Classroom Management (*M* = 3.59; *SD* = 0.50), Learning Styles (*M* = 3.57; *SD* = 0.50), and Equity (*M* = 3.54; *SD* = 0.55). The percentage of teachers who identified these topics as "Necessary" or "Very Necessary" is 99%, 100%, 100%, and 98%, respectively. The definitions that were provided on the survey for these topics were:

> **Science Subject Matter.** The teacher possesses knowledge of those basic concepts, principles, facts, laws and theories that constitute the current body of scientific knowledge. For example: the teacher is knowledgeable enough of astronomy to teach the content and answer most all questions the students might ask.
> **Classroom Management.** Procedures and techniques teachers employ in planning learning tasks, using educational resources, and conducting instruction to maximize student learning. For example: providing helpful hints for setting up laboratories.
> **Learning Styles.** Students have preferred modes and styles of learning. Teachers can use a diversity of instructional strategies to meet the needs of all students. For example: basing instruction on learning styles by including a variety of activities and approaches.
> **Equity.** Teacher provides learning experiences so that students develop positive attitudes, self-efficacy, and an understanding of science and technology. For example: making sure minorities, physically challenged, & both genders are involved in activities.

The five topics with a mean score between 3.25 and 3.5 include STS (*M* = 3.46; *SD* = 0.53), Hands-On/Minds-On (*M* = 3.44; *SD* = 0.50), Summative Assessment and Evaluation (*M* = 3.34; *SD* = 0.50), Formative Assessment and Evaluation (*M* = 3.29; *SD* = 0.56), and Constructivism (*M* = 3.28; *SD* = 0.55). The percentage of teachers who identified these topics as necessary or very necessary is 99%, 100%, 99%, 95%, and 95%, respectively. The definitions provided on the survey for these topics were:

> **Science/Technology/Society.** Curriculum and instruction includes emphases on the history and nature of science and technology; the interactions among science, technology, and society; on science-related social issues; understanding how things are made and how

they work; and how science relates to our lives through such things as the environment, medicine, and engineering. For example: a unit on acid rain or studying the development of the germ theory of disease.
Hands-On/Minds-On Activities. Teachers choose and use effective science activities which promote student learning and positive attitudes toward science. Example: In a unit on sound, students actually experience how sound travels through air, water, and solids by manipulating equipment
Summative Assessment and Evaluation. Teachers gather data from diverse sources to judge the degree which the students achieved the intended outcomes for the program (Assessment "of Learning"). For example: paper and pencils test, performance assessment, portfolio, etc.
Formative Assessment and Evaluation. Teachers engage in a continuous process of gathering data from diverse sources to make decisions about instruction (Assessment "for learning"). For example: group discussion, performance assessment, etc.
Constructivism. A learning theory that assumes that all learners construct their own meaning for concepts based on their personal experiences with the natural world. For example: instruction is based on students' prior knowledge, students are provided with the opportunity to make inferences based on experimentation and peer discussion/debate

The five topics with the lowest mean scores (3.00 to 3.25) and lowest combined percentage of "Necessary" or "Very Necessary" responses include Inclusion (*M* = 3.24; *SD* = 0.62), Thematic Approach (*M* = 3.20; *SD* = 0.62), The Nature of Science (*M* = 3.18; *SD* = 0.55), Electronic Learning (*M* = 3.05; *SD* = 0.59), and Cooperative Learning (*M* = 3.05; *SD* = 0.63). The percentage of teachers who identified these topics as "Necessary" or "Very Necessary" is 90%, 89%, 93%, 85%,and 83%, respectively. Cooperative Learning, Electronic Learning, Thematic Approach, and Inclusion are noteworthy as 10% of the respondents selected these topics as "Not Very Necessary" – 17%, 15%, 11%, and 10%, respectively. The definitions provided on the survey for these topics were:

Inclusion. The science classroom consists of students with varying knowledge and ability level. Teachers can use a diverse array of instructional materials and strategies to meet the needs of all learners. For example: open-ended assignments, offering choice in terms of learning activities, adapting materials to match the ability level of students above or below grade level expectations, etc.
Thematic Approach. A curricular organization using major concepts or ideas in science and technology to provide a sense of continuity across a unit, chapter, or year. For example: systems, patterns of change.

The Nature of Science. Teachers enable students to understand and engage in scientific inquiry; to make evidence-based decisions through an understanding and appreciation for the modes of reasoning involved in scientific inquiry. Also includes the social and historical contexts in which science evolved along with the values underlying the work of scientists. For example: the teacher has students use a candle, water, flask, and pan to see why water rises in a flask when it is put over a burning candle sitting in a pan of water. Students reason why water rises and discuss with each other why they think the water rises. The teacher does not give an "exact answer", but allows students to explore the idea over several hours or days.
Electronic Learning. Teachers use computer technology as the medium of instruction to promote student learning. For example: web-based or LAN-based communication tools, interactive digital technologies (tutorials, simulations, demonstrations).
Cooperative Learning. An approach emphasizing conceptual learning through social interaction within small groups of students. For example: balancing instruction within small groups emphasizing the social skills along with content to be learned

Table 4.2 -*Percentages of Teachers Responding to Each Topic: Degree of Necessity to be an Effective Science Teacher.*

	Response (%)							
Topic	UN	NVN	N	VN	N+VN	n	*M*	*SD*
Science Subject Matter	0	1.2	32.9	65.9	98.8	82	3.65	0.51
Classroom Management	0	0	41.5	58.5	100	82	3.59	0.50
Learning Styles	0	0	42.7	56.1	98.8	81	3.57	0.50
Equity	0	2.4	41.5	56.1	97.6	82	3.54	0.55
STS	0	1.2	51.2	47.6	98.8	82	3.46	0.53
Hands-On/Minds-On Activities	0	0	56.1	43.9	100	82	3.44	0.50
Summative A&E	0	1.2	63.4	35.4	98.8	82	3.34	0.50
Formative A&E	0	4.9	61.0	34.1	95.1	82	3.29	0.56
Constructivism	0	4.9	62.2	32.9	95.1	82	3.28	0.55
Inclusion	0	9.8	56.1	34.1	90.2	82	3.24	0.62
Thematic Approach	0	11.0	58.5	30.4	88.9	82	3.20	0.62
The Nature of Science.	0	7.3	67.1	25.6	92.7	82	3.18	0.55
Electronic Learning	0	14.6	65.9	19.5	85.4	82	3.05	0.59
Cooperative Learning	0	17.1	61.0	22.0	83.0	82	3.05	0.63

UN (Unnecessary); NVN (Not Very Necessary); N (Necessary); VN (Very Necessary);
N+VN (combined Necessary and Very Necessary); M (Mean Response); *SD* (Standard Deviation)

Chi squared tests, which identified a statistically significant difference ($p < 0.05$) between teacher demographic data groups and data obtained for each of the fourteen contexts for teaching and learning topics, are listed in Table 4.3. Results showed that there was no statistically significant difference ($p > .05$) between the level of degree in education and the fourteen topics related to the contexts of teaching and learning.

Furthermore, no statistically significant difference existed between the teacher demographic data groups and data obtained from the following context for teaching and learning topics: Classroom Management, Learning Styles, Equity, STS, Summative Assessment, Constructivism, Thematic Approach, The Nature of Science, Electronic Learning and Cooperative Learning.

Although science teachers reserved their strongest beliefs overall for Science Subject Matter ($M = 3.65$, $SD = .51$) regarding the degree of necessity to be an effective teacher, there was a significant difference between this topic and three categories of demographic data, namely: Teaching Experience, $\chi^2 (2, N = 82) = 8.65$, $p < .05$; Science Degree (B.Sc), $\chi^2 (2, N = 82) = 8.42$, $p < .05$; and Level taught, $\chi^2 (2, N = 82) = 6.66$, $p < .05$. High school science teachers, teachers with greater than five years experience, and teachers who hold a Bachelor's degree in science scored higher than the associated groups in relation to this topic (see Table 4.3).

A significant difference existed between formative assessment and two categories of demographic data, namely, Science Degree (B.Sc), $\chi^2 (2, N = 82) = 6.19$, $p < .05$; and Gender, $\chi^2 (2, N = 82) = 6.28$, $p < .05$. Teachers who do not hold a science degree reported a higher frequency (59%) of very necessary responses for formative assessment as compared to those who have a science degree (28%). Furthermore, 12% of male teachers reported formative assessment to be unnecessary as compared to female teachers who reported formative assessment as either necessary or very necessary.

A significant difference existed between Inclusion and Level Taught, $\chi^2 (2, N = 82) = 9.33$, $p < .05$. Intermediate teachers reported a higher combined frequency of necessary and very necessary responses for inclusion as compared to those who teach high school (see Table 4.3).

Table 4.3 - *Pearson's Chi Squared: Demographic - Context for Teaching/Learning Topics*

Topic	Demographic	*df*	χ^2	*Asymp. Sig. (2-tailed)*
Hands-On/Minds-On Activities	Teaching Experience	1	3.863	.049
Science Subject Matter	Teaching Experience	2	8.652	.013
Formative Assessment	Science Degree (B.Sc.)	2	6.189	.045
Science Subject Matter	Science Degree (B.Sc.)	2	8.416	.015
Inclusion	Level Taught	2	9.327	.009
Science Subject Matter	Level Taught	2	6.666	.036
Formative Assessment	Gender	2	6.284	.043

Note: Regarding Degree in Education, no statistically significant differences between Bachelor and Masters

				Response (%)			
Topic	Demographic	Group	*n*	UN	NVN	N	VN
Hands-On/Minds-On Activities	Teaching Experience	1-5years	15	0	0	33.3	66.7
		> 5 years	67	0	0	61.2	38.8
Science Subject Matter	Teaching Experience	1-5years	15	0	6.7	53.3	40.0
		> 5 years	67	0	0	28.4	71.6
Science Subject Matter	Science Degree (B.Sc.)	Yes	65	0	0	27.7	72.3
		No	17	0	6	52.9	41.2
Science Subject Matter	Level Taught	Intermediate	32	0	3.1	46.9	50.0
		Senior High	50	0	0	24.0	76.0
Inclusion	Level Taught	Intermediate	32	0	3.1	43.8	53.1
		Senior High	50	0	14.0	64.0	22.0
Formative Assessment	Science Degree (B.Sc)	Yes	65	0	4.6	67.7	27.7
		No	17	0	5.7	35.3	58.8
Formative Assessment	Gender	Male	34	0	11.8	52.9	35.3
		Female	48	0	0	66.7	33.3

UN (Unnecessary); NVN (Not Very Necessary); N (Necessary); VN (Very Necessary)

The final statistically significant difference existed between Hands-On/Minds-On Activities and Teaching Experience, χ^2 (1, N = 82) = 3.86, p < .05. All teachers reported Hands-On/Minds-On Activities as being necessary or very necessary. However, teachers with 5 years of experience or less reported a higher frequency of very necessary (67%) responses as compared to teachers with greater than 5 years experience (39%).

Spearman's rhos, used to assess the strength of the relationship between teacher beliefs of the fourteen topics and the degree of implementation of these topics in practice, are provided in Table 4.4. The results show that a strong correlation, indicated by a 2-tailed significance at or below the 0.01 level, exists between beliefs and implementation for each of the fourteen topics surveyed. Although a high correlation exists between beliefs and degree of implementation of these topics in practice, these values do not reflect the degree of implementation based on one's beliefs. Essentially, high correlations indicate that stronger beliefs suggest stronger implementation, not necessarily a high frequency of implementation. The degree of implementation of the topics surveyed, based on self-report data, are provided in Table 4.5.

Table 4.4 – *Spearman's Rho (Belief – Implementation)*

Topic	*N*	Spearman's *rho*	Significance (2-tailed)
Inclusion	82	0.638**	0.000
Science Subject Matter	82	0.597**	0.000
Thematic Approach	82	0.521**	0.000
Constructivism	82	0.536**	0.000
The Nature of Science	82	0.566**	0.000
Cooperative Learning	82	0.541**	0.000
Formative Assessment and Evaluation	82	0.507**	0.000
Science/Technology/Society	82	0.521**	0.000
Classroom Management	82	0.461**	0.000
Equity	82	0.425**	0.000
Learning Styles	81	0.347**	0.001
Summative Assessment and Evaluation	82	0.303**	0.006
Hands-On/Minds-On Activities	82	0.301**	0.006
Electronic Learning	82	0.284**	0.010

** Significant at the 0.01 level (2-tailed)

Degree of implementation.

Percentages of teachers responding to each of the fourteen topics measuring the degree of implementation of the topic in their classroom during the year are listed in Table 4.5. This table also provides the mean response and associated standard deviation for each topic surveyed. The mean values shown in Table 4.5 were obtained by assigning the values 1 through 5 to the response options "never" through "almost every day", respectively.

