Adult college students' perceptions on science education: Reclaiming lost ground in science education in preparation for Health Science Programs.

By

Anita Graham

A thesis

submitted in partial fulfillment of the requirements

for the degree of

Master of Education

Faculty of Education

Lakehead University

Thunder Bay, Ontario

Canada

June 2008

Your file Votre référence
ISBN: 978-0-494-43402-4
Our file Notre référence
ISBN: 978-0-494-43402-4

I dedicate this work to my husband, family and friends.

Thanks for listening whenever I needed to vent, encouraging whenever I started to wilt,

and supporting me in every way through this journey.

ABSTRACT

This study was based upon the issues surrounding science education and how they impact students' further science education as well as their everyday lives. The research was a qualitative study that used an interview guide. Six adult college students who had graduated from the Pre-Health Sciences Program and continued with Health Science Programs were interviewed for this study. Their perceptions on how science education had influenced their further science education as well as everyday lives were analyzed and similar themes evolved from the data. Findings revealed that high school science education for these students generally did not generate interest or desire to learn science, except when they participated in lab activities. In contrast, these students found that the college science education interested them and inspired them to learn. This may be more due to intrinsic values for learning science since students articulated that they needed to learn the science because they wanted to enter Health Science Programs after the science prerequisites were fulfilled. The findings showed that students wanted labs and hands-on activities as part of their learning. Also, science literacy in the students was evident from the stories they shared about their everyday lives.

TABLE OF CONTENTS

CHAPTER ONE

Statement of the Problem

Introduction

This study on adult college students' perceptions of their science education explored their experiences with learning science in high school and in college and the impact it had on further education and their everyday lives. By asking adult college students about their experiences with science education, a clearer understanding of how the science curriculum has met their needs thus far could be ascertained.

Personal ground

As a post-secondary science educator in a Pre-Health Science Program at a college in Ontario, I have experienced student frustration with science. Much of my teaching includes science courses that are equivalent to the grade twelve Ontario curriculum. Students enrol into these courses to meet prerequisite needs for college programs such as nursing, paramedic, dental hygiene and medical radiation technology. Either they hadn't previously taken the needed science course(s), or they had taken them during high school and found that their grades were too low to compete for a seat in whichever program they had wanted, or they had been out of school for so long that they felt they needed to refresh their science knowledge.

Throughout past courses with my students in the Pre-Health Science Program, I have learned of their diverse experiences and frustrations about science. Some students hated learning science and were taking the course strictly as a prerequisite. Some students questioned what they were learning and what its relevance and usefulness was. There were also some students who enjoyed science and learned whatever was offered in the course.

These students are adults – many in their twenties, some in their thirties, forties and even fifties. Their experiences with science, thus far, interests me and I feel that capturing their experiences and better understanding them would enhance my effectiveness as a teacher and hopefully benefit future development of science curriculum for secondary school education as well as post-secondary school education.

While changes to incorporate a Science/Technology/Society [STS] perspective in the science curriculum have been ongoing within the Pre-Health Science Program, it is still in question whether these changes have influenced student perceptions positively, negatively, or not at all. This study's intent was to establish a clearer understanding about specific college adult students' experiences with science education during secondary school and the college Pre-Health Science Program. It also looked at the impacts that science education had towards preparing them as citizens as well as preparing them for their further education in a Health Science Program. These adult students had taken science courses at school and science courses in the Pre-Health Science Program. In addition, they are also presently taking, or recently have graduated from, a Health Science Program at the same Ontario college where they graduated from the Pre-Health Science Program. For the purpose of this study, an adult student has been defined as a person age 21 or older

Significance

The uniqueness of the adult students studied provided an opportunity to see how well science education had met their needs. These adult students had been active citizens for a number of years already and would be able to identify what kinds of influences science education had on them as a citizen in society. They did not plan to become future scientists, but have instead used this Pre-Health Science Program to gain admittance into Health Science

Programs such as Registered Nursing, Practical Nursing, Paramedic, Dental Hygiene, Dental Assisting, and Medical Radiation Technology. Even though they did not use science education specifically for becoming a future scientist, the Health Science Programs required this background of prerequisites as a preparation for the program.

Pre-Health Science students have had the opportunity in high school to obtain their science prerequisites for Health Science Programs but that does not mean that it has prepared them to be successful in further education. Some do not have high enough grades in these science classes to gain acceptance into Health Science Programs, or some have dropped out of, or simply avoided, taking science classes during high school. There are others that take Pre-Health Science as a science refresher because they have been out of school for a number of years and feel that they have forgotten too much science, and would be at a disadvantage when trying to learn content in a Health Science Program. Ultimately, Pre-Health Science is a second round for these students in gaining a high school science education.

There has been much debate on how best to develop science curriculum so that it provides a meaningful education for all students, whether they intend to enter the science field or use it within their everyday lives. The importance of this endeavour was noted by Gallagher, (1971, p. 337), when he stated, "For future citizens in a democratic society, understanding the interrelationships of science, technology and society may be as important as understanding the concepts and processes of science." Knox and Schmidt (2006) consider it crucial for today's Canadians to be able to understand science and make informed decisions in society about science issues. They also suggest that the 21st century, knowledge-based, global economy demands a highly skilled and well-educated Canadian workforce that is innovative and committed to quality to be able to compete globally with larger populated countries (Knox &

Schmidt, 2006). In the past twenty years, there has been both national and international agreement that science education must become compulsory for all students' education due to its great importance in our society (Osborne & Collins, 2000).

Internationally, there has been much agreement about the importance placed on science education, however, there is little agreement on how the curriculum should be developed to meet both the needs of future scientists and future citizens (Osborne, 2003). Science curriculum development has been ongoing with the intent to incorporate a more societal perspective. One aspect of curriculum change within this intent was the introduction of STS (science-technology-society) into the curriculum (Aikenhead, 2003). Incorporating 'scientific literacy' is also an important focal point. Knox and Schmidt (2006, p. 74) define scientific literacy as pertaining to the basic knowledge, skills and process of science, and problem solving that "enables us to understand and advance the links between science, technology, innovation, the economy and our society." Hodson (2005) explains that as science changes over time, our concept of what science literacy is must be changed as well. He further notes that while there is an important place within science education for science literacy components such as active citizenship and gaining a sense of responsibility for our behaviour towards our environment, there is always a need to gain an understanding of the major concepts and theories of science.

Having the curriculum meet the needs of both perspectives – future scientist and future citizen preparation – has been difficult to attain. 'Science for All' (Fensham, 1985) became a worldwide slogan for science educators in the 1980s. Fensham argues that even in the 1950s, two separate needs for science were identified in many countries. One was to prepare students for careers in the science and technology field, and the other was to prepare students to be more scientifically literate citizens. These two ideologies, Fensham argued, conflict with each other

and are not complimentary. However, many countries failed to discriminate this and kept these ideologies together as new science curricula were created (Fensham, 1985).

There are increasingly more students who are less interested in entering the science field, because learning science is seen as unappealing, hard to understand, and not meeting their interests and needs (Osborne, 2003). Elementary students are learning more science than ever before, yet this early start in science education still does not curb the loss in interest in science for many secondary school students and they subsequently drop out of science (Hodson, 2003). So, even with the best intentions to change the science curriculum to better serve future scientists and citizens, the curriculum falls short of meeting these needs as well as the needs of a constantly changing society (Osborne & Collins, 2000). Traditional science education focuses on teaching students in a scientific manner and stresses the scientific process (Aikenhead, 2005). Aikenhead (2005) stated that this style is only effective for a certain number of students and alienates other students from science learning. He further noted that many high school students would respond better to a science education that focussed more on personal and societal science issues.

Decisions made at the high school level have subsequent impacts throughout the students' lives. Choosing to drop science courses, or not enrol in them at all during high school creates problems for students who later choose to enter the Health Science field. Science prerequisites are not met due to these choices, and subsequently, students are not accepted into Health Science Programs. The Comprehensive Career Needs Study (CCNS) done by Magnusson and Bernes in 2001 (cited in Code, Bernes, Gunn & Bardick, 2006) included junior and senior school students from 52 schools in Alberta and assessed what their perceived career concerns were. The data from this study showed that senior high school students had difficulty

committing to a career choice and displayed frustration with not knowing what they would like to pursue (Code et al., 2006). Bloxom and Bernes (2003) also used data from the CCNS study and noted that there is a need for more specialized counselling when dealing with post-secondary school program choices. Higher education institutions need to provide more information about their programs to high school counsellors (Bloxom & Bernes, 2003).

The current study involved students at a local college, who had taken courses that are equivalent to those in the final years of the secondary school science curriculum. They did this as part of a Pre-Health Science Program, for the purpose of meeting the prerequisite expectations of Health Science Programs and are now currently enrolled in, or recently graduated from, one of these Health Science Programs. While the goal of the Pre-Health Science Program is directed towards preparation for a range of health science programs, those of us teaching science in this program also have some expectation that it will provide a successful education in scientific literacy.

Limitations

With regards to this research study, there are several limitations. Due to the small number of participants, the findings described viewpoints from a small sample of students and thus did not necessarily describe the related general population's views. There are six Health Science Programs at the college where this study took place. To both maintain a reasonably sized study as well as obtain as wide a breadth as possible with participant experiences, I selected one participant from each Health Science Program. The selection tried to balance gender as well as a diverse range of age. All six of the participants that were asked to participate in the study accepted and completed the study.

This small sample included only students that had been successful with their Pre-Health Science education. Therefore, this study does not reflect any insight on those students who were not successful in the Pre-Health Science Program. Though the focus of this study was directed towards successful students, future studies including unsuccessful students would certainly be valuable in this field of study.

Also, since I had taught these students previously, they may have felt the need to speak highly of their experiences so as to not offend me. I communicated to them, as clearly as possible, that my feelings would not be hurt in any way and that I sincerely welcomed any and all of their comments and meant to use them proactively to better my teaching. Due to the length of time that had passed since these participants have been in high school, there was not always a clear memory of their high school years and thus some participants had only few details to describe about those experiences.

Thesis Structure

Chapter two is a review of literature and provides a historical overview of the science curriculum, its changes, impacts and future directions it may lead to. Its purpose is to better understand the state in which the science curriculum is currently in as well as to illuminate the research problem and provide evidence pertaining to issues within it. Chapter three states the research problem, outlines the qualitative research design and methodology, and details the research questions. Chapter four provides a summary of the themes and findings from the data collection stage. Chapter five discusses the findings, relates them to the literature, and provides implications towards theory, practice and research.

CHAPTER TWO

Review of the Literature

Introduction

My research examined adult college student perceptions of their science education. To help gain an understanding of the roots of science education this literature review provides an overview of the science curriculum's historical origins and its subsequent changes over the last few decades. It also addresses the emergence of scientific literacy, science curriculum changes and their impact, students' perceptions of science education, and the future directions in science education. The purpose of this review of literature is to better understand the state in which the science curriculum is currently in and how it impacts students.

Historical intentions and subsequent changes

From its beginnings, science education's goals were to teach students the significance of science and the important achievements from a cultural perspective (Osborne, 2003).

In Canada in the 17th and early 18th centuries, the main focus of education was on religion, reading and writing. Science in the classroom was not considered important except when discussed within the topic of natural history (Connelly, Crocker & Kass, 1985). During the 19th century, Canadian elementary schools were trying to meet the needs of future farmers, fishermen and merchants so the curriculum generally focussed on religion, reading, writing, grammar, math and geography (Connelly et al., 1985). By the end of the 19th century, public interest in science had increased, and high schools subsequently incorporated the study of chemistry, botany, physics, zoology and agriculture into student education. Agriculture remained a large part of science study into the 20th century (Connelly et al., 1985).

DeBoer (1991, 2000) and Osborne (2003) explain the changes that occurred after the Second World War. Many European countries recognized the need for superior technology capable of producing highly effective military weapons and equipment. Noting the effectiveness of the Americans' atomic bomb as well as other military devices, European science education became focused solely on preparing scientists and engineers with the intent to use their skills and advances in science to better defend their countries (Osborne, 2003).

A strong influence on United States' science education in the late 1950s came from the launching of Sputnik by the Soviet Union. The American public viewed this launch as a threat to their security as well as their perceived superiority in science and technology (Bybee, n.d.). The launching of this satellite created a strong response from the United States' government and in the 1960s and 1970s, they charged scientists with the task of generating a science curriculum that would prepare students in the structures and processes of the science discipline (DeBoer, 1991; Gaskell, 2003). The United States wanted to have future scientists that were well educated so that it could become a stronger country and be more able to compete globally (Gaskell, 2003; Osborne, 2003). Stewart and Rudolph (2001) noted a recurring theme in United States science curricula, especially in the 1960s, was the intent to educate students to have a better understanding of how scientists practice in their field.

In the 1960s, Canadian provincial science education had moved towards streaming different levels of science classes that would serve students depending on whether they where entering university, college, trade schools or the workforce (Connelly et al., 1985). As discussed earlier in this document, 'Science for All' (Fensham, 1985) became a worldwide slogan for science educators in the 1980s. In Canada, Gaskell (2003) explains that scientists have tended to be preoccupied with preparing secondary students for university science courses

rather than concerned with educating students not entering science fields. This preparation of students was maintained by the established university entrance requirements that students needed to meet (Osborne, 2003).

More and more, however, science educators, governments and even scientists are recognizing the need for change in science education. Forty years ago in 1968 Robinson believed that the challenge for science education would be to educate all young people to understand the nature of science in a more humanistic way. The general public needs an understanding of science to better address issues and make well informed societal decisions (Knox & Schmidt, 2006; Roth, 2007).

The emergence of scientific literacy

In 1968, Robinson argued that science knowledge and education could no longer be only for those few entering the science field. Years later, this sentiment is still felt. Osborne and Collins (2000) argued that science education can no longer be viewed solely as preparation of future scientists due to the static nature of, or in some instances drop, in employment opportunities of scientists and related science careers. This change in demand is not the only issue. There has also been a change in the science field which has been going on for decades in which social and psychological aspects have become an important part of the expansion and advance of scientific knowledge (Robinson, 1968). Wellington (2001) believes that there is a conflict of goals when science education attempts to establish future scientists as well as future scientifically literate citizens.