The Nature of Science ($M = 2.73$; $SD = 0.89$) and Science Subject Matter ($M = 4.57$; $SD = 0.67$) had the lowest and highest mean score for this scale, respectively. The percentages of teachers who reported having implemented the topics in one of the three highest frequency options (about once a week; several times a week; almost every day) ranged from 48.7% to 98.8%. Teachers reserved their strongest degree of implementation for the same four topics for which they had highest beliefs regarding the necessity to be an effective science teacher. The topics having mean scores above 4.0 include Science Subject Matter ($M = 4.57$; $SD = 0.67$), Classroom Management ($M = 4.30$; $SD = 0.87$), Equity ($M = 4.22$; $SD = 0.98$), and Learning Styles ($M = 4.10$; $SD = 0.71$). The percentage of teachers who reported the frequency of implementation of these topics as "At Least Once a Week", "Several Times a Week", or "Almost Every Day" is 99%, 95%, 92%, and 98%, respectively.

The five topics with a mean score between 3.25 and 4.0 include Thematic Approach ($M = 3.89$; $SD = 1.07$), Constructivism ($M = 3.70$; $SD = 0.81$), STS ($M = 3.61$; $SD = 1.04$), Inclusion ($M = 3.50$; $SD = 1.15$), and Formative Assessment and Evaluation

($M = 3.48$; $SD = 0.91$). The percentage of teachers who reported the frequency of implementation of these topics as "At Least Once a Week", "Several Times a Week", or "Almost Every Day" is 87%, 93%, 81%, 77%,and 83%, respectively.

Teachers reserved their lowest degree of implementation for five topics with a mean score below 3.25. These topics include The Nature of Science ($M = 2.73$; $SD = 0.89$), Electronic Learning ($M = 3.00$; $SD = 1.02$), Summative Assessment and Evaluation ($M = 3.01$; $SD = 0.85$), Hands-On/Minds-On Activities ($M = 3.11$; $SD = 0.79$), and Cooperative Learning ($M = 3.13$; $SD = 0.94$). The percentage of teachers who reported the frequency of implementation of these topics as "At Least Once a Week", "Several Times a Week", or "Almost Every Day" is 49%, 65%, 70%, 78%, and 72%, respectively.

Table 4.5 -*Percentages of Teachers Responding to Each Topic: Degree of Implementation in Your Classroom during the Year.*

	Response (%)							
Topic	N	LOW	AOW	STW	AED	*n*	*M*	*SD*
Science Subject Matter	0	1.2	6.1	26.8	65.9	82	4.57	0.67
Classroom Management	0	4.9	12.2	30.5	52.4	82	4.30	0.87
Equity	0	8.5	13.4	25.6	52.4	82	4.22	0.98
Learning Styles	0	2.4	13.4	56.1	28.0	81	4.10	0.71
Thematic Approach	2.4	11.0	14.6	39.0	32.9	82	3.89	1.07
Constructivism	0	7.3	30.5	47.6	14.6	82	3.70	0.81
STS	0	19.5	22.0	36.6	22.0	82	3.61	1.04
Inclusion	2.4	20.7	25.6	26.8	24.4	82	3.50	1.15
Formative A&E	0	17.1	29.3	42.7	11.0	82	3.48	0.91
Cooperative Learning	1.2	26.8	36.6	28.0	7.3	82	3.13	0.94
Hands-On/Minds-On Activities	0	22.0	48.8	25.6	3.7	82	3.11	0.79
Summative A&E	0	30.5	42.7	22.0	4.9	82	3.01	0.85
Electronic Learning	2.4	32.9	37.8	15.9	11.0	82	3.00	1.02
The Nature of Science	1.2	50.0	25.6	20.7	2.4	82	2.73	0.89

N (Never); LOW (Less than Once a Week); AOW (About Once a Week); STW (Several Times a Week); AED (Almost Every Day); *M* (Mean Response); *SD* (Standard Deviation)

Qualitative survey question.

Upon completion of the 28 questions regarding beliefs and degree of implementation related to the 14 topics, teachers were asked to respond to the following statement:

> Explain why differences exist (if they do exist) between topics that you believe are necessary to be an effective science teacher and the degree of implementation of these topics in your teaching practice.

Fifty-one of the eighty-two participants responded to this question. However, four responses would suggest that the participants misunderstood the question and were not considered; therefore, forty-seven responses (n = 47) were included for coding and statistical purposes. The data were coded according to categories and sub-categories that emerged from the participant responses. Table 4.6 provides the frequency in which each of the sub-categories was identified in survey participant responses (eg. 22 survey participants identified curriculum time in their responses). Furthermore, the percentage frequency provided in Table 4.6 was determined by dividing the frequency value by the total number of survey participants who responded to the open-response survey items (eg. 22 of the 47 participants, or 47%, identified curriculum time in their response to this open-response item). As participants were able to identify more than one factor in their responses, the total percentage provided in Table 4.6 exceeds 100%.

Table 4.6 - *Frequency of Teacher Responses to Reasons for Difference between Beliefs about a Topic and Degree of Implementation of the Topic.*

Category	Sub-Category	Frequency	% Frequency
Time	Curriculum	22	47%
	Preparation	10	21%
	General	7	15%
	Class Length	2	4%
Class	Size	8	17%
	Composition	8	17%
	Maturity	5	11%
	Management	2	4%
Resources	Equipment	9	19%
	General	6	13%
	Curriculum	1	2%
	Financial	1	2%
Knowledge	Content	5	11%
	Pedagogy	7	15%
Support	Parental	1	2%

Time appeared to be the factor most frequently selected to explain why differences exist between topics that teachers believe are necessary to be an effective science teacher and the degree of implementation of these topics in their teaching practice. Nearly half (47%) of respondents identified the lack of time required to meet curriculum expectations as contributing to existing differences between beliefs and implementation. The second most frequent factor identified was lack of preparation time. More than one in five (21%) respondents identified preparation time as a contributing factor. Fifteen percent of respondents identified "time" as a contributing factor, however, clarity was not provided in their response to identify whether they were referring to curriculum length, class length, preparation time, or any other issue related to time. Other factors identified include class size (17%), class composition (17%), equipment (19%), and pedagogical knowledge (15%). Thirteen percent of respondents identified "general resources" as a contributing factor; however, clarity was not provided in their responses to identify whether they were referring to equipment, curriculum resources (other than equipment), or financial resources.

Professional Issues

Self-efficacy and outcome expectancy.

Teachers responded to twenty-five items (see Table 4.7) measuring their beliefs about professional issues (self-efficacy, outcome expectancy) in the *Professional Issues* (PI) part of the survey. The item identifiers provided in Table 4.7 contain two components (e.g., PI23_SE). The first component describes the item number within the *Professional Issues* (PI) part of the survey. The second component identifies if the question is assessing *Self-Efficacy* (SE) or *Outcome Expectancy* (OE) (see Chapter 3: Methodology for definitions). Therefore, the item "PI23_SE" is assessing self-efficacy and it is the 23rd item within the *Professional Issues* part of the survey.

Table 4.7 – *Professional Issues Survey Items (Self-Efficacy, Outcome Expectancy)*

PI1_OE	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.
PI2_SE	I am continually finding better ways to teach science.
PI3_SE*	Even when I try very hard, I do not teach science as well I do most subjects.
PI4_OE	When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.
PI5_SE	I know the steps necessary to teach science concepts effectively.
PI6_SE*	I am not very effective in monitoring science experiments.
PI7_OE	If students are underachieving in science, it is most likely due to ineffective science teaching.
PI8_SE*	I generally teach science ineffectively.
PI9_OE	The inadequacy of a student's science background can be overcome by good teaching.
PI10_OE*	The low science achievement of some students cannot generally be blamed on their teachers.
PI11_OE	When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.
PI12_SE	I understand science concepts well enough to be effective in teaching science.
PI13_OE*	Increased effort in science teaching produces little change in some students' science achievement.
PI14_OE	The teacher is generally responsible for the achievement of students in science.
PI15_OE	Students' achievement in science is directly related to their teacher's effectiveness in science teaching.
PI16_OE	If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.
PI17_SE*	I find it difficult to explain to students why science experiments work.
PI18_SE	I am typically able to answer students' science questions.
PI19_SE*	I wonder if I have the necessary skills to teach science.

PI20_OE*	Effectiveness in science teaching has little influence on the achievement of students with low motivation.
PI21_SE*	Given a choice, I would not invite the principal to evaluate my science teaching.
PI22_SE*	When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.
PI23_SE	When teaching science, I usually welcome student questions.
PI24_SE*	I do not know what to do to turn students on to science.
PI25_OE*	Even teachers with good science teaching abilities cannot help some kids to learn science.

*Negatively phrased items (low score indicates strong beliefs)

Table 4.8 - *Percentages of Teachers responding to each Item: Professional Issues*

		Response (%)					
Item	*N*	SDA	DA	A	SA	*M*	*SD*
PI1_OE	82	1.2	45.1	51.2	2.4	2.55	.57
PI2_SE	82	0	1.2	56.1	42.7	3.41	.52
*PI3_SE	82	39.0	51.2	6.1	3.7	1.74	.73
PI4_OE	82	1.2	26.8	63.4	8.5	2.79	.60
PI5_SE	82	1.2	8.5	74.4	15.9	3.05	.54
*PI6_SE	82	30.5	52.4	17.1	0	1.87	.68
PI7_OE	81	13.6	75.3	8.6	2.5	2.00	.57
*PI8_SE	82	53.7	41.5	4.9	0	1.51	.59
PI9_OE	82	1.2	23.2	68.3	7.3	2.82	.567
*PI10_OE	82	1.2	14.6	63.4	20.7	3.04	.64
PI11_OE	82	2.4	26.8	69.5	1.2	2.70	.54
PI12_SE	82	1.2	1.2	46.3	51.2	3.48	.59
*PI13_OE	82	4.9	39.0	53.7	2.4	2.54	.63
PI14_OE	82	2.4	48.8	47.6	1.2	2.48	.57
PI15_OE	82	3.7	40.2	52.4	3.7	2.56	.63
PI16_OE	82	0	22.0	70.7	7.3	2.85	.52
*PI17_SE	82	30.5	65.9	3.7	0	1.73	.52
PI18_SE	82	1.2	1.2	62.2	35.9	3.32	.56
*PI19_SE	82	42.7	50.0	7.3	0	1.65	.62
*PI20_OE	82	9.8	48.8	35.4	6.1	2.38	.75
*PI21_SE	82	41.5	46.3	7.3	4.9	1.76	.79
*PI22_SE	82	30.5	67.1	2.4	0	1.72	.50
PI23_SE	82	0	0	31.7	68.3	3.69	.47
*PI24_SE	82	14.6	70.7	14.6	0	2.00	.54
*PI25_OE	82	2.4	23.2	61.0	13.4	2.85	.67

SDA (Strongly Disagree); DA (Disagree); A (Agree); SA (Strongly Agree), *M* (Mean Response); *SD* (Standard Deviation)
* Negatively phrased items (low score indicates strong beliefs)
* Item descriptions for each item are provided in Table 4.7.

Percentages of teachers responding to each of the twenty-five questions measuring their beliefs about professional issues (self-efficacy, outcome expectancy) are listed in Table 4.8. This table also provides the mean response and associated standard deviation for each question surveyed. The mean values shown in Table 4.8 were obtained by assigning the values 1 through 4 to the response options "strongly disagree" through "strongly agree", respectively.

The data in Table 4.8 shows consistency in teachers' responses to the thirteen questions relating to self-efficacy. Teachers with high self-efficacy beliefs are expected to select "Agree" or "Strongly Agree" to the following items:

PI2_SE: I am continually finding better ways to teach science.
PI5_SE: I know the steps necessary to teach science concepts effectively.
PI12_SE: I understand science concepts well enough to be effective in teaching science.
PI18_SE: I am typically able to answer students' science questions.
PI23_SE: When teaching science, I usually welcome student questions.

The reported combined frequencies of "Agree" and "Strongly Agree" of these five items (PI2_SE, PI5_SE, PI12_SE, PI18_SE, and PI23_SE) are 99%, 90%, 98%, 98%, and 100%, respectively. Conversely, teachers with high self-efficacy beliefs are expected to select "Disagree" or "Strongly Disagree" to the following items:

PI3_SE: Even when I try very hard, I do not teach science as well I do most subjects.
PI6_SE: I am not very effective in monitoring science experiments.
PI8_SE: I generally teach science ineffectively.
PI17_SE: I find it difficult to explain to students why science experiments work.
PI19_SE: I wonder if I have the necessary skills to teach science.
PI21_SE: Given a choice, I would not invite the principal to evaluate my science teaching.
PI22_SE: When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.
PI24_SE: I do not know what to do to turn students on to science.

The reported combined frequencies of "Disagree" and "Strongly Disagree" of these eight items (PI3_SE, PI6_SE, PI8_SE, PI17_SE, PI19_SE, PI21_SE, PI22_SE, and PI24_SE) are 90%, 82%, 95%, 96%, 93%, 87%, 98%, and 85%, respectively.