Osborne and Collins (2000, p. 9) argue that over the last twenty years, "the emerging significance of scientific topics on the political agenda through such issues as global warming, ozone depletion, food safety and the genetic modification of organisms has demanded that

science education pay more attention to its role in developing a scientifically literate public." These scientific issues are important for society to understand. Robinson (1968) believed that social and ethical issues would continually develop as new science knowledge was generated. In the 1960s, scientific innovations such as DDT (dichlorodiphenyltrichloroethane), Thalidomide and CFCs (chlorofluorocarbons) were implemented with devastating results, and the environmental impacts of the Chernobyl disaster and ozone layer depletion have caused much public apprehension. Instead of a suspicious, hostile public, science research and scientists need a public that understands and is well aware of the scientific issues concerning society. By understanding science concepts, we can better understand what we experience in the world around us (Wellington, 2001). Hodson (2005) believes that we depend more and more on the information given to us by scientists about the safety hazards inherent with pharmaceuticals, pesticides and other materials that we are in contact with in our everyday lives. It is becoming increasingly important for society to be able to interpret such scientific information and be able to recognize the context of the data given as well as its reliability and validity instead of just accepting the information at face value (Hodson, 2005). This ability could encourage public appreciation of science research and ultimately encourages engagement, discussion and democratic decisions with the scientific issues in a critical, knowledgeable and ethical fashion (Millar & Osborne, 1998).

How scientifically literate are the general public? The level of scientific literacy of Canadian adults is not exactly known (Knox & Schmidt, 2006). The National Science Board (2006) found that Americans, though strongly in support of science and technology, they are not very well informed about those topics. The Board further states that Americans generally know little about science, and that it has been found to be this way from the 1990s until now. The

information sources that Americans are using most for obtaining science information are television, internet and media (National Science Board, 2006). Falk, Storksdieck and Dierking (2007) argue that science learned in school does not contribute very much to the long-term public understanding of science. Miller (1998) believes that although there has been an increase in concern towards understanding the level of science literacy in adults, there has been little debate or agreement on how to best measure scientific literacy.

It is important to better understand how science literacy becomes established in society and to then use those channels more effectively to improve science literacy (Einsiedel, 1992). The mass media is one of those channels and is used by most people as their source of information for science-related issues (Einsiedel, 1992). Einsiedel found, in a study done in 1986-1987, that Canadian newspapers tended to present general science issues, such as medical or environmental, with a positive context that contained little effort in explaining any negative issues that potentially would have been present. She felt a cause of this phenomenon was attributed to the newspaper writer's need to catch public interest and entertain the readers instead of educating them with a more well-rounded account. In a more recent study done from 1990-2001 in the United Kingdom and United States, mass media coverage consistently showed more positive frameworks for stories covering medical topics and more negative frameworks for stories covering agricultural biotechnology. It was subsequently found that public opinion mirrored these same positive and negative frameworks (Marks, Kalaitzandonakes, Wilkins & Zakharova, 2007). Though these authors maintain that public opinion should not be viewed solely as a reflection of the mass media reports, they suggest it provides some insight on how media can influence public opinion over a long period of time (Marks et al., 2007) A study, using newspaper articles from 1995 in Canada and the United States, by Zimmerman, Bisanz,

Bisanz, Klein and Klein (2001), found that newspaper science articles often described a broader range of science than what high school students were learning in their science curricula, which raised questions as to whether students were gaining adequate knowledge and understanding of science that would be beneficial when applied over the course of their lives. The idea of encouraging the public to engage in scientific issues in society raises the discussion of science literacy and how it pertains to its use within society.

The term 'scientific literacy' started appearing in United States' educational literature in the late 1950s (Hodson, 2005). Scientific literacy's definition has been difficult to establish but since the arrival of the term, it has implied a general description of understanding basic concepts of science and the nature of science, as well as the interaction of science with society (Hodson, 2005). Scientific literacy is defined by Knox and Schmidt (2006) as pertaining to the basic knowledge, skills and process of science, problem solving and what "enables us to understand and advance the links between science, technology, innovation, the economy and our society," (p.74). The Program for International Student Assessment (PISA) describes 'scientific literacy' as "the use of key scientific concepts in order to understand and help make decisions about the natural world. It also involves being able to recognize scientific questions, use evidence, draw scientific conclusions and communicate these conclusions" (2003, p. 1). The idea of what scientific literacy *is* tends to change over time and social context. One of the most recent changes to the idea of scientific literacy is that it helps to build economic prosperity (Hodson, 2005).

Hodson (2005) argues that for science literacy to exist in society, citizens will need to learn more *about* science than simply *learn* science. Roth and Stuart (2002) believe that science literacy is practiced during conversations in the community as science-related issues are

addressed and that participating in the decision-making and problem-solving arising from these science-related issues is where science literacy is performed. These authors further articulate the need to rethink the science literacy applications in the science curriculum of today and feel that it needs to reflect a sense of participation within a community and bridge the gap between school and everyday knowledge, as well as encourage life-long learning. Roth (2003) believes that the application of scientific literacy is used by citizens when they become involved in science issues that are important to them. By having science educators set up situations in which students can learn science through participating with science issues in their everyday lives, students can gain a scientific literacy (Roth, 2003).

A scientifically literate public would be able to use conversations to make better decisions towards science issues in society (Roth & Stuart, 2002). Science education needs to allow opportunities for students to practice argumentation skills and critically evaluate science information (Osborne, Erduran, & Simon, 2004). In a study done by Osborne et al., it was found that high school students were able to improve the quality of their argumentation skills through practicing them over time. Argumentation is a practice needed by all people (Osborne et al., 2004), however, it is often absent in the educating of students in science classes (Osborne et al., 2003, Watson, Swain, & McRobbie, 2004). It has been noted, through previous studies, that normal science classes contain little opportunity for discussion (Watson et al., 2004). Through their findings, Watson et al. describe that students and teachers view scientific inquiry as a single process learned, then applied to all other inquiries. They further state that reflection and discussions were absent from the inquiry. Scientific inquiry is not performed as a single process by scientists. Scientists spend great amounts of time reflecting as well as discussing, defending and debating their findings (Watson et al., 2004). More focus on science as a social activity is

needed and a key component of that focus should be the through the practice of debate and dialogue (Kelly, 2005). Roth (2003, p.19) articulated that, "If we think of scientific literacy in different terms, as choreography of a particular kind in which we learn to participate from the beginning, we take radically different approaches to teaching science in schools." Also, students gain the experience of leadership roles and sharing authority (Kelly, 2005). Social practice is gained as well; Kelly (2005, p. 11) maintains, "The cultural practices that constitute membership in a community (eg., standardized genres) are thus created interactionally through discourse processes (eg., multiple educational events, peer review, editorial admonishments and so forth)."

Another aspect of science education to consider is the communication between science educators and scientists. Eijkelhof (2003) believed that even though scientists and science educators do not always agree on the best practices for students, they need to work together on the development and teaching of science curriculum. Science educators can work with scientists to stay up to date with new scientific developments, and to continue to learn and validate what they are teaching. Scientists need science educators and science education to continue to recruit enthusiastic science students, as well as maintain and further gain public interest and support for their research endeavours (Eijkelhof, 2003).

Science can be exciting and has some very interesting, relevant topics that everyone can enjoy (Wellington, 2001). Topics including the universe, matter and living things are subjects that people are interested in (Millar & Osborne, 1998). The understanding of proper health, diet and lifestyle are important social concerns, and Millar and Osborne believe that teaching people these things gives them a feeling of empowerment and subsequently they are more apt to participate in public debate on these issues. They also note that teaching young people about

these things is important merely for the sake that it is so interesting and that it transmits the excitement that science is comprised of. Part of the excitement that science exudes also comes from the discoveries made by scientists and the creativity inherent in their work. The creativity and ingenuity of scientists such as Newton and Darwin capture the wonder of science and its intent to see established ideas in a different light (Osborne, 2003). Science education often attempts to make science 'fun' for students and uses activities, for instance, cool chemistry lab demonstrations, that 'hook' the students' interest in the science topic they are learning (Appelbaum & Clark, 2001). Appelbaum and Clark believe that a better way to generate science interest in students would be to have a classroom containing a wealth of different science possibilities and let the students interact with them and learn about science. They further state that their motivation in learning science would be intrinsic when they learn science experientially in a student-directed environment.

In a study done by Ornstein (2006) American students from grades six to twelve were surveyed on their attitudes towards science. Ornstein believed that the results of his study support the ideology of more hands-on science activities as well as student-directed inquiry. He stressed that the *frequency* of hands-on activities are not as important as their ability to provide successful and meaningful learning.

Scientific inquiry, in which students learn how to approach science like a scientist, is one way to teach students science (Hodson, 1999). Through scientific inquiry, Hodson suggests, students practice how to plan, conduct, analyse and report scientific investigations as they learn science. He further notes that by allowing students to create and start with an authentic science question, meaning one that the teacher does not have an answer for, students and teachers can work together towards answers. Students would have a vested interest in the study which would

typically reflect science in everyday life, which keeps science from becoming irrelevant to students (Hodson, 1999).

Robinson (1968) believed that science education should be an essential part of general education. The science curriculum must be revised to meet the needs of our younger generation or it is at risk of escalating to the point where it is irrelevant to their needs and those of society (Millar & Osborne, 1998) and result in a tension between not only school science and media portrayed science, but also the needs between future scientists and future citizens.

Change and its impact

In 1995, the Third International Mathematics and Science Study (TIMSS) showed Canada ranking above the international average (21 countries participating) in mathematics and science literacy for final year secondary school students (Mullis, Martin, Beaton, Gonzalez, Kelly & Smith, 1998). The TIMSS results for students grade 8 to the final year of secondary school placed Canadian students behind only three other countries (Sweden, Netherlands, and Iceland) in their understanding of math and science literacy (Robitaille, Taylor, Orpwood, & Donn, n.d.). The OECD PISA Study, done in 2000, showed Canadian students, age 15, ranking fifth in science out of 31 participating countries (Council of Ministers of Education, Canada, Statistics Canada, Human Resources Development Canada, n.d). While these results establish Canada in a relatively good position internationally, Hodson (2003) believes Canadian students are not developing and applying their scientific knowledge at the level that science education intended. He believes that they do not have the level of science understanding to enable them to use their scientific knowledge effectively and that they are not able to express the nature and methods of science. Canadian elementary students are learning more science education than ever before, yet this early start in science education still does not curb the loss in interest in

science for many secondary school students and they subsequently drop out of science (Hodson, 2003).

These shortfalls – lack of understanding of basic science concepts as well as societal science issues – are further exacerbated by the enormous amount of content that is squeezed into the science curriculum. The United States science and math curriculum is so full of content that as teachers try to cover all of the content, the students do not get the opportunity to learn many of the details within the content (West, 1996). This massive curriculum causes the science content to become fragmented and the concepts are subsequently taught separately and appear detached from the body of science (Millar & Osborne, 1998). DeBoer (2000) stated that science education needs to find a balance between science content and the other goals science education has. He further states that scientific literacy would be much easier to implement in the classroom if we removed the emphasis on students learning a particular body of content. Millar and Osborne (1998) believe that the curriculum reflects science education as value-free, objective and disconnected from society with many 'facts' to be memorized and learned, and little significance being placed on the future needs and interests of young people. Science education expects students to perform rote recalling of a large number of facts and concepts that have little social relevance to them (Fensham, 1985). Olson and Lang (2004) stated that science lessons often focus more on the technical terminology of science and less on the influences of science from a societal aspect.

Some efforts at science curriculum change were apparent over the last few decades – but their impacts were lacking. Aikenhead (2003) stated that over the last century, several efforts at changing science curriculum to incorporate a more societal perspective failed. By the late 1970s and early 1980s another effort was made to incorporate a new structure called STS (science-

technology-society) into science curriculum. This implementation occurred throughout many countries such as Canada, United States, Italy, Australia, and United Kingdom with some slight modifications with each country. In Canada, the Ontario science curriculum places emphasis on science literacy and STSE (Science, Technology, Society and the Environment), a new addition to the curriculum (Ontario Ministry of Education, 2000). This approach allows students to learn about science issues, such as environmental, and the impacts that science has in our society. The Ontario science curriculum's intent is to teach the students the basic science concepts, skills and strategies for use with scientific inquiry, and the relationship that science has with technology, society, and the environment (Ontario Ministry of Education, 2000). The incorporation of STS assessment will remain marginalized, however, unless educators and policymakers better address the needs of STS (Bartley & Orpwood, 2005). Bartley and Orpwood believe that to improve science literacy, STS instruction and assessment must be included in science education.

With these problems relating to science curriculum still evident, Osborne and Collins (2000) believe that more emphasis needs to be placed on imparting the relevance of science to students. The reasoning behind this view is that the curriculum still contains too strong a focus on the scientists' views and too little emphasis on the societal function that science performs – and the consequence of this is an ever widening gap between science and society. A better understanding of students and what they believe to be relevant and important about science might help science educators reduce this gap.

Students' perceptions of science education

Papanastasiou (2004) used data from the Third International Mathematics and Science Study (TIMSS) to better understand the relationship between attitudes towards science, self-

beliefs, and science achievement with senior high school students from Australia, Cyprus and the United States of America. It was found in all three countries, that when students had a high self-perception of their ability in science, they also had a positive view towards the importance of science.

In a study by Little (2001), past students were emailed and asked to reply to questions concerning their experiences in her class. These students had been in her grade 7 class anywhere from 1-9 years ago, and the oldest were now 20 years old. Many students remembered playing with ray boxes and mirrors, using Bunsen burners, and counting blades of grass in a field. Such active participation suggests a positive perception of science education. Students in Little's study also suggested that there should be less memorizing tasks and more hands-on-learning and more time spent on interpreting, analyzing and applying things based on their experiences. Opportunities to do projects and more interaction with other students and less sitting down doing textbook questions were also suggested (Little, 2001).