Teachers with strong outcome expectancy beliefs were expected to select "Agree" or "Strongly Agree" to item PI7_OE (If students are underachieving in science, it is most likely due to ineffective science teaching.); however, a combined frequency of "Disagree" and "Strongly Disagree" of 89% was reported for this item. Furthermore, teachers with strong outcome expectancy beliefs were expected to select "Disagree" or "Strongly Disagree" to question PI10_OE (The low science achievement of some students cannot generally be blamed on their teachers.); however, a combined frequency of "Agree" and "Strongly Agree" of 84% was reported. Although these two outcome expectancy items showed consistency in teacher responses, they both indicate low outcome expectancy beliefs. The data in Table 4.8 shows a clear divide among teachers' responses in the remaining ten items related to outcome expectancy as at least 84% of the teacher responses fell into the combined frequency "Agree" and "Disagree" categories, with each category representing a minimum of 22% of the total responses.

Pearson's chi squared tests, which identified a statistically significant difference ($p < 0.05$) between teacher demographic data groups and the data obtained for each of the twenty-five items related to professional issues (self-efficacy; outcome expectancy), are listed in Table 4.9.

The 13 items related to self-efficacy were combined into a single self-efficacy scale. The negatively coded items were re-coded by assigning the values 1 through 4 to the response options "strongly agree" through "strongly disagree", respectively. Descriptive statistics performed on the combined self-efficacy scale yielded a mean 3.3049, median of 3.2308, and skewness statistic of -0.176. The value of Cronbach's alpha was 0.852. Independent sample t-test comparing teacher demographic data to the data contained in the combined self-efficacy scale is provided in Table 4.10. The results show a statistically significant difference ($p < .05$) between groups related to degree held, $t(80) = 2.89$, $p < .01$ (science degree, no science degree) and level taught [$t(80) = 2.18$, p<.05 (intermediate, senior high)]. Senior high teachers and those teachers who hold a science degree scored significantly higher on the combined self-efficacy scale than those who teach at the intermediate level and those who do not have a science degree, respectively.

Table 4.9 - *Pearson's Chi Squared: Demographic – Professional Issues Topics*

Demographic	Topic	*df*	*chi sqr*	*Asymp. Sig. (2-tailed)*
Level Taught	PI12_SE	3	7.956	0.047
Level Taught	PI19_SE*	2	6.711	0.035
Level Taught	PI23_SE	1	5.576	0.018
Gender	PI21_SE*	3	12.622	0.006
Gender	PI24_SE*	2	6.725	0.035
Science Degree (B.Sc.)	PI3_SE*	3	15.341	0.002
Science Degree (B.Sc.)	PI12_SE	3	16.605	0.001
Science Degree (B.Sc.)	PI19_SE*	2	13.435	0.001
Level Degree (B.Ed. / M.Ed.)	PI11_OE	3	10.049	0.018
Level Degree (B.Ed. / M.Ed.)	PI19_SE*	2	7.556	0.023
Level Degree (B.Ed. / M.Ed.)	PI20_OE*	3	8.840	0.031
Teaching Experience	No statistically significant differences between Groups (0-5 Years / > 5 years)			

				Response (%)			
Topic	Demographic	Group	*n*	SDA	DA	A	SA
PI3_SE*	Science Degree (B.Sc)	Yes	65	47.7	47.7	3.1	1.5
		No	17	5.9	64.7	17.6	11.8
PI11_OE	Level Degree	B.Ed.	59	0	32.2	67.8	0
		M.Ed.	23	8.7	13.0	73.9	4.3
PI12_SE	Science Degree (B.Sc.)	Yes	65	1.5	0	36.9	61.5
		No	17	0	5.9	82.4	11.8
PI12_SE	Level Taught	Intermediate	32	3.1	3.1	59.4	34.4
		Senior High	50	0	0	38.0	62.0
PI19_SE*	Level Taught	Intermediate	32	25.0	65.6	9.4	0
		Senior High	50	54.0	40.0	6.0	0
PI19_SE*	Science Degree (B.Sc.)	Yes	65	50.8	46.2	3.1	0
		No	17	11.8	64.7	23.5	0
PI19_SE*	Level Degree	B.Ed.	59	39.0	57.6	3.4	0
		M.Ed.	23	52.2	30.4	17.4	0
PI20_OE*	Level Degree	B.Ed.	59	10.2	39.0	44.1	6.8
		M.Ed.	23	8.7	73.9	13.0	4.3
PI21_SE*	Gender	Male	34	47.1	29.4	17.6	5.9
		Female	48	37.5	58.3	0	4.2
PI23_SE	Level Taught	Intermediate	32	0	0	46.9	53.1
		Senior High	50	0	0	22.0	78.0
PI24_SE*	Gender	Male	34	26.5	58.8	14.7	0
		Female	48	14.6	70.7	14.6	0

SDA (Strongly Disagree); DA (Disagree); A (Agree); SA (Strongly Agree),
*Negatively phrased items (low score indicates strong beliefs)

Table 4.10 - *Independent Sample T-Test: Demographic – Combine Self-Efficacy Scale*

Topic	Demographic		*df*	*t*	*Sig. (2-tailed)*
Self-Efficacy	Science Degree (B.Sc.)		80	2.89	.005
Self-Efficacy	Level Taught		80	2.18	.032

Topic	Demographic	Group	*n*	*M*	*SD*
Self-Efficacy	Science Degree (B.Sc.)	Yes	65	3.36	0.35
		No	17	3.09	0.31
Self-Efficacy	Level Taught	Intermediate	32	3.20	0.36
		Senior High	50	3.37	0.34

The 12 items related to outcome-expectancy were combined into a single outcome-expectancy scale. The negatively coded outcome expectancy items were re-coded by assigning the values 1 through 4 to the response options "strongly agree" through "strongly disagree", respectively. Descriptive statistics performed on the combined outcome-expectancy scale yielded a mean 2.5051, median of 2.5000, and skewness statistic of 0.831. The value of Cronbach's alpha was found to be 0.667. Independent sample t-test comparing teacher demographic data to the data contained in the combined outcome-expectancy scale revealed that no statistically significant differences existed ($p < 0.05$) between the combined outcome-expectancy scale and any of the teacher demographic data categories.

Qualitative survey questions.

Upon completion of the 25 questions related to professional issues (self-efficacy, outcome expectancy), teachers were asked to complete two open-response questions.

The first of these questions asked the following: *What is the primary factor(s) that enhances your ability to be an effective teacher of science?*

Seventy-one of the eighty-two participants responded to this question. Categories and sub-categories emerged from participant responses (see Table 4.11). Table 4.11 provides the frequency in which each of the sub-categories was identified in survey participant responses (eg. 28 survey participants identified content knowledge in their responses). Furthermore, the percentage frequency provided in Table 4.11 was determined by dividing the frequency value by the total number of survey participants who responded to the open-response survey items (eg. 28 of the 71 participants, or 39%, identified content knowledge in their responses to this open-response item). As participants were able to identify more than one factor in their responses, the total percentage provided in Table 4.11 exceeds 100%.

Table 4.11 - *Frequency of Teachers Responses of Factors that Enhances their Ability to be an Effective Teacher of Science*

Category	Sub-Category	n	Frequency	% Frequency
Knowledge	Content	71	28	39%
	Pedagogy	71	9	13%
Passion	Content	71	23	32%
	Teaching/Students	71	15	21%
	Learning	71	12	17%
Personal Attributes	Organized	71	5	7%
	Communication	71	4	6%
	Dedicated	71	2	3%
	Flexible	71	1	1%
	Patient	71	1	1%
Resources	Equipment	71	5	7%
	General	71	4	6%
	Human	71	3	4%
Time	Collaboration	71	4	6%
	General	71	2	3%
	Preparation	71	1	1%

Content knowledge and passion for the content taught were identified most frequently by respondents as factors that enhance one's ability to be an effective teacher of science. More than one-third (39%) and nearly one-third (32%) of respondents identified content knowledge and passion for the content taught, respectively, as factors that enhance their ability to be effective teachers of science. Passion for students and teaching was identified as the third most frequent (22%) factor that enhances one's ability to be an effective teacher of science. Other factors identified include pedagogical knowledge (13%) and passion for learning (17%).

The final open-response questions asked the following: What primary factor(s) presents challenges to your ability to be an effective teacher of science?
Sixty-nine of the eighty-two participants responded to this question. Categories and sub-categories emerged from participant responses (see Table 4.12). Table 4.12 provides the frequency in which each of the sub-categories was identified in survey participant responses (eg. 18 survey participants identified preparation time in their responses). Furthermore, the percentage frequency provided in Table 4.12 was determined by dividing the frequency value by the total number of survey participants who responded to the open-response survey items (eg. 18 of the 69 participants, or 26%, identified preparation time in their response to this open-response item). As participants were able to identify more than one factor in their responses, the total percentage provided in Table 4.12 exceeds 100%.

Table 4.12 - F*requency of Teachers Responses of Factors that Present Challenges to their Ability to be an Affective Teacher of Science*

Category	Sub-Category	n	Frequency	% Frequency
Time	Preparation	69	18	26%
	Curriculum	69	7	10%
	General	69	6	9%
	Collaboration	69	4	6%
	Class Length	69	1	1%
Class	Composition	69	11	16%
	Size	69	10	14%
	Behavior/Motivation	69	8	12%
	Management	69	1	1%
	Absenteeism	69	1	1%
Resources	Equipment	69	14	20%
	General	69	5	7%
Knowledge	Content	69	12	17%
	Pedagogy	69	6	9%
Support Assistant		69	1	1%

Time for course preparation was identified most frequently by respondents as a factor that presents challenges to one's ability to be an effective teacher of science. More than one-quarter (26%) of respondents identified the lack of preparation time as a factor that presents a challenge to one's ability to effectively teach science. Furthermore, 10% of respondents identified the time to meet robust curriculum expectations as a challenge to be an effective science teacher. Nine percent of respondents identified "time" as a contributing factor, however, clarity was not provided in their response to identify whether they were referring to curriculum length, class length, preparation time, or any other issue related to time. Another category that emerged from the data was related to the class demographics. Components of this category included class composition (16%) in terms of ability levels, class size (14%), and student behavior/motivation (12%). Lack of equipment was identified second most frequently (20%) by respondents as a factor that presents challenges to one's ability to be an effective teacher of science. Furthermore, seven percent of respondents identified general resources as a contributing factor; however, clarity was not provided in their responses to identify whether they were referring to equipment, curriculum resources (other than equipment), or financial resources. Other factors identified included lack of teacher content knowledge (17%) and pedagogical knowledge (9%).

Interview Data

Teacher interviews were conducted with a purposeful sample of six educators who completed the survey and agreed to be questioned. Pseudonyms were used as identifiers on all data collected from the interviews. The demographic distribution among those interviewed was as follows: males (3), female (3); M.Ed. (3), B.Ed (3); B.Sc. (4), no B.Sc. (2); greater than 5 years experience (4), 1-5 years experience (2); intermediate level (2), senior high level (4). Kara and Jacky are intermediate science teachers with more than five years of experience. Furthermore, Kara and Jacky both have a graduate (Masters) degree in education and do not have an undergraduate degree in science. Craig, Susan, Brian and Richard are all high school science teachers who have an undergraduate degree in science. Susan has more than five years experience and has a graduate (Masters) degree in education. Chris has more than five years of teaching experience and an undergraduate degree in education. Both Richard and Brian have less than five years of teaching experience and an undergraduate degree in education. An interview protocol (see appendix E) was administered in which interview participants were asked questions pertaining to (a) general beliefs, (b) the context for teaching and learning, and (c) professional issues. The following provides the specific questions that were asked during the interviews and a summary of the key findings from the interviews.

General beliefs.

During the first part of the interview, participants were asked to respond to the following questions: "Why do you have specific beliefs about factors affecting student learning? In other words, what has 'shaped' your beliefs?"; "Have your beliefs changed over time?"; and "Has there been something (situation, event, etc) that may have caused a change in your beliefs?".

Four themes emerged from the interview data to describe why the interviewees have specific beliefs about factors affecting student achievement. These themes included teaching experiences, life experiences and upbringing, their own learning experiences, and formal education training. Teaching experiences and life experiences were the most frequently discussed topics with five of the six interviewees referencing these factors in their responses. Four interviewees referenced learning experiences, and two interviewees referenced formal education training as factors that shaped their beliefs. There was certainly an indication from the interview responses that beliefs are shaped by many different types of experiences over a long period of time. For instance, Kara stated that "everything about education is always the sum total of your life experience" and that these experiences "will influence any beliefs that you have in teaching." Craig provided a very similar response as he stated that what shaped his beliefs about factors affecting student learning "would be a combination of life experience and teaching experience and what I went through as a learner and what I have seen as a teacher and just I guess all those things combined." Similarly, Susan indicated that her beliefs have been shaped by her educational experience, socio-economic background, and the environments in which she has taught. Brian, Richard, and Jacky had provided responses that focused more on one particular factor to the question concerning what shaped their beliefs about student learning. Jacky indicated her upbringing played a key role in shaping her beliefs. She grew up in rural Newfoundland in a large family of six children who were all different. She indicated that the number one factor that shaped her beliefs about effective student learning arose from the fact that some members of her family had difficulties learning. Consequently, she recognized at an early stage in her career that her upbringing appeared to permit her to better recognize differences among students. She stated, "When I started teaching or doing education, I noticed in my practice teaching, in my 4 months of practice teaching and in my first year, that you could tell that every student is different; therefore, their upbringing, I could tell, just like mine, affected the way they learn." Brian focused more on his classroom experiences as the key factors that shaped his beliefs. Brian stated,

> The things that shaped my beliefs as to what affects student learning would, by the most part, be classroom experience. Some of it was based on what I did learn in my B.Ed. program with respect to research findings from as far back as Piaget, Vigotsky, constructivism and behaviourism, and what not. But what really shaped my beliefs was more what I actually saw at the practical level in the classroom.

Richard indicated that his life experiences shaped his beliefs. However, he did focus on a particular learning experience with a particular teacher as a pivotal moment that shaped his beliefs. He indicated that "everybody has that pivotal moment when they look back and something, either great, or bad, happened and they used that to make the decisions."

He continued to describe a particular teacher that that brought much passion into the classroom and was able to make the students become interested and engaged. Richard also described other professors that did not share the same passion for teaching. Reflecting on these learning experiences, Richard indicated that "it's both good and bad experiences that will shape what you believe to be right."

When interviewees were asked if their beliefs have changed over time and if there has been something (situation, event, etc) that may have caused a change in their beliefs, all had indicated that their beliefs have changed over time. However, the changes could be best described as gradual or moderately refined.

Craig stated,

> Yes, my beliefs have probably changed over time. I don't think I've gone through any major shake up in my beliefs about teaching over time, but they've probably been refined. Some things that I thought initially have probably been confirmed. I don't think there has been any major shift but probably some minor changes.

Similarly, Richard described changes in his beliefs as being gradual as well. Richard stated,

> I don't think that there's so much change over time as it's that they've been polished and tweaked. With new experiences you will adapt and modify past behaviours. So in summary, your stronger beliefs will always be there but when you experience something then you say hmm, how can I make this better, and then you go back and tweak it.

Jacky indicated that she does not know if her beliefs have changed over time, but rather they have become more focussed. She reflected on a particular student who had poor living conditions and drug influences from the family. She indicated, "That really got me thinking about the environment and how it affects student's learning." Susan also indicated that teaching experiences with students of lower ability level early in her career have changed her beliefs because she had to look at learning in a different way. Furthermore, she indicated that having recently completed a Master's degree in education has caused changes in her beliefs; however, she did not elaborate why. Kara indicated that "beliefs have to change because your experiences are constantly changing and forming".

Kara and Brian were able to identify a specific situation that caused a change in their beliefs. Kara described a particular experience when working with students in Nunavut. She assumed they were able to perform what she described as a particular "block" of work. However, she indicated that they could not. Kara further explained that when she broke the block of work into smaller pieces and sometimes even smaller pieces, that the students could in fact perform the work. Kara stated, "The way I approached teaching had to change when I saw students come up against barriers. Then I had to question whether the barriers were truly the student's barriers or were they my barriers, or were the barriers in the way it was being taught or the way it was being learned or the situation it was being learned in. So that experience definitely changed my beliefs." Similarly, Brian indicated that his beliefs have changed over time with regard to his attempt to reach the disinterested student. Brian believed at the beginning of his career that "some of these kids just don't care. They just don't want to be here. I can't reach them. In other words, it's their responsibility to want to learn, not mine." Brian now believes that although "there are some kids that have bigger issues" that prevent them from learning, perhaps it is he who has not "found a proper way to engage students in the new material." Brian noticed that student learning, performance, and attention were affected once his student projects started becoming a little more open because his students were provided with a little more ownership as to what they wanted to do and study.

In summary, it is evident that the formation of teacher beliefs about factors affecting student achievement is very complex. From the interviews in this study, four general themes emerged that suggested that belief formation is a function of teaching experiences, life experiences, teachers' own learning experiences, and formal education and training. Furthermore, it was also evident from responses of all interviewees that beliefs do change over time; however, the changes in beliefs were best described as moderate and gradual.

Context for teaching and learning.

Interview participants were provided with the data from Table 4.2 (*Percentages of Teachers responding to each Topic: Degree of Necessity to be an Effective Science Teacher*) and Table 4.5 (*Percentages of Teachers responding to each Topic: Degree of Implementation in Your Classroom during the Year*). Once it was evident that the interviewees understood how the data was displayed and what the data were saying, they were asked why they thought select topics had high implementation frequencies and others low. In general, the responses to this question regarding implementation frequency surrounded the issue of curriculum coverage time.

Three interviewees indicated that the Nature of Science may have lower frequency of implementation in classroom practice because it is less efficient in delivering the curriculum content. One interviewee had also indicated that Hand-On/Minds-On Activities, Summative Assessment and Evaluation, and Electronic Learning had low implementation frequencies due to the issue of curriculum coverage time. Furthermore, other reasons mentioned for select topics (Nature of Science, Electronic Learning) having a low implementation frequency were related to teacher background knowledge and comfort level with the topics. The nature of science had the lowest level of implementation of the fourteen topics surveyed. Consequently, the nature of science was described as having a low frequency of implementation due to the amount of time it takes to engage students in the nature of science, as well as the low teacher comfort level with addressing the nature of science and scientific inquiry. Brian indicated that teachers may not be "comfortable with different ways to approach inquiry, problem solving, and decision making." Craig indicated that the nature of science "is really important, but the reality is that it takes longer." Technology was referenced by two interviewees as having a low level of implementation mainly because of the availability of technology resources. Furthermore, teacher comfort level in using technology was also described by one interviewee as a reason for its low implementation.

Craig questioned if it was expected that all topics have the same implementation frequency. He indicated that "being less frequent doesn't necessarily mean less important, it's just appropriate timing." For example, he mentioned that he may only engage students in summative assessment, such as a classroom test, once every two weeks. Kara described "while all of these are valuable, the ones that I see at a higher frequency are easier to do efficiently. The ones that are at the lower frequency are not as easy to do on a day to day basis in the constraints of the public school system." For instance, Kara indicated that "science subject matter, classroom management, equity, learning style, thematic approach, constructivism, these are all things that I can easily prepare for and have my plan in place before I walk through the door. So I'm fully in control of those things." Kara further stated that many factors beyond her control have to work in order to engage in the use of technology such as availability and the working condition of technology, a sentiment that was also shared by Susan and Richard. Furthermore, Kara stated that the four topics with the lowest frequency of implementation (Hand-On/Minds-On Activities, Summative Assessment and Evaluation, Electronic Learning) were "more time-consuming in classroom settings where outcomes need to be covered." Similarly, Craig mentioned that select topics have a lower frequency of implementation, such as the nature of science, as a result of time limitations. He stated that "when you're pressed for time from all directions, something has got to give and I think unfortunately that's one of the ones that does." Richard also described that the nature of science has a low implementation frequency because it is time consuming. He stated, "The truth of matter is we have to go through with the curriculum and the fastest way to do it is to just more or less front end load the main science subject matter." Richard indicated that topics with high implementation frequency, such as classroom management, are essential because "there's no way you just can function in the classroom if you don't have adequate preparation and then you're just wasting time, you're back pedalling, and you're back into the whole 'not enough time'." Brian indicated that low implementation frequency of topics was a function of teacher comfort level in general. For example, he indicated that the reason for the low implementation of the nature of science may be that "teachers perhaps don't have a very strong background in science and perhaps they are not familiar or comfortable with different ways to approach inquiry, problem solving or decision making." Brian was also not surprised by the low use of technology and felt that it was also a function of comfort level. Similarly, Jacky indicated that the reasons for differences for select topics may be that "a teacher is not interested or hasn't got the skill."

Interview participants were provided with the data from Table 4.3 (*Pearson's Chi Squared: Demographic – Context for Teaching and Learning*). This table illustrated the four topics (Hand-on/Minds-on Activities, Science Subject Matter, Inclusion, and Formative Assessment) that were included on the survey which showed statistically significant differences between group responses. Once it was evident that the interviewees understood how the data were displayed and what the data were saying, they were asked why they thought there may be differences between group responses. The following provides a summary of the key findings for the interviews for each of the four topics.

Hand-on/Minds-on activities – teaching experience.

The survey results showed that teachers with up to five years experience reported a higher frequency of very necessary responses regarding the importance hands-on/minds-on activities as compared to those teachers with greater than five years experience. Five of the six interview participants attributed this difference to what they perceive as differences in the pre-service science methods courses. Craig described this by stating that there may be "more emphasis being placed on it in teacher education programs now than there was years ago." Kara offered another explanation that focused on potential differences in learning experiences of the two groups. Kara stated that "it's probably a reflection of their own experiences, because our own learning experiences are so much more an influence on how we teach, I think, than anything else." Jacky was surprised by the difference and did not provide an explanation.

Science subject matter – teaching experience.

The survey results showed that teachers with more than five years experience reported a higher frequency of very necessary responses regarding science subject matter as compared to those teachers with up to five years experience. Richard, Kara, and Brian described that knowledge comes with experience and the importance of knowledge of science subject matter is only realized after having taught for several years. Brian summarized this explanation by describing that "those with greater experience do realize that it takes time to figure out where the bugs are. It takes time to appreciate that there are questions in this conception that are going to come up with the course and those with less than five years perhaps aren't even going to know that as of yet." Richard reflected on the past three years and stated, "I know my stuff better after teaching for three years than I did on that first year and I know that my students are better off as a result."

Science subject matter – science degree (B.Sc.).

The survey results showed that teachers with a science degree reported a higher frequency of very necessary responses regarding the importance of science subject matter as compared to those teachers with no science degree. Kara was surprised by the findings and she, Jacky, Craig, and Susan did not provide a reason for the difference. Brian was not surprised with this finding. He explained that his science degree allows him to have "more contextual information" and that he can better apply what he is teaching to "the real world". Richard explained that if you don't have the content knowledge that "it's one of those things where you don't know what you don't know." He further explained that "if you don't know what you're missing, it's hard to say whether it's important or not. Whereas if you have that background, you know how important things are and you know what things you can't ignore."

Science subject matter – level taught.

The survey results showed that senior high science teachers reported a higher frequency of very necessary responses regarding the importance of science subject matter as compared to those teachers who teach intermediate science. Kara, Brian, and Richard each explained that high school science is more specialized and that the topics have more depth versus breadth as compared to intermediate science. Consequently, they emphasized the importance of knowledge of the science subject matter in achieving the depth required of high school science courses. Brian indicated that

> science sometimes gets a little more specialized [at the senior high level] so if you are teaching grade 12 physics, perhaps you'd need to have a stronger subject matter knowledge than if you're teaching just one component of physics [at the intermediate level], say electricity. You need to have a more in depth knowledge base [at senior high] as opposed to breadth that you might simply need at the intermediate level.

Similarly, Richard stated that "whenever you get to the senior high, you get into more specialization and in order to specialize, you have to know that area very well." Kara attributed the difference in the group response to a need for high school teachers to prepare students for university.

Inclusion – level taught.

The survey results showed that intermediate science teachers reported a higher frequency of very necessary responses regarding the importance of inclusion as compared to those teachers who teach senior high science. Jacky did not provide an explanation for this; however, the remaining five interviewees all attributed the difference among groups to the streaming that occurs in high school science courses. The interviewees claim that teachers at the intermediate level have to engage in inclusionary practices more frequently because there is a broader range of student abilities in their classrooms as compared to high school science classes. In high school, students have a choice of classes at varying difficulty levels that they can attend. Susan indicated that "the intermediate teachers are more used to inclusion. It's something that happens a lot more in their everyday classes because they are de-streamed." Brian was not surprised that select senior high teachers did not think inclusion was necessary because he claimed that "there is just fewer students at different, or at a very extreme ends of the spectrum at the senior high level" as compared to the diversity in ability level found in the classrooms at the intermediate level.

Formative assessment – science degree (B.Sc.).

The survey results showed that teachers with no science degree reported a higher frequency of very necessary responses regarding the importance of formative assessment as compared to those teachers who have a science degree. Four interviewees did not provide an explanation. Kara and Brian provided a similar explanation based on the need for those teachers without a science degree to frequently know if students' are understanding the concepts because of their potentially more limited knowledge of the science content. As a possible reason for the difference between groups, Kara stated, "I would place a higher value on formative assessment because I need to stay very closely in touch with where they are in case there is something else I need to prepare for in order to correct that learning whereas someone with a science degree might not need that advanced time." Brian was surprised by the findings; however, he explained that a possible reason for the difference "would be that if I do not have a bachelor of science degree, and perhaps if my knowledge base is not as strong, then I am going to be doing more forms of assessment to make sure that the students actually understand the material that I am teaching."

Formative assessment – gender.

The survey results showed that female teachers reported a higher frequency of necessary responses regarding the importance of formative assessment as compared to male teachers. Twelve percent of male teachers reported formative assessment as being not very necessary. Kara, Jacky, and Susan all attributed the difference to females being more compassionate or nurturing than males. Brian claimed that the difference could be attributed to "the male dominant behaviour that is sometimes exhibited in science." Brian further explained that "sometimes men just assume that what we are doing is right and that if they know what they are doing then the students must get it, whereas I would think that a female teacher may be more apt to check with students to make sure they are getting it, to make sure that they are on the same page as the teacher."