Osborne and Collins (2000) found that there is a growing interest by students to become more informed about the socioscientific topics and better understand the dilemmas, both ethical and moral, that develop from them. Students suggested that science education should incorporate scientific issues that were presently being focused on in the media (Osborne & Collins, 2000). When parents were asked for their opinions towards socioscientific topics, they also felt that science education should better address the socioscientific issues and scientific research that came from the media. They believed that the media was more apt to sensationalize the science information and that science education should be more critical, asking more appropriate questions and assessing the information in a more balanced perspective (Osborne & Collins, 2000).

The Relevance of Science Education (ROSE) project data from England, which is a part of the larger international ROSE project, was used by Jenkins and Nelson (2005) to determine students' attitudes towards science. Their research found that students believed science education did not improve their critical thinking skills, and did not generate interest in pursuing science careers, or an appreciation of nature. Students did, however, claim that science education taught them how to take better care of themselves and be more curious about things, and that science education would be helpful in their everyday lives.

Using the students' perceptions of their science education in the development of the science curriculum, may encourage the development of a science education in which there is a greater focus on student learning needs and interests.

Future directions for science education

Over the last century, many attempts have been made to address the issues that plague science education but those attempts have not improved science education's effectiveness for teaching students what is most important for them to know (American Association for the Advancement of Science, 2000). Science education needs to work towards generating curricula that encourages science understanding for everyone. "Science for all" encourages an education that includes everyone's needs and is considered valuable to all people (Osborne, Erduran & Simon, 2004). Science education for both future citizens and future scientists need to be addressed.

Analysis of the labour market points towards a need for a society that has a broad understanding of science for not only their work, but also for their participation in society (Millar & Osborne, 1998). Science issues concerning a sustainable environment, economy and society need to be addressed by citizens that are scientifically and technologically literate

(British Columbia Ministry of Education, 2001). Workforce predictions point toward an increase in demand for scientists and engineers, at a time where there will also be a decrease in supply (Science and Technology Division, 1991). Students need to be encouraged to study science in order to meets the future demands in the science and technology field. The long-term health of the Canadian economy will need a science education that develops student interest in science (Council of Ministers of Education, Canada, 1997; Science and Technology Division, 1991). There is a general understanding that the countries most likely to be successful will be ones that invest in developing economies that are scientifically driven and knowledge-based (Knox & Schmidt, 2006). Knox and Schmidt feel that Canada is doing very little to achieve this end.

Science needs to be taught in such a way that it portrays science knowledge as a social construction (Driver, Newton, & Osborne, 2000; Roth, 2007). Hogan (2000) believes that people who understand how scientific knowledge evolves and is generated can better evaluate scientific claims with a critical eye and not just accept them as truth.

Students should understand how scientific inquiry is conducted and learn to appreciate the strengths, weaknesses and limitations, when connected to certain situations or contexts, that are involved when making scientific claims (Driver, Newton, & Osborne, 2000; Millar & Osborne, 1998). When students understand and appreciate these things, they are better prepared citizens in society. Millar and Osborne (1998) recommend that the aim of science education should be to enable students to be comfortable and competent with issues pertaining to science and technology. They also believe that science education should allow students to become more adept with reading and understanding of scientific issues in newspaper articles and television programs. These students are the next generation of adult citizens and will need to make

decisions on socioscientific issues as they sift through information from the press and other media sources (Osborne, Erduran & Simon, 2004). Elshof (2005) believes that science education should provide opportunities for critical thinking skills to evolve with the processing of media information, as students learn to separate solid, credible scientific information from misleading and/or inaccurate claims that claim to be scientific and then apply them purposefully in their everyday lives as a scientifically literate citizen.

Scientific literacy has become a large focal point for science education (Connelly, Crocker & Kass, 1985; DeBoer, 2000; Hodson, 2003; Knox & Schmidt, 2006). Roth (2003) believes that scientific literacy is a learned phenomenon and gives an example whereby citizens question a scientist about his or her actions and the results those actions had. Roth feels that scientific literacy is practiced and better learned as scientists and ordinary citizens with many different backgrounds communicate together over science issues that hold relevance to everyone. When placed into the context of science curricula, Roth contends that there is a need to rethink how the curricula is designed and carried out. The role of science curriculum must be developed not from within the science domain, but, rather, from a more external societal view to better serve society's needs (Osborne, 2003; Roth, 2007). Millar and Osborne (1998) believe that trying to incorporate both scientific literacy as well as training for future scientists within the same science curriculum causes tension and may not be effective. They further state that educators have been too willing to accept that both of these ends can be met within the same curriculum.

The Council of Ministers of Education, Canada, (1997) describes a vision that all Canadian students should have the opportunity to develop scientific literacy. They further entail that students should have learning experiences that develop inquiry, problem-solving and

interest in science as well as understand the relationships of science and technology with their everyday lives.

Another aspect that needs to be addressed is the lack of contact between teachers and students with scientists. More interaction between them can help teachers better communicate the scientists' enthusiasm about the science field (Science and Technology Division, 1991). The report from the Science and Technology Division (1991) states that, in Canada, this strategy of communication with scientists could be implemented into teachers' colleges and programs so that teachers entering the field have the skills to incorporate the connection of scientists into the science education.

The Council of Ministers of Education, Canada, (1997, Section 3, p. 1) believes that the goals of science education should be the following:

- encourage students at all grade levels to develop a critical sense of wonder and curiosity about scientific and technological endeavours,
- enable students to use science and technology to acquire new knowledge and solve problems, so that they may improve the quality of their own lives and the lives of others,
- prepare students to critically address science-related societal, economic, ethical, and environmental issues,
- provide students with a foundation in science that creates opportunities for them to pursue progressively higher levels of study, prepares them for science-related occupations, and engages them in science-related hobbies appropriate to their interests and abilities, and;

- develop in students of varying aptitudes and interests, a knowledge of the wide variety of careers related to science, technology, and the environment.

An effective science education should contain the following elements: all students should study science (specifically biology, chemistry, earth science and physics); investigation and inquiry should be emphasized (with labs and experimentation playing an important role); the application of science with everyday life should be examined; relationships between science, technology and society should be examined; and learning science should be seen as a lifelong learning pursuit (Keeves & Aikenhead, 1995).

In Canada, the Ontario science curriculum has implemented the STSE (Science, Technology, Society and the Environment) framework (Ontario Ministry of Education, 2000), to ensure that students are learning the connections between science and their everyday lives. Through resources such as national and regional organizations, libraries, scientific and research societies, universities and colleges and media, science awareness and science literacy initiatives are being offered to students of all ages as well as to the general public (Knox & Schmidt, 2006). Knox and Schmidt believe that this is certainly taking the right direction in science literacy, but are not sure if it will be enough to reach to goal of a scientifically literate public.

Summary

This chapter has provided an overview of current research pertaining to student perceptions of their science education as well as the historical intentions and its subsequent changes of science curriculum over the last few decades. It also addressed the emergence of scientific literacy, science curriculum changes and their impact, students' perceptions of science education, and the future directions in science education.

CHAPTER THREE

Research Design and Methodology

Introduction

In this chapter I describe the design and the methodology for this qualitative research study. Also included are the research questions, definition of terms, ethical considerations, criteria for selecting participants, qualitative design, data collection procedures, and data analysis.

Statement of the Problem

The purpose of my research was to gain an understanding of the student perceptions of science education and the influences they believe it had on their further science education as well as everyday lives.

The Research Questions

1. How did the science education during secondary school and Pre-Health Sciences prepare the students, now enrolled in a Health Science Program, as citizens in society?

   From this question, a supplementary question can be asked. How do the students perceive their secondary science and Pre-Health Sciences course as relating to scientific literacy?

2. How did the science education during secondary school and Pre-Health Sciences prepare them for their Health Science Programs?

From this question, a supplementary question can be asked. How do the students perceive their secondary science and Pre-Health Sciences course as relating to their career choice in the Health Sciences program?

3. What aspects of their science education do these students perceive were the most beneficial for them in terms of scientific literacy and as health workers?
   From this question, a supplementary question can be asked. Why do they hold these perceptions?
4. What aspects of their science education do these students believe were the least beneficial for them in terms of scientific literacy and as health workers?
   From this question, a supplementary question can be asked. Why do they hold these perceptions?
5. What do they perceive needs to be incorporated into, or removed from, the science curricula that would benefit them in terms of scientific literacy and as health workers?
   From this question, a supplementary question can be asked. Why do they hold these perceptions?

Definition of Terms

Science literacy

The definition of science literacy has been difficult to establish, and it has slight differences depending on who is using the term. Knox and Schmidt (2006, p. 74) define science literacy as pertaining to the basic knowledge, skills and process of science, problem solving and that it "enables us to understand and advance the links between science, technology, innovation, the economy and our society." Science literacy has held a general description of understanding

basic concepts of science and the nature of science, as well as the interaction of science with society (Hodson, 2003). The Program for International Student Assessment (PISA, 2003, p. 1) describes 'scientific literacy' as "the use of key scientific concepts in order to understand and help make decisions about the natural world. It also involves being able to recognize scientific questions, use evidence, draw scientific conclusions and communicate these conclusions."

Adult student

For the purpose of this study, adult student will be defined as a student that is the age of 21 or older.

Pre-Health Sciences Program

The Pre-Health Sciences Program is a one year program found in many Ontario colleges. Its curriculum is an Ontario science curriculum equivalent and provides students with the prerequisites necessary to gain entry into many Health Sciences Programs such as Nursing, Paramedic, Dental Hygiene and Assisting, Medical Radiation Technology. Students that do not have their high school science courses, or have grades too low in them, use Pre-Health as an alternative to going back to the high school curriculum.

Procedures

Research Design

The following section outlines the structure of the research design for my study. The selection of the design will be explained in detail and the section also provides an overview of the methods, instrument, participants, setting, and time frame.

Methods

A qualitative methodology, case study approach, was selected for this study. McMillan (2004) states that a case study is often identified as a qualitative methodology due to its nature of studying an experience or entity in-depth during a particular time and place. For this study, it was the experiences of the students being studied in-depth. The Pre-Health Science Program was the particular place and the time frame being studied was the participant's secondary school and college science education. Creswell (2003) states that ethnographies are qualitative examinations of an intact culture within a group over a period of time, about which researchers look at the lived experiences of those in that culture. The methodology of this study can be considered ethnographic because this group of participants came from a particular intact culture formed within the Pre-Health Sciences Program. This study is also considered a narrative inquiry and the participants provided narrative descriptions of their perception of a particular event that they were engaged in (Polkinghorne, 1995).

The data collection methods included semistructured, digital recorded interviews, policy documents, field notes, substantive notes, and analytical notes. Themes were then identified within the data and an analysis of it was performed.

Instrument

The instrument that I used was an interview guide. The use of semistructured interviews provided questions that were specific in intent yet open-ended enough to allow further probing and clarification (McMillan, 2004). An interview guide was developed and participants were interviewed by using this guide, to obtain the data. Creswell (2003) describes semistructured questions as open-ended questions, designed by the researcher, with intent to obtain data to answer their prior questions that arose in the beginning stages of the study. The interview

questions for this study were semistructured and designed with the intent to draw upon particular areas of interest based on the focus of the study as well as the literature reviewed. The intent of the questions was to draw responses that dealt with science education's influence on the participants' further education as well as their everyday lives. Focal points were science curriculum, participants' learning experiences with science, the transition into further health science programs, and the influence that science education had on the participants' everyday lives. A copy of the interview guide can be found in Appendix E.

Participants

Purposeful sampling was used to obtain data for this study. McMillan (2004) described purposeful sampling as a method where the researcher selects specific participants based on their ability to provide in-depth, detailed information due to their close connection with the topic. The participants in this study were purposefully chosen based on pre-determined criteria. The criteria were that participants that had successfully completed their science courses in the Pre-Health Science Program and were presently enrolled in, or recently graduated from, one of the Health Science Programs at the college. This ensured their close connection to the topic being studied and their ability to provide information-rich details of their experiences about this topic.

The number of participants selected was limited to six. There are six different Health Science Programs currently being offered at this local college and selecting one student from each of these programs provided a broad perspective pertaining to the Health Science Programs. Patton (2002, p. 246) believes that when choosing sample sizes in a qualitative setting, the minimum sample number must allow for "reasonable coverage of the phenomenon given the purpose of the study and stakeholder interests." Due to time constraints, costs, and participant

availability, having six participants provided opportunity for information-rich data and was also a reasonable sample size to successfully meet time constraints, costs, and participant availability.

Setting

The study took place at an urban college in Ontario, Canada. The participants were students enrolled in, or recently graduated from Health Science Programs. These students had all graduated from the Pre-Health Science Program.

Time Frame

The time frame for conducting this research was as follows. My research proposal was submitted to the Research Ethics Board at Lakehead University in June, 2007.

My proposal was approved by the Research Ethics Board at Lakehead University in July, 2007. I then submitted a request to the college that I had selected for the study, for permission to interview students that had, or still were, enrolled there. I received approval from the college later in July. I then obtained written consent from the participants before conducting the interviews.

I began my data collection by interviewing the six participants at the end of July, 2007. After transcribing the interviews, I sent a copy of the transcript to the participants that I interviewed for them to edit. None of the participants elected to make editing changes. The data collection and data analysis process took approximately five months to complete.

Data analysis was ongoing throughout the data collection phase. Data analysis of transcripts began after I received confirmation from the participants that the transcripts represented their intentioned responses. When data analysis was completed, I began writing my findings.

Research Process

Data Collection Procedures

Once Lakehead University's Research Ethics Board contacted me and stated they were satisfied that I would carry out the research in an ethical manner and the college had given permission for me to study students who have attended there, the recruitment and interviewing process began.

Participants were given a consent form, outlining the research study and the rights of the participant. Data collection commenced after the participants had signed the consent form.

During the data collection process, participants were made aware of their rights on the following aspects. Participants would remain anonymous through the use of pseudonyms, could withdraw at any time, ask questions at any time and would also receive a copy of the results. Participants were made aware of the purpose of the study so that they better understand the direction of the research and any impacts on them (Creswell, 2003).

The interviews were conducted by the researcher through the use of a digital recorder, and their timeframe lasted anywhere from approximately forty minutes to one hour.