Professional issues.

Interview participants were provided with the data from Table 4.8 (*Percentages of Teachers responding to each Item: Professional Issues*) and the description of each of the 25 items included in the Professional Issues part of the survey provided in Table 4.7. The data from the survey shows that responses to the self-efficacy items appear to be quite high. However, responses to the outcome expectancy items were not nearly as high and were divided among the survey population. Once it was evident that the interviewees understood how the data were displayed, what the data were saying, and what was meant by self-efficacy and outcome expectancy, they were asked why they believe outcome expectancy to be low among P.E.I. secondary science teachers, while self-efficacy appears to be relatively high. Responses from interview participants all indicated that outcome expectancy was reported lower than self-efficacy because there are very many factors that affect student learning that are beyond the control of the classroom teacher.

Craig indicated that the reason for the lower outcome expectancy is that "there are so many outside influences." He described that "for some kids, no matter how good you are, you're going to have trouble reaching them." Brian's response complemented Craig's by stating that students "have issues outside of the classroom that are disenabling them to learn, or they simply don't care." Similarly, Kara stated that "good teaching alone can't do it." Kara's primary concern was that there is often a wide gap in knowledge and skills among students and because of this gap Kara claims that "we are not going to bring them up to where they need to be." Furthermore, Kara described that there are many students in our system with learning disabilities that are undiagnosed. She indicated that we need to have information about the children and the children themselves need the information as well. Susan also supported the idea that there are many outside influences. She provided "student motivation, whether or not they do their homework, whether or not they pay attention in class, and whether or not they are engaged in the subject" as possible factors that have a high influence on student achievement and learning. Furthermore, in relation to student achievement and learning, Susan indicated that the students' "background, previous education, and intelligence may have much more to do with it." Richard also claimed that there are many factors that affect student learning. He described that "not every kid is going to have a career in science and some are not necessarily going to succeed in science. But, if you can possibly make them leave your classroom a little bit better than they were whenever they came in, they still might not be going out with 90s but if you improve them a little bit, well then you've done the best you can do."

In summary, interviewees were not surprised by the reports of high self-efficacy and of low outcome expectancy among the secondary science teacher population. Although the interviewees indicated that they believed that most teachers view themselves as very competent at teaching, they indicated that there are many factors that affect student achievement and learning that are beyond the influence of the classroom teacher. Some of the factors referenced include student apathy, student knowledge and skill level, study habits, and undiagnosed learning disabilities.

The following chapter – Discussion –rationalizes the findings in the context of the P.E.I. secondary science setting. Limitations and implications of this study are also addressed.

DISCUSSION AND CONCLUSION

The following is a discussion of the key findings from this study. The discussion is organized according to the sections (a) Beliefs and Implementation, (b) Professional Issues, (c) Implications, (d) Conclusion, and (e) Limitations of Study.

Beliefs and Implementation

The results of the survey are very encouraging as they show that P.E.I. secondary science teachers have strong efficacy beliefs and hold strong beliefs for each of the fourteen topics included on the survey. Over ninety percent of teachers reported that they believe that all but three topics surveyed were necessary or very necessary to be an effective science teacher and eighty-nine percent of teachers reported that they believe that a thematic approach was necessary or very necessary (see Table 4.2). The topics with the lowest percent of necessary or very necessary responses included Cooperative Learning and Electronic Learning which yielded a respectable 83% and 85% of necessary or very necessary responses, respectively. Furthermore, the survey results suggested that having stronger beliefs translated into greater implementation of those beliefs in classroom practice. This finding complements the results of several studies (e.g. Ballone & Czerniak, 2001; Eberle, 2008; Nespor, 1985; Pajaras, 1992; Snider & Roehl, 2007) that have indicated that teachers' beliefs have strong implications for classroom practice teaching. In this study, over 70% of teachers reported having implemented all but two - The Nature of Science and Electronic Learning – of the fourteen contexts for teaching and learning topics at least once a week. The following subsections will discuss these two topics in relation to the findings of this study and current research.

The nature of science.

Perhaps the most concerning finding of this study was that 50% of secondary science teachers reported that they address the nature of science (NOS) less than once a week even though the survey results indicate that a large percentage (93%) of teachers reported that the nature of science is necessary or very necessary to be an effective science teacher. Teachers responded to the following definition of the nature of science:

> Teachers enable students to understand and engage in scientific inquiry; to make evidence-based decisions through an understanding and appreciation for the modes of reasoning involved in scientific inquiry. Also includes the social and historical contexts in which science evolved along with the values underlying the work of scientists. For example: the teacher has students use a candle, water, flask, and pan to see why water rises in a flask when it is put over a burning candle sitting in a pan of water. Students' reason why water rises and discuss with each other why they think the water rises. The teacher does not give an "exact answer", but allows students to explore the idea over several hours or days.

The view of the nature of science as being necessary to be an effective science teacher along with low level of implementation of the nature of science in classroom practice is consistent with the findings of many studies. Waters-Adams (2006) reinforced that an understanding of the nature of science at a theoretical level does not predict practice as it is only one element of several influences, and probably not the most important. Based on a study involving 37 science teachers, Tsai (2002) stated that teacher beliefs about teaching, learning and the nature of science were interrelated or "nested." Waters-Adams (2006) also noted this 'nested' relationship and further elaborated that teachers become confident in their science practice only when there is a resonance between their ideas on how to teach science, their understanding of the nature of science, and their general beliefs about teaching children. For example, Wallace and Kang (2004) reported that the culturally based beliefs of exam preparation and efficiency of curriculum coverage stood in contrast to teachers' personal learning goals related to inquiry. The personal learning goals expressed by teachers (e.g., independent thinking, creativity, and deriving ideas from patterns in data) in the Wallace and Kang (2004) study were not explicitly mandated in curriculum; therefore, teachers struggled to reconcile their personal goals for their students with the goals mandated by curriculum.

In a critical review of the literature on improving science teachers' conceptions of nature of science (NOS), Abd-El-Khalick and Lederman (2000) indicated that "several variables have been shown to mediate and constrain the translation of teachers' NOS conceptions into practice. These variables include pressure to cover content, classroom management and organizational principles, concerns for student abilities and motivation, institutional constraints, teaching experience, discomfort with understandings of NOS, and the lack of resources and experiences for assessing understandings of NOS" (p. 670).

The data obtained from the teacher interviews in this study suggests similar findings. The nature of science was specifically described by interviewees as having a low frequency of implementation due to the amount of time it takes to engage students in the nature of science, as well as the low teacher comfort level with addressing the nature of science and scientific inquiry. In general, teachers were asked on the survey to respond to the statement, "Explain why differences exist (if they do exist) between topics that you believe are necessary to be an effective science teacher and the degree of implementation of these topics in your teaching practice." Time was the predominant factor that survey respondents identified to explain why differences exist between topics that teachers believe are necessary to be an effective science teacher and the degree of implementation of these topics in their teaching practice. Nearly half (47%) of respondents identified the lack of time required to meet curriculum expectations as contributing to existing differences between beliefs and implementation. This would suggest that certain practices, although believed to be important to science education, are not implemented as frequently as one would like because of the time it takes to execute the practice. The second most frequent factor identified was preparation time. More than one in five (21%) respondents identified preparation time as a contributing factor. Similarly, when asked on the survey to identify what primary factors present challenges to one's ability to be an effective teacher of science, preparation time was the most frequently (26%) reported factor and knowledge of content was the third most frequently recorded factor (17%).

Central to the teaching of science and in fostering the development of scientific literacy among students is a formal understanding of the nature of science, and conveying this essence of science to students. "Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge that students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them" (Atlantic Provinces Education Foundation [APEF], 1998). In developing the attributes of scientific literacy, it must be first understood that the purpose of science is to gain an understanding of the natural world, and "the principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts" (National Science Teachers Association [NSTA], 2000). The nature of science begins with a formal understanding of the meaning of scientific law and scientific theory, and that the reliability of current scientific knowledge is based on present contexts that can change as new evidence is obtained or a more accurate model is created to represent and explain present evidence. According to Lederman (as cited by Abd-El-Khalick & Lederman, 2000), the nature of science "typically refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (p. 666). Although no single universally used and agreed upon scientific method exists (Abd-El-Khalick and Lederman, 2000; APEF, 1998; NSTA, 2000; NSTA, 2004; Wallace and Kang, 2004), it is generally understood that the acquisition of scientific knowledge calls "for naturalistic explanations supported by empirical evidence that are, at least in principle, testable against the natural world" (NSTA, 2000) and that these explanations and evidence are not solely based on observation, but are socially constructed and are based, in part, by "rational argument, inference, skepticism, peer review and replicability of work" (NSTA, 2000). The National Research Council (1996) defines scientific inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work." They further elaborate on scientific inquiry by stating that it "also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world."

Practical scientific inquiries can play an important role in developing students' understanding of the epistemology of science - of the relation between evidence and theory (Watson & Swain, 2004). To foster an understanding of the nature of science, teachers must not only teach about the nature of science and its importance, but also engage students in experiences related to the nature of science. Only explicit teaching about the nature of science leads to any epistemic improvement in pupils' knowledge and understanding (Osborne, Erduran, Simon, & Monk, 2001). Similarly, in strong support of the National Science Education Standards (NSES), the NSTA (1998) asserted that "inquiry should be viewed as an instructional outcome (knowing and doing) for students to achieve in addition to its use as a pedagogical approach." In their official position statements concerning scientific inquiry as a teaching approach, the NSTA (2004) declared that teachers plan an inquiry-based science program that "[implements] approaches to teaching science that [causes] students to question and explore and to use those experiences to raise and answer questions about the natural world" and that teachers "guide and facilitate learning using inquiry by selecting teaching strategies that nurture and assess the students developing understandings and abilities."

Wallace and Kang (2004) indicated that several recent studies suggest that inquiry-based learning can be a very successful practice for those teachers "who persist in promoting inquiry, either by posing interesting questions for students to answer, or by facilitating children to pose their own questions" (p. 939). Wallace and Kang (2004) provided two reasons, gleaned from several studies, to explain the success in practices involving inquiry-based learning. The first reason included positive student attitudes towards inquiry. Students like to ask their own questions and find ways to answer them. The second reason described students' improved ability to ask researchable questions and improved ability to coordinate questions with evidence as they become more familiar with inquiry-based learning.

Electronic learning.

Another concerning finding from this study was that 35% percent of secondary science teachers reported that they address electronic learning less than once a week even though the survey results indicate that 85% of teachers reported that electronic learning is necessary or very necessary to be an effective science teacher. Teachers responded to the following definition of electronic learning: "Teachers use computer technology as the medium of instruction to promote student learning. For example: web-based or LAN-based communication tools, interactive digital technologies (tutorials, simulations, demonstrations)." The above data may suggest that factors other than teacher beliefs can prevent teachers from implementing electronic learning more frequently in classroom practice.

In a review of the literature on factors affecting teachers' use of information and communications technology, Mumtaz (2000) identified three interlocking factors - institution, resources, and the teacher - that affect teachers' adoption of information and communication technology (ICT). Mumtaz decribed that "limited resources within schools are a great impediment to the take-up of ICT" (p. 336). Mumtaz (2000) explained that the lack of computers and software in the classroom seriously limit what teachers are able to do with ICT, with ICT integration, and with ICT experience for both pupils and teachers. Regarding institutional factors, Mumtaz (2000) explained that schools provide no ICT support network for teachers and give little time to teachers to manage and become familiar with ICT. Furthermore, Mumtaz's (2000) findings from the literature review suggests that "the teacher factors that involved beliefs about the way the subject should be taught and skills associated with competence in managing classroom activities and computer-handling technical skills were the most influential in teachers' use of computers" (p. 337). Likewise, Lim and Khine (2006) concluded that although teachers strive to integrate ICT into the curricula, many are faced with barriers that affect the effective integration. Lim and Khine (2006) explain that "while first-order barriers hinder some teachers that include limited time, training, and support, others struggle to overcome second-order barriers including their own beliefs of how their students learn and how ICT can be used to facilitate learning" (p. 118). The British Educational Communications and Technology Agency (BECTA), a lead partner in the United Kingdom strategic development and delivery of its e-strategy for the schools and the learning and skills sectors produced a series of documents titled "What the research says" to provide a summary of available research evidence for the use of ICT. The key barriers to the use of ICT in teaching, identified through a variety of current research publications and compiled in the BECTA (2003a) publishing titled, *What the research says about barriers to the use of ICT in teaching,* include: "lack of access to appropriate ICT equipment; lack of time for training, exploration, and preparation; lack of models of good practice in ICT; negative attitudes towards computers in education; computer anxiety and a lack of confidence; fear of change and a lack of personal change management skills; unreliable equipment; and lack of technical, administrative and institutional support."