After the interviews were transcribed, they were sent back to the participants to provide opportunity for them to edit any part of the interview.

Ethical Considerations

Before conducting my research, approval of the research study was given by Lakehead University's Research Ethics Board and the college that I had selected. All data from the interviews and field notes were kept in a secure location. Upon completion of the thesis, the data will be securely stored for 7 years at Lakehead University (Lakehead University, 2005).

Data Analysis & Interpretation

Data Analysis

McMillan (2002, p. 259) describes data analysis as a "ground up" approach to generate theories. McMillan further states that this is important in qualitative research because the researcher can remain open to any findings and possible patterns that the data contain. Using the literature as a guide, I used the "ground up" approach with my data. Polkinghorne (1995, p. 13) describes paradigmatic analysis of data as the "examination of the data to identify particulars as instances of general notions or concepts," and I began the analysis with this method.

Coding and Themes

I read through all the interviews to become better acquainted with all of the data and then started to break the data into meaningful phrases that relayed a particular point. These phrases were then be grouped into categories and those categories were given a descriptive term to properly identify them (Creswell, 2003). Creswell calls this process *coding* and through the clustering of similar data, these categories begin to emerge. The categories are considered *themes* and they articulate what has emerged from the content analysis (Patton, 2002; Polkinghorne, 1995).

Triangulation

Triangulation strengthens the credibility of a study by combining methods or data, or using different samples (McMillan, 2004; Patton, 2002). This research study used students from six different Health Science Programs. Patton would consider it as data triangulation because it was using a variety of sources for data. Another part of triangulation is the inclusion of a second method, such as a second interview (Lincoln & Guba, 1985). This study provided the participants the opportunity to review their transcribed interview and they were encouraged to

add any information that they felt was important but did not include during the interview. Through this step, triangulation can be accomplished by using the review of the transcript much like a second interview. Though the participants did not elect to make any changes to the transcripts, the opportunity was given to them.

Interpretation

After coding was completed and the themes had emerged, the interpretation of these results commenced. Interpretation's intent is to find significance in the data, make sense of it, and provide meaning to it (Patton, 2002). McMillan (2002) views interpretation as a time to answer questions such as: Why are the results this way? What do these results mean? What may have impacted them? What limitations have been noticed? How do these results relate to other research findings?

I then tried to "make sense" of the data and provided an interpretation that answers the questions McMillan (2002) viewed as interpretation.

Summary

In this chapter I have described the design and the methodology for this qualitative research study. Included were all the aspects of the research study's process which provided the framework for conducting the research. The study used a qualitative, ethnographic approach that was narrative in style. The interviews were done using an interview guide containing open-ended questions and for further credibility, the transcribed interviews were returned to the participants for clarification of their data. The data was then analyzed and themes were generated that reflected the participants' perceptions.

CHAPTER FOUR

Prologue of Participants

Participant Profiles

All six participants were graduates from the Pre-Health Sciences Program at the college where I teach. They each had entered a different health science program after Pre-Health Science. The programs consisted of Paramedics, Dental Hygiene, Dental Assisting, Practical Nursing, Registered Nursing, and Medical Radiation Technology. Each participant was given a pseudonym in respect to ethical considerations, keeping their identities anonymous and responses confidential.

Jayce chose Paramedics as his career and is 22 years old. He grew up in a small northern Ontario town and enjoys nature and outdoor activities. His interest in health has influenced his everyday life and he enjoys keeping in good physical condition through working out and choosing a healthy diet. Jayce has completed the Paramedic Program and presently works as a paramedic.

Carrie chose Dental Hygiene as her career and is in the process of completing her education. She is 23 years old, and at the moment she is a full-time student in Dental Hygiene. She will be graduating from this program in the spring of 2008 and is considering on taking the Nursing Program due to the low numbers of dental hygienist jobs in her town. She enjoys learning and expressed an interest in continuing her education in the health field.

Sharon chose Dental Assisting as her career and is presently working in that field. She is 25 years old and is quite happy to have established a job in her home town. She does not have

any interest in pursuing more education at this point in her life and is happy to spend her spare time enjoying friends and family instead of studying.

Emma chose Practical Nursing as her career and is in the process of completing her education. She is 32 years old, has been employed full-time but at the moment she is a full-time student finishing her nursing program in the spring of 2008. Family is very important to her and she enjoys spending time with them. She looks forward to her completion of education and hopes to obtain a job in nursing soon thereafter.

Connor chose to pursue an education in Registered Nursing. He grew up in a small northwestern Ontario town and worked in the forestry industry for many years. He is 37 years old and is presently working towards completion of his nursing education. Connor places personal health high on his priority list and enjoys working out often to stay in shape and maintaining a healthy diet. He looks forward to entering the nursing field and working in a hospital's emergency department.

Gary chose Medical Radiation Technology as his career choice. He has had numerous jobs over the years, including labourer jobs within the railroad and lumber industries. He is 45 years old and is presently working towards completion of his education. He finds the Medical Radiation Technology Program very interesting and is very glad that he chose to enter this field.

Findings

Introduction

This chapter details the themes and findings that emerged through the data analysis. It provides the reader with the participants' thoughts as well as an analysis of the findings.

Ten main themes emerged and are as follows: (a) negative high school science experiences; (b) negative college science experiences; (c) college needs; (d) positive high school science experiences; (e) positive college science experiences; (f) education in health science; (g) applicability in society; (h) lifelong learning; (i) science awareness and; (j) science education for everyone. The following sections describe the findings for each of these themes.

Description of findings

Negative high school science experiences

All participants except one were able to recall their high school years. Gary could not remember much about his high school years so this aspect could not include his views. When Gary was asked about his high school experiences his first reply was, "Well…," and when I probed further and asked if he remembered any high school experiences again, he said, "Not really." Quite possibly it had been just too long ago for him to remember. Those who did respond had indicated a sense of disconnection to science classes. Sometimes it was articulated as internal shortfalls, such as lack of interest or drive, as well as immaturity and laziness, and other times it was related to technical and content issues.

Three participants felt disconnected because of personal lack of interest. Connor recalls his high school years and explained:

> You know what? To be quite honest with you, I was just too, really immature to care. If you told me to cut there, I cut there. To be quite honest, I didn't want to be there. I had no interest in learning science. I had no drive or desire to just learn. I just thought I'd never use it, as though it's not needed. I needed to develop a slap shot.

Jayce felt that he did not show good work habits in school and stated:

> Yeah, I didn't apply myself and basically I did so poorly because none of my assignments were on time. I did... like, I passed all my tests and my exams, but they were only worth about 70% of your grade, so I was losing all of that other 30%. Like having a mid-term... I was lazy.

Emma recognized her lack of interest in high school and explained:

> I kind of just missed it all (laughs). I think because it didn't interest me. Again, I think it had a lot to do with people that teach you, your teachers, your surroundings. When you're young, you're really not getting it or wanting to get it – taking the time.

She further notes how her attitude changed as she attended college.

> I find that because I'm a little bit older than other people in college, some of my classmates, that I find myself just putting more time into it to learn. Like, I might not be as smart as the girl next to me. I put more time and effort into getting it so that I can be the best I can at the career I've chosen. So I think now I absorbed more. I didn't miss anything. I got involved, whereas in high school, I didn't.