The data from this study also suggests that barriers to the use of electronic learning exist. Electronic learning was specifically described by interviewees as having a low frequency of implementation due to the low availability of technology resources. Furthermore, interviewees indicated that the low frequency of implementation of electronic learning could also be attributed to teacher comfort level with technology. In general, teachers were asked on the survey to respond to the statement, "Explain why differences exist (if they do exist) between topics that you believe are necessary to be an effective science teacher and the degree of implementation of these topics in your teaching practice." Nineteen percent respondents identified equipment and 13 % of respondents identified general resources as contributing factors that explain why differences exist between topics that they believe are necessary to be an effective science teacher and the degree of implementation of these topics in their teaching practice. Similarly, when asked on the survey to identify what primary factors present challenges to one's ability to be an effective teacher of science, equipment was the second most frequently (20%) reported factor. It is important to note that the type of equipment and resources that are lacking was not reported in the teacher responses to the survey question. Therefore, further research is needed to identify the specific electronic learning resources and equipment required to more effectively teach science.

The Canadian Council on Learning (2009) report entitled *The State of E-Learning in Canada* suggests that "a flexible approach to education and training is essential to prepare Canadians for the 21st century. This broadened paradigm will involve the full integration of learning technologies into education and training" (p. 5). The NSTA, in their position statement entitled, "The Role of E-Learning in Science Education", state that "E-Learning can and should significantly enhance science teaching and learning" (NSTA, 2008). The NSTA (2008) supports E-Learning as a promising way: to more effectively provide access to concepts; to meet the need of those students whose prefered mode of learning involves digital technologies; and to provide future workers with skills that are critical to succeed in a 21st century workplace. Furthermore, the NSTA (2008) declares that E-Learning should strengthen science teaching and learning by providing active and constructive learning experiences where students gather, analyse, and communicate data using digital technologies that simulate real-word problems and mimic the processes of science and advancements in science in the real world. Complementing the NSTA position, a variety of current research publications articulating the key benefits of ICT in science education were compiled in the BECTA publishing titled *What the research says about ICT in science.* The BECTA document states that "ICT increases opportunities for communication and collaboration; ICT can make science more interesting, authentic and relevant; ICT allows more time for observation, discussion and analysis; and using ICT increases opportunities for communication and collaboration" (BECTA, 2003b).

Professional Issues

Prince Edward Island science teachers reported having high self-efficacy beliefs which suggests that they have strong beliefs in their own ability to affect student achievement in science. This was indicated by consistently strong responses to each of the thirteen items related to self-efficacy on the survey. Although self-efficacy beliefs were strong for each item, a statistically significant difference on the combined self-efficacy scale existed between senior high and intermediate teachers and between teachers who hold a science degree and those that do not. The data suggests that teachers who do not hold a science degree and those who teach at the intermediate level have lower self-efficacy beliefs. A possible explanation for this finding could be related to teacher content knowledge. More than one-third (39%) of survey respondents identified content knowledge as a factor that enhances their ability to be effective teachers of science. It could be assumed that teachers who do not have a science degree have lower self-efficacy because they may have less content knowledge. Furthermore, low content knowledge could also be attributed to the lower self-efficacy of intermediate science teachers as intermediate science courses include a broader selection of topics that involve a combination of physical science, life science, and earth-space science topics.

The outcome expectancy belief data shows a divide among teachers' responses in ten of the twelve items included on the survey. At least 84% of the teacher responses to these items fell into the combined frequency 'Agree' or 'Disagree' categories, with either agree or disagree representing a minimum of 22% of the total responses. Although the data was shared among the 'agree' and 'disagree' responses, there was no statistically significant difference between groups on the combined outcome expectancy scale. Teacher responses were more unified on two of the outcome expectancy items. Eighty-nine percent of teachers selected either 'disagree' or 'strongly disagree' to the item which states, “If students are underachieving in science, it is most likely due to ineffective science teaching.” Furthermore, 84% of teachers responded either ‘agree’ or ‘strongly agree’ to the item which states, “The low science achievement of some students cannot generally be blamed on their teachers.” The responses to these items both suggest low outcome expectancy beliefs. Interview participants were asked why they believe outcome expectancy to be low among P.E.I. secondary science teachers, while self-efficacy appears to be relatively high. Responses from interview participants all indicated that outcome expectancy was reported lower than self-efficacy because there are many factors that affect student learning that are beyond the control of the classroom teacher. Factors mentioned by interviewees include student apathy, motivation, homework, knowledge, and learning disabilities. In a review of the literature, Abd-El-Khalick and Lederman (2000) identified a variety of situational factors that have been shown to mediate and constrain teacher conceptions into practice. Those factors beyond the control of the classroom teacher included pressure to cover content, concerns for student abilities and motivation, institutional constraints, and the lack of resources. Snider and Roehl (2007), in a study of teacher’s beliefs about pedagogy and related issues, reported that over half of the 344 teachers in their study “believed that factors such as home environment or dyslexia prevent children from learning basic skills despite the schools’ best efforts” (p. 873).

Implications

This section of the discussion will describe implications of the findings related to the nature of science, electronic learning, and self-efficacy. Each of these contexts suggests that teachers be provided with ongoing professional development. Consequently, the final subsection of the implications section will describe what research says about the nature of professional development opportunities for teachers.

The nature of science.

The data collected on The Nature of Science (NOS) suggests that although the majority of teachers believe strongly in this topic, more work needs to be done to support the incorporation of the nature of science in the teaching and learning of science. Based on the relatively low frequency of implementation of the NOS and in consideration of the interview data suggesting time constraints and low teacher comfort level with regard to incorporating the nature of science into everyday teaching and learning, targeted strategies that illustrate effective and efficient methods of incorporating the nature of science must be described and modeled for secondary science teachers (professional development is described later in this section). This finding may also have implications for teacher candidates. Teacher candidate preparation courses should be reviewed to ensure that methods of addressing the nature of science are clearly identified within the course frameworks. Furthermore, the low implementation of the nature of science and scientific inquiry may have policy implications. Currently, the nature of science and scientific inquiry are addressed pervasively in Prince Edward Island's science curriculum documents in a section that does not contain the specific curriculum outcomes. Specific curriculum outcomes, which identify what students are expected to know and do, are clearly articulated in curriculum documents; however, how teachers target the outcomes to foster student learning is suggestive only. Perhaps, as recommended by the NSTA

(1998) and Wallace & Kang (2004), scientific inquiry and the nature of science should be made explicit as specific curriculum outcomes within the science curriculum documents. This recommendation would provide secondary science teachers with more guidance regarding topics that are conducive to addressing the nature of science and pedagogical suggestions (e.g., historical case studies, explicit teaching of the nature of science, science-technology-society-environment connection) as to how to engage students in the nature of science with select science content. The challenge of this suggestion is to identify the balance between the specific outcomes that explicitly incorporate the nature of science and scientific inquiry and those knowledge and skill outcomes that may be addressed entirely at the discretion of the science teacher.

Electronic learning.

Electronic learning was also reported as having a relatively low implementation frequency. The interview data suggested two possible reasons for the low implementation. The first reason suggested that the low availability of resources inhibits the use of electronic learning in classroom practice. This finding is consistent with research literature (BECTA, 2003a; Mutmaz, 2000). It is important to acknowledge that for some teachers, resources are preventing them from implementing beliefs that they feel are necessary to be an effective science teacher. Therefore, future research should investigate school science and technology resources, and their availability. Furthermore, research must be conducted to target the type of resources required at each level in order to identify the gap between what is currently available and what is required. A long-term technology plan must be created to ensure that Island teachers and students always have the necessary technology resources to assist with the efficient and effective teaching and learning of science. The second reason for the low frequency of implementation of electronic learning, provided by the interview data, was attributed to teacher comfort levels with technology. However, it is not apparent from this study if teachers are uncomfortable with their technological knowledge, technological pedagogical content knowledge, ability to troubleshoot when problems with technology arise, or a combination thereof. Low teacher competence with technology and ICT integration, computer anxiety and a lack of confidence with the use of technology, lack of models of good practice, and lack of technological support are examples of barriers to the use of ICT that have been reported in the research literature (see BECTA, 2003a; Lime & Khine, 2006 ; Mutmaz, 2000). Consequently, schools and school districts must have an available technical support mechanism in order to mitigate issues related to teacher confidence with technology. Furthermore, ongoing professional development opportunities must be made available to teachers in order to allow them to observe models of successful ICT integration and to build their technological pedagogical content knowledge involving ICT integration (professional development is described later in this section).

Self-Efficacy.

Regarding professional issues, although self-efficacy beliefs were strong, the data suggests that teachers who do not hold a science degree and those who teach at the intermediate level have a lower self-efficacy. It was described earlier in the discussion that low content knowledge may be the linkage between self-efficacy and the two groups of demographic data. Furthermore, when asked on the survey "What is the primary factor(s) that enhances your ability to be an effective teacher of science?" the most frequently identified factor (39%) was content knowledge and the second most frequently identified factor (32%) was passion for the content. This data supports the findings of the Swackhamer, Koellner, Basile, and Kimbrough (2009) study which reported that in-service teachers' outcome-efficacy increased in teachers who have taken a larger quantity of math or science content courses. Furthermore, the qualitative data obtained from the Swackhamer et al. (2009) study indicated that teachers who enrolled in a larger number of math and science content courses reported that they had gained additional content knowledge in the areas of math and science which in turn gave them more confidence to teach these subjects from day to day. Consequently, schools, school boards, and the Department of Education need to work together to identify science educators with low content knowledge and low self-efficacy beliefs, and to provide a mechanism by which to assist them in building content knowledge and confidence in their ability to teach science effectively. One possible mechanism to assist with building content knowledge, pedagogical content knowledge, and efficacy could be to provide ongoing professional development opportunities where novice and expert teachers can collaborate in communities of practice (Bransford, Brown, & Cocking, 1999; Loucks-Horley, Stiles, Mundry, Love, and Hewson, 2010). Collaboration among teachers in the content areas may also mitigate issues related to preparation time. Preparation time was identified by 26% of survey participants as the primary factor which presents challenges to one's ability to be an effective teacher of science. Furthermore, preparation time was identified by 21% of survey participants as a reason why differences exist between teacher beliefs and implementation of their beliefs.

Professional development.

Practicing teachers continuously learn about teaching in a variety of informal and formal ways. These include classroom experiences, formal and informal interactions with colleagues, formal training, graduate programs, and experiences separate from their formal professional work. The quality of these learning experiences is difficult to determine, "even when resources are formally provided for teachers' continued development, opportunities for effective learning vary in terms of quality" (Bransford et al., 1999, p. 180). Furthermore, Loucks-Horley et al. (2010) have indicated that several studies have shown that contextual factors such as professional culture, leadership, systemic support and time for teacher learning influence the type and quality of professional development. Knowledge and beliefs about adult learners and professional development have changed in the past few years as a result of recent studies that have linked "quality professional development and teacher expertise with students' opportunity to learn challenging mathematics and science" (Loucks-Horsley et al., 2010, p. 67). Consequently, Loucks-Horsley et al. (2010) compiled a list of basic principles of effective professional development which support the common vision for effective science and mathematics education articulated by professional organizations (National Council of Teachers of Mathematics, National Research Council) and standards for teacher professional development (National Staff Development Council). Effective professional development

- is designed to address student learning goals and needs;
- is driven by a well-defined image of effective classroom learning and teaching;
- provides opportunities for teachers to build their content and pedagogical content knowledge and reflect on practice;
- is research based and engages teachers as adult learners in the learning approach they will use with their students;
- provides opportunities for teachers to collaborate with colleagues and other experts to improve their practice;
- supports teachers to develop their professional expertise and to serve in leadership roles;
- links with other parts of the education system;
- is continuously evaluated and improved

(Loucks-Horsley et al., 2010, p. 68).

Bransford et al. (1999) stated that effective professional development (PD) opportunities for teacher learners must be learner-centered, knowledge-centered, assessment-centered, and community-centered.

Learner-centered environments consider that teacher learners arrive with different needs and attempts to build on the strengths, interests, and needs of the individual learners. Teachers should be involved in shaping their own professional development and opportunities should be provided for teachers that have different stages of participation and involve different roles – participant, mentor, and facilitator. Synchronous and asynchronous technologies that are now readily available can improve the ability to offer learner-centered PD experiences.

Knowledge-centered environments include a focus on pedagogical content knowledge in addition to being learner-centered. Bransford et al. (1999) claimed that PD experiences often focus on generic pedagogy (e.g., cooperative learning) rather than how to integrate pedagogy within a content area. By integrating pedagogy directly within content areas, participants are provided with an opportunity to develop their pedagogical knowledge and content knowledge for teaching science.

Assessment-centered environments provide an opportunity for teacher learners to test their new learning in their classroom practice. In the classroom, the feedback received from students provides the teacher with evidence of success and identifies areas of further development. Involving colleagues in the assessment of practice is also a valuable technique that can be used to inform teachers if the new ideas work. Likewise, the feedback from the teacher learners provide those delivering the professional development with evidence of the success of implementation which can be used to further tailor PD opportunities. Consequently, by asking the teacher learners for feedback on the success of implementation of the new ideas in their classroom practice, those providing the professional development are modeling the very assessment-centered environment that they are asking the teacher learners to engage in.