Connor, Jayce and Emma attributed their lack of personal interest to immaturity, laziness, and not taking the time.

Carrie and Sharon expressed frustration with the technical end of learning science. Carrie summed up her high school science experience by exclaiming:

> I hated it! I hated science. Um, I passed everything with 50s, I barely made it, but I did what I had to do to get my prerequisites for high school (laugh) to be able to graduate. You had to have all your stuff and I know that science was grade 9 and

> grade 10 you have to and then after that I never thought about it. I never wanted to go on.

She was able to articulate more detailed issues with her frustration with learning science by adding, "It was just, I don't know I just found it really hard, I don't know, it just wasn't my thing. I didn't like doing labs, and dissecting."

Sharon sounded overwhelmed as she described her frustration with the technical aspect of learning science:

> But it... I don't know... well parts of it seemed... I don't know how to say this... I didn't like the technical side of it... the, like there were some things that just made sense and that was that but then there were some parts that didn't... I don't know.

Negative college science experiences

The participants did not project a lack of interest due to laziness or immaturity during their college education. They did show disconnection to learning science at college by expressing frustration with the science content and lack of applicability towards their future health science career.

Some participants expressed their frustration with being disconnected with leaning the science content when the content was taught too fast, learning became boring, and when the topics did not see to apply to them personally. Sharon felt a sense of disconnection to the science content and explained her experience with it, "...not necessarily learning it but your just kind of learning it for the minute... to get through it, you know and that's never fun (laugh)." Gary expressed his learning as simply memorizing and stated, "Just read it and have it memorized for the test." He also recognized the length of time that he would remember what he

memorized and summed it up by saying, "Have it memorized and refresh for the test, but in a few weeks down the road again, I won't (remember)." Carrie's disconnection was the repetitive nature and commented, "Oh, I hated drawing the cells! (laugh) Cause I found it really repetitive and, like, boring. Really boring." Sharon did not feel the teacher engaged the students very well during class and explained:

> Ya... and she would basically bring in overheads and read overheads and we're looking at our textbook - and there it is... you know we really didn't need to go to class... and even with like the testing and that kind of thing... it was pretty much the same, like she really didn't engage us a whole lot she just basically read to us and that was that and then just kind of said you have a test coming up... study for it (laugh) like it wasn't very um, like…

Connor felt disconnected with the science content because it did not always teach him health related science topics that he would use in health science education later on.

> Well, the bio at the Pre-Health didn't appeal to me very much, because, again, it was another blanket – it really didn't target in on....because I'm taking the nursing program, I'm more concerned with the human anatomy, whereas the study of trees didn't appeal to me too, too much. Conifers really aren't my thing (laughs).

College needs

All of the participants except one described the need for labs at the college. The college does not have the capacity to do labs in a laboratory setting at this time, so subsequently the types of labs are restricted and the frequency of labs are reduced. This will be rectified within a

year as the college moves towards funding this area and supplying the funds to develop and implement labs for the Pre-Health Science Program. One participant also suggested outings as something that would be beneficial.

Emma felt she would have learned chemistry better with labs and articulated this by saying:

> I think in college, I think labs would have made me – especially in chemistry. I would have grasped more of chemistry if we would have had more labs, to be more hands on. I found that reading and drawing pictures on the board didn't make me see it. I need to be involved.

Gary expressed the importance of having labs and stated, "Okay, I think labs too because they're important. Like I said, you can read about it and read about it. Until you see it done, it's not the same." Sharon also suggested labs and stated, "I would say labs, like, definitely for Pre-Health." Jayce described more of a general need for participating during class and said, "Only that there wasn't as much hands-on. Just adding more hands-on is a big one." Carrie used the word 'project' but described her desire for labs and stated, "I would've liked to do a real cool chemistry project, like beakers and stuff. That would've been neat, but because of circumstances at school, it's not called for."

Gary suggested outings as a way to keep people interested and learn science through different methods. He explained:

> Some kind of outing or something – just something to take us out of the classroom and show us something cool that we haven't seen or don't really know about. You know, just to keep people interested in the class. Like I said, you can't always sit and watch PowerPoint or whatever.

Positive high school science experiences

Three participants expressed their interest in high school science class when they were participating in labs.

Jayce recalled a favourite high school teacher and the interesting hands on learning he experienced in science class during that time.

> Probably I think the coolest was my OAC biology. I had some guy who had two Ph.D's in biology and he was teaching high school because he'd get the summers off and he didn't really want to work too much anymore. So he had a lot of connections to the University of Toronto, so he got a lot of parts from the neurology section. He got, like, pigs feet and stuff like that, so there was a lot of hands-on stuff.

Sharon enjoyed the biology labs and remembered what she dissected as well as what was brought in for display.

> Um, probably like, the labs, I know in high school, I remember in grade ten we got to dissect frogs... and I'll never forget that that was totally cool. A girl in my class, we all kind of got, she lived on a farm and she brought in a cow's heart and we all to doing that. That I won't forget. That was interesting.

Dissecting was Emma's favourite part of biology class and she elaborated by saying:

> In high school I remember a biology class where we used to dissect different things, you know – frogs and pigs. That was always my favourite, so I loved getting in there and seeing how things worked in the body.

Positive college science experiences

The participants expressed a connection to their science learning in college in different ways. They expressed their readiness for learning, appreciation for participation, and appreciation for effective teaching.

Connor wanted to learn about science and stated, "You know, what I think I really enjoyed was just the fact that I was learning it, I wanted to learn it, it was just there, and kind of sticking with me. Carrie recognized she needed to learn science for her future health science education and expressed this understanding:

> I enjoyed it all. There was nothing really that I didn't like. No. Cause I was there because I had to be there, because I was going, this was what I had to do to get into the profession. I wanted to do. I needed, I had to be there. Like, like period! (laugh)

Carrie and Emma both appreciated the learning experience with debates. Carrie stated:

> Getting involved like, doing class stuff, like I remember doing debates and stuff too, it wasn't just specific out of the textbook stuff learning. It was more involved, like, you made it fun for the students. Like, it's not like you're just standing there lecturing us, we actually got to be involved in stuff. Stuff like that. Ya.

Emma liked the different learning that was experienced with debating and stated, "I love debates. I love to talk and debate my ideas with other people, and throw them off of each other and grow from that." She further explained that it happened more often in college and remarked, "More in college (debating). I think we would… biology was a big thing, because a lot of people had different beliefs."

Emma was also pleased with the quality of the teachers at the college and explained:

> A lot of it has to do with the teachers too, because you need a teacher to be interested in something. So I found at the College that both chemistry, anatomy – biology teachers kept me focused and interested in what was being taught. So I found that I retained more. I've had other teachers that were just, you know, blah, blah, blah.

Gary appreciated his teacher's demos in class for not only creating interest but also helping him understand concepts.

> Yeah, (my teacher) brought in a couple of things once in awhile. Like a kid's railway track – probably something he made for his kid about motion and stuff like that. They're interesting and for me, it's easier for me to learn if I see it.

Education in health science

All of the participants recognized the value of learning science before entering the Health Science