Community-centered environments encourage teacher collaboration and learning. The development of communities of practice is an important approach to enhancing teacher learning. "Research evidence indicates that the most successful teacher professional development activities are those that are extended over time and encourage the development of teachers' learning communities" (Bransford et al., 1999, p. 192). Communities of practice involve "collaborative peer relationships and teachers' participation in educational research and practice" (Bransford et al., 1999, p. 185).

Wenger, McDermott, and Synder (2002) describe communities of practice as "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (p. 4). In communities of practice, teachers are provided with opportunities to share experiences and practices involving student learning which may be similar to the learning practices that they will use with their students. Teachers are also provided opportunities to engage in shared decision making. Wenger et al. (2002) further describe that

> once these communities find a legitimate place in the organization, they offer new possibilities – many yet undiscovered – for weaving the organization around knowledge, connecting people, solving problems, and creating business opportunities. And because communities of practice are not confined by institutional affiliation, their potential value extends beyond the boundaries of any single organization. (p. 4)

Essentially, science educators should be afforded ongoing professional development opportunities which are learner centered, knowledge centered, assessment centered, and community centered as suggested by Bransford et al. (1999). Furthermore, these opportunities should consider the basic principles for effective professional development articulated by Loucks-Horsley et al. (2010). Schools, school boards, and the Department of Education should continue to find ways to catalyze the creation and maintenance of communities of practice where discussions, support and sharing of knowledge, expertise and practice can be ongoing. Once defined, assessed, and evaluated, the methods used by the governing entities should shape policy related to ongoing professional development for science educators.

Conclusion

This study served to explore factors that secondary science teachers believe affect student achievement in science, and the extent to which teacher beliefs transfer to teacher practice. It appears that teacher beliefs in each of the fourteen topics surveyed (Classroom Management, Learning Styles, Inclusion, Equity, STS, Formative Assessment, Summative Assessment, Constructivism, Thematic Approach, Hands-On/Minds-On Activities, The Nature of Science, Science Subject Matter, Electronic Learning and Cooperative Learning) are strong for most Prince Edward Island secondary science teachers. The data shows that beliefs and implementation of beliefs in classroom practice are positively correlated. Regarding implementation, at least seventy percent of teachers reported that they implemented all but two topics – The Nature of Science and Electronic Learning – at least once a week. The data shows that other factors such as curriculum time, preparation time, and equipment present barriers to the implementation of beliefs in classroom practice. Similarly, preparation time and availability of equipment were the most frequently identified factors that present challenges to being an effective teacher of science. Continued provision for effective, ongoing professional development opportunities and catalyzing the creation of, and supporting established communities of practice may assist in mitigating barriers that prevent science educators from implementing practices that they believe are important to be an effective teacher of science.

In addition to strong beliefs about the fourteen topics surveyed, P.E.I. secondary science teachers reported having strong beliefs in their ability to affect student learning (self-efficacy beliefs). However, it is apparent from the data that teachers believe that for some students, there are other influential factors that are preventing them from learning despite the teachers' best efforts and ability.

Further research that focuses on a single context for teaching and learning is recommended to gain a deeper understanding of teacher beliefs and implementation of their beliefs in classroom practice. Furthermore, the Sociocultural Model of Embedded Belief System (see Figure 1.1) may be a promising lens to view future research on individual context for teaching and learning topics. The Sociocultural model takes a comprehensive look at teachers' motivation to engage in an instructional practice based on several reciprocal interactions involving teacher knowledge, skills, and attitudes towards instruction and implementation of the practice. This model also examines how environmental factors, environmental constraints, social norms, teacher efficacy, and teacher epistemologies reciprocally interact with teacher knowledge, skill, motivation, and attitudes.

Limitations of Study

This study involved secondary science teachers of Prince Edward Island. The findings should not suggest similar findings at other grade levels in this province or any grade level in other jurisdictions. Conclusions about the context for teaching and learning topics should consider that the survey data collected regarding teacher beliefs and the implementation of their beliefs were teacher reported and based on one survey item per topic. The assessment and evaluation of data from multiple items and a broader array of data collection techniques should provide a more accurate portrayal of teacher beliefs and the enactment of their beliefs in classroom practice. Furthermore, it is not evident from this study which aspects of a topic that teachers believe strongly in or implement frequently. For example, a teacher may implement inclusionary practices each day and feel strongly about inclusionary practices. However, it is not evident from this study which inclusionary practice the teacher is referring to or is enacting in classroom practice. A similar argument can be made for any of the other thirteen topics surveyed. Further investigation of the context for teaching and learning topics involving multiple data collection techniques, such as classroom visitations, is recommended in order to provide a more accurate and comprehensive account of teacher beliefs and the enactment of their beliefs in classroom practice.

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Appendix A: District Access Letters

Factors Affecting Student Achievement: A Study of Teachers' Beliefs.

Jonathan Hayes
Memorial University of
Newfoundland

Dr. Kevin Macleod
Curriculum Delivery Department
Eastern School District
Prince Edward Island, Canada

Thursday, June 11, 2009

Dear Dr. Macleod:

SUBJECT: PERMISSION TO SURVEY/INTERVIEW SECONDARY SCIENCE TEACHERS

I am a graduate student in the Masters of Education program at Memorial University of Newfoundland. The focus of my research is on teacher beliefs pertaining to the context for teaching/learning and professional issues. The specific objectives of the study are to investigate: the factors that science teachers believe affect student achievement in science; and teacher perceptions of how their beliefs are enacted in classroom practice. I am requesting your permission to invite secondary science teachers to participate in an online survey study involving their beliefs. The survey will take approximately 5-10 minutes to complete. Furthermore, as a second stage of this study, I am also requesting your permission to conduct an interview with a purposeful sample of secondary science teachers who have completed the survey. The purpose of the interviews is to obtain contextual data and multiple perspectives through which meaning can be constructed. Essentially, the interview data will be used to corroborate the data collected from the survey. The interview process will take approximately 45 minutes of the participant's time. The interview will be audio recorded for accuracy of data collection. The data from the audio recording will be transcribed to electronic print at a later date to assist in data analysis.

Study Rationale

Presently, minimal data in relation to science teacher beliefs and practice exist for PEI science teachers. As decision-making surrounding the implementation of curriculum and education policy must be informed by the evaluation of sound assessment of teacher beliefs, then much attention to the beliefs of teachers and teacher candidates should be a focus of educational research. The significance of this study is to inform decision making regarding science-related initiatives at the school, district, and provincial levels.

Survey: Anonymity - Confidentiality – Consent

Participation in this survey is completely voluntary. Confidentiality and anonymity will

Appendix A: District Access Letters

be guaranteed as the survey will not be asking for teacher identification or contact information. Furthermore, teachers will not be asked for information that will identify their school or school board/district. Teacher consent to participate in this survey study will given by their submission of a completed survey. Two reminders will be sent to all potential participants prior to the final submission date.

Interview: Anonymity - Confidentiality – Consent

Participation in the interview process is voluntary. Participants are free to withdraw from the study at any time and also to withdraw any data that pertains to them. I (principal investigator) will attempt to protect participant anonymity from those not directly involved in the research. Specifically, pseudonyms will be used as identifiers on all data collected from the interview and I will ensure that the research assistant (transcriber) complies with guidelines for ethical research. I will share my interpretations of the interview data (research summaries) with participants to obtain their feedback prior to the publication of results. All data will be stored in a locked cabinet in the office of the principal investigator (myself). The research assistant (transcriber) and I will be the only individuals who will have access to the data. Furthermore, data transcription will be done confidentially. Within five years of completing the research, all data will be destroyed.

Participation Incentive

As a small incentive to participate in the survey, teachers will have an opportunity to win one of ten $50 gift certificates at a local restaurant. Upon completion of the survey teachers will be asked if they would like a chance to enter a draw for a gift certificate. Should teachers choose to participate they will be redirected to a separate website which will ask for their name and contact information. Again, this personal information is completely independent of, and thus is not linked to, their survey data. Furthermore, the participation incentive will be administrated by a third party.

A paper representation of the online survey instrument is attached to this correspondence for your review. **Please advise if I have permission to invite your secondary science teachers to participate in this online survey study and interview process.**

Thank you for considering my request. I am happy to address any of your questions or concerns. I can be reached at jghayes@edu.pe.ca or via telephone at 902-393-5445.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at (709) 737-8368.

Sincerely,

Jonathan Hayes

Appendix A: District Access Letters

Factors Affecting Student Achievement: A Study of Teachers' Beliefs.

Jonathan Hayes
Memorial University of
Newfoundland

Mr. Dale Sabean
Superintendent
Western School Board
Prince Edward Island, Canada

Thursday, June 11, 2009

Dear Mr. Sabean:

SUBJECT: PERMISSION TO SURVEY/INTERVIEW SECONDARY SCIENCE TEACHERS

I am a graduate student in the Masters of Education program at Memorial University of Newfoundland. The focus of my research is on teacher beliefs pertaining to the context for teaching/learning and professional issues. The specific objectives of the study are to investigate: the factors that science teachers believe affect student achievement in science; and teacher perceptions of how their beliefs are enacted in classroom practice. I am requesting your permission to invite secondary science teachers to participate in an online survey study involving their beliefs. The survey will take approximately 5-10 minutes to complete. Furthermore, as a second stage of this study, I am also requesting your permission to conduct an interview with a purposeful sample of secondary science teachers who have completed the survey. The purpose of the interviews is to obtain contextual data and multiple perspectives through which meaning can be constructed. Essentially, the interview data will be used to corroborate the data collected from the survey. The interview process will take approximately 45 minutes of the participant's time. The interview will be audio recorded for accuracy of data collection. The data from the audio recording will be transcribed to electronic print at a later date to assist in data analysis.

Study Rationale

Presently, minimal data in relation to science teacher beliefs and practice exist for PEI science teachers. As decision-making surrounding the implementation of curriculum and education policy must be informed by the evaluation of sound assessment of teacher beliefs, then much attention to the beliefs of teachers and teacher candidates should be a focus of educational research. The significance of this study is to inform decision making regarding science-related initiatives at the school, district, and provincial levels.

Survey: Anonymity - Confidentiality – Consent

Participation in this survey is completely voluntary. Confidentiality and anonymity will

Appendix A: District Access Letters

be guaranteed as the survey will not be asking for teacher identification or contact information. Furthermore, teachers will not be asked for information that will identify their school or school board/district. Teacher consent to participate in this survey study will given by their submission of a completed survey. Two reminders will be sent to all potential participants prior to the final submission date.

Interview: Anonymity - Confidentiality – Consent

Participation in the interview process is voluntary. Participants are free to withdraw from the study at any time and also to withdraw any data that pertains to them. I (principal investigator) will attempt to protect participant anonymity from those not directly involved in the research. Specifically, pseudonyms will be used as identifiers on all data collected from the interview and I will ensure that the research assistant (transcriber) complies with guidelines for ethical research. I will share my interpretations of the interview data (research summaries) with participants to obtain their feedback prior to the publication of results. All data will be stored in a locked cabinet in the office of the principal investigator (myself). The research assistant (transcriber) and I will be the only individuals who will have access to the data. Furthermore, data transcription will be done confidentially. Within five years of completing the research, all data will be destroyed.

Participation Incentive

As a small incentive to participate in the survey, teachers will have an opportunity to win one of ten $50 gift certificates at a local restaurant. Upon completion of the survey teachers will be asked if they would like a chance to enter a draw for a gift certificate. Should teachers choose to participate they will be redirected to a separate website which will ask for their name and contact information. Again, this personal information is completely independent of, and thus is not linked to, their survey data. Furthermore, the participation incentive will be administrated by a third party.

A paper representation of the online survey instrument is attached to this correspondence for your review. **Please advise if I have permission to invite your secondary science teachers to participate in this online survey study and interview process.**

Thank you for considering my request. I am happy to address any of your questions or concerns. I can be reached at jghayes@edu.pe.ca or via telephone at 902-393-5445.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at (709) 737-8368.

Sincerely,

Jonathan Hayes

Appendix B: Survey Cover Letter

Factors Affecting Student Achievement: A Study of Teachers' Beliefs.

Jonathan Hayes
Memorial University of Newfoundland

Tuesday, June 17, 2009

Dear Teacher:

I am a graduate student in the Masters of Education program at Memorial University of Newfoundland. I am inviting you to participate in an online survey study involving secondary science teacher beliefs. The study will focus on beliefs pertaining to the context for teaching/learning and professional issues. The specific objectives of the study are to investigate: the factors that science teachers believe affect student achievement in science; and the extent that teacher beliefs become enacted in teacher practice.

Study Rationale

Presently, minimal data in relation to science teacher beliefs and practice exist for PEI science teachers. As decision-making surrounding the implementation of curriculum and education policy must be informed by the evaluation of sound assessment of teacher beliefs, then much attention to the beliefs of teachers and teacher candidates should be a focus of educational research. The significance of this study is to inform decision making regarding science-related initiatives at the school, district, and provincial levels.

Anonymity - Confidentiality - Consent

Participation in this study is completely voluntary. I expect that it will take approximately 5-10 minutes of your time to complete. Confidentiality and anonymity will be guaranteed as the survey will not be asking you for your identification or contact information. Furthermore, you will not be asked for information that will identify your school or school board. Your consent to participate in this survey study will be given by your submission of a completed survey. Should you elect to participate in the survey please complete and submit it by Friday, June 26th (5pm). The survey is found at (http://www.surveygizmo.com/s/146734/teacher-beliefs). Two reminders will be sent to you prior to the final submission date (if you completed/submitted the questionnaire or have chosen not to participate, please disregard the reminders).

Appendix B: Survey Cover Letter

Participation Incentive

As a small incentive (and a token of my appreciation) to participate in this survey you will have an opportunity to win one of ten $50 gift certificates at a local restaurant. Upon completion of the survey you will be asked if you would like a chance to enter a draw for the gift certificate. Should you choose to participate you will be redirected to a separate website which will ask for your name and contact information. Again, this personal information is completely independent of your survey data. Furthermore, the incentive will be administrated by a third party.

Thank you for considering my request. I am happy to address any of your questions or concerns. I can be reached at jghayes@edu.pe.ca or via telephone at 902-393-5445.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at (709) 737-8368

Sincerely,

Jonathan Hayes

Appendix C: Interview Cover Letter and Consent Form

Factors Affecting Student Achievement: A Study of Teachers' Beliefs.

Jonathan Hayes
Memorial University
of Newfoundland

(Insert Date), 2009

Dear Teacher:

I am a graduate student in the Masters of Education program at Memorial University of Newfoundland. You have indicated on the Teacher Beliefs Survey that you are willing to consider participating in an interview. Consequently, I have identified you and five of your colleagues (secondary science teachers) as potential interview participants. I am inviting you to participate in an interview.

The purpose of the interview is to obtain contextual data and multiple perspectives through which meaning can be constructed. Essentially, the interview data will be used to corroborate the data collected from the Teacher Beliefs Survey. As you may recall, this study is focused on teacher beliefs pertaining to the context for teaching/learning and professional issues. The specific objectives of the overall study are to investigate: the factors that science teachers believe affect student achievement in science; and teacher perceptions of how their beliefs are enacted in classroom practice. Should you choose to participate the interview process will take approximately 45 minutes of your time. The interview will be audio recorded for accuracy of data collection. The data from the audio recording will be transcribed to electronic print at a later date to assist in data analysis.

Study Rationale

As indicated in the survey component of this study, minimal data in relation to science teacher beliefs and practice exist for PEI science teachers. As decision-making surrounding the implementation of curriculum and education policy must be informed by the evaluation of sound assessment of teacher beliefs, then much attention to the beliefs of teachers and teacher candidates should be a focus of educational research. The significance of this study is to inform decision making regarding science-related initiatives at the school, district, and provincial levels.

Appendix C: Interview Cover Letter and Consent Form

Anonymity - Confidentiality - Consent

Your participation in this study is voluntary. If you choose to participate, you are free to withdraw from the study at any time and also to withdraw any data that pertains to you. I (principal investigator) will attempt to protect your anonymity from those not directly involved in the research. Specifically, pseudonyms will be used as identifiers on all data collected from the teacher interview and I will ensure that the research assistant (transcriber) complies with guidelines for ethical research. I will share my interpretations of the interview data (research summaries) with you to obtain your feedback prior to the publication of results.

All data will be stored in a locked cabinet in the office of the principal investigator (myself). A research assistant (transcriber) and I will be the only individuals who will have access to the data. Furthermore, data transcription will be done confidentially. Within five years of completing the research, all data will be destroyed.

Thank you for considering my request. I am happy to address any of your questions or concerns. I can be reached at jghayes@edu.pe.ca or via telephone at 902-393-5445.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at (709) 737-8368

Sincerely,

Jonathan Hayes

Appendix C: Interview Cover Letter and Consent Form

Factors Affecting Student Achievement: A Study of Teachers' Beliefs
Memorial University of Newfoundland
Faculty of Education
2009

Statement of Informed Consent

I have read the attached description of this study and my questions have been answered to my satisfaction.

I, _______________________________________, agree to participate in this study.
Please print your name

_______________________________________ _____________________
Participant Signature Date

To the best of my ability, I, Jonathan Hayes, have answered all of his/her questions.

___________________________ _____________________
Researcher Signature Date

If you would like to receive a summary of the results of this study, please print your name and provide a complete mailing address in the space below. Thank you.

__________ **Yes, I would like to see a summary of the results of this study.**

My full name and mailing address is:

____

____

____

____

Appendix D: Survey Instrument

Teacher Beliefs Survey: Context for Teaching and Learning & Professional Issues

Part I	**General Information: 5 questions**
Part II	**Context for Teaching and Learning: 29 questions**
Part III	**Professional Issues: 27 questions**

Part I: - General Information

DIRECTIONS: Please answer the following questions by selecting one of the available options which best describes your situation.

1. Do you hold an undergraduate or graduate degree in Science?
☐ Yes ☐ No
2. What is the highest degree that you hold in Education?
☐ B.Ed. ☐ M.Ed. ☐ Ph.D.

3. How many years of teaching experience have you completed?
☐ less than 1 year ☐ 1-2 years ☐ 3-5 years ☐ greater than 5 years

4. Which of the following science courses do you teach? Check all that apply.
☐ Grade 7 Science
☐ Grade 8 Science
☐ Grade 9 science
☐ Grade 10 science
☐ Physics
☐ Biology
☐ Chemistry
☐ Agriscience /Agriculture
☐ Applied Science
☐ Other

5. Have you within the past ten years participated on a science curriculum committee?
☐ Yes ☐ No

6. Please identify your gender.
☐ Male ☐ Female

Appendix D: Survey Instrument

Part II - Context for Teaching and Learning

DIRECTIONS: Below are fourteen listed topics commonly included in national recommendations for the reform of science education. For each topic you will be asked to complete two rating scales. The first is titled "Degree of Necessity to be an Effective Science Teacher" and the second is titled "Degree of Implementation in Your Classroom During the Year."

1. Judge how necessary you believe each of the items is to be an effective science teacher at the grade level you teach, and select the option that corresponds to your choice from the rating scale provided.
2. Select the option that corresponds to your estimate of how often you implement the principles/ideas/or practices in you classroom.

Constructivism. A learning theory that assumes that all learners construct their own meaning for concepts based on their personal experiences with the natural world. For example: instruction is based on students' prior knowledge, students are provided with the opportunity to make inferences based on experimentation and peer discussion/debate

1. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

2. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Learning Styles. Students have preferred modes and styles of learning. Teachers use a diversity of instructional strategies to meet the needs of all students. For example: basing instruction on learning styles by including a variety of activities and approaches

3. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

4. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Inclusion. The science classroom consists of students with varying knowledge and ability level. Teachers can use a diverse array of instructional materials and strategies to meet the needs of all learners. For example: open-ended assignments, offering choice in terms of learning activities, adapting materials to match the ability level of students above or below grade level expectations, etc.

5. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

6. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Appendix D: Survey Instrument

Thematic Approach. A curricular organization using major concepts or ideas in science and technology to provide a sense of continuity across a unit, chapter, or year. For example: systems, patterns of change.

7. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

8. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Classroom Management. Procedures and techniques teachers employ in planning learning tasks, using educational resources, and conducting instruction to maximize student learning. For example: providing helpful hints for setting up laboratories.

9. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

10. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Formative Assessment and Evaluation. Teachers engage in a continuous process of gathering data from diverse sources to make decisions about instruction (Assessment "for learning"). For example: group discussion, performance assessment, etc.

11. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

12. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Summative Assessment and Evaluation. Teachers gather data from diverse sources to judge the degree which the students achieved the intended outcomes for the program (Assessment "of Learning"). For example: paper and pencils test, performance assessment, portfolio, etc.

13. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

14. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Appendix D: Survey Instrument

Equity. Teacher provides learning experiences so that students develop positive attitudes, self-efficacy, and an understanding of science and technology. For example: making sure minorities, physically challenged, & both genders are involved in activities.

15. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

16. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Science/Technology/Society. Curriculum and instruction includes emphases on the history and nature of science and technology; the interactions among science, technology, and society; on science-related social issues; understanding how things are made and how they work; and how science relates to our lives through such things as the environment, medicine, and engineering. For example: a unit on acid rain or studying the development of the germ theory of disease.

17. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

18. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Electronic Learning. Teachers use computer technology as the medium of instruction to promote student learning. For example: web-based or LAN-based communication tools, interactive digital technologies (tutorials, simulations, demonstrations).

19. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

20. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Science Subject Matter. The teacher possesses knowledge of those basic concepts, principles, facts, laws and theories that constitute the current body of scientific knowledge. For example: the teacher is knowledgeable enough of astronomy to teach the content and answer most all questions the students might ask.

21. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary – ☐ Necessary – ☐ Not Very Necessary – ☐ Unnecessary

22. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Appendix D: Survey Instrument

Cooperative Learning. An approach emphasizing conceptual learning through social interaction within small groups of students. For example: balancing instruction within small groups emphasizing the social skills along with content to be learned

23. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary - ☐ Necessary - ☐ Not Very Necessary - ☐ Unnecessary

24. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

Hands-On/Minds-On Activities. Teacher choose and uses effective science activities which promote student learning and positive attitudes toward science. Example: In a unit on sound, students actually experience how sound travels through air, water, and solids by manipulating equipment

25. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary - ☐ Necessary - ☐ Not Very Necessary - ☐ Unnecessary

26. Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

The Nature of Science. Teachers enable students to understand and engage in scientific inquiry; to make evidence-based decisions through an understanding and appreciation for the modes of reasoning involved in scientific inquiry. Also includes the social and historical contexts in which science evolved along with the values underlying the work of scientists. For example: the teacher has students use a candle, water, flask, and pan to see why water rises in a flask when it is put over a burning candle sitting in a pan of water. Students reason why water rises and discuss with each other why they think the water rises. The teacher does not give an "exact answer", but allows students to explore the idea over several hours or days.

27. Degree of Necessity to be an Effective Science Teacher
☐ Very Necessary - ☐ Necessary - ☐ Not Very Necessary - ☐ Unnecessary

28 Degree of Implement in Your Classroom During the Year
☐ Almost Every Day – ☐ Several Times a Week – ☐ About Once a Week – ☐ Less Than Once a Week – ☐ Never

29. Explain why differences exist (if they do exist) between topics that you believe are necessary to be an effective science teacher and the degree of implementation of these topics in your teaching practice.

____

____

____

____

Appendix D: Survey Instrument

Part III - Professional Issues

DIRECTIONS: Please indicate the degree to which you agree or disagree with each statement below by selecting the option that corresponds to your choice from the rating scale provided.

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

2. I am continually finding better ways to teach science.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

3. Even when I try very hard, I do not teach science as well I do most subjects.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

5. I know the steps necessary to teach science concepts effectively.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

6. I am not very effective in monitoring science experiments.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

7. If students are underachieving in science, it is most likely due to ineffective science teaching.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

8. I generally teach science ineffectively.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

9. The inadequacy of a student's science background can be overcome by good teaching.
   ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

10. The low science achievement of some students cannot generally be blamed on their teachers.
    ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.
    ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

12. I understand science concepts well enough to be effective in teaching science.
    ☐ Strongly Disagree - ☐ Disagree - ☐ Agree - ☐ Strongly Agree

Appendix D: Survey Instrument

13. Increased effort in science teaching produces little change in some students' science achievement.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

14. The teacher is generally responsible for the achievement of students in science.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

17. I find it difficult to explain to students why science experiments work.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

18. I am typically able to answer students' science questions.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

19. I wonder if I have the necessary skills to teach science.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

20. Effectiveness in science teaching has little influence on the achievement of students with low motivation.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

21. Given a choice, I would not invite the principal to evaluate my science teaching.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

22. When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

23. When teaching science, I usually welcome student questions.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

24. I do not know what to do to turn students on to science.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

25. Even teachers with good science teaching abilities cannot help some kids to learn science.
☐ Strongly Disagree – ☐ Disagree – ☐ Agree – ☐ Strongly Agree

Appendix D: Survey Instrument

26. What is the primary factor(s) that enhances your ability to be an effective teacher of science?
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27. What primary factor(s) presents challenges to your ability to be an effective science teacher?
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Appendix E: Survey Protocol

General Beliefs Questions:

1. Why do you have specific beliefs about factors affecting student learning? In other words, what has "shaped" your beliefs?

2. Have your beliefs changed over time?

3. Has there been something (situation, event, etc) that may have changed your beliefs?

Context for Teaching and Learning

1. PEI teachers hold strong beliefs for the context for teaching and learning. Also, there is a strong correlation between teacher beliefs and implementation of their beliefs. However, the frequency of implementation of beliefs into classroom practice is high for select topics and low for others. Could you comment on why select topics were high and others low?

2. There is a statistically significant difference between responses of teacher groups and select topics within the context of teaching and learning. Could you comment as to why their may be differences between group responses?

Professional Issues

1. PEI teacher self-efficacy appears to be quite high. However, PEI teacher outcome expectancy is not nearly as high and is divided among the survey population. Why do you believe outcome expectancy to be low among PEI secondary science teachers considering self-efficacy appears to be relatively high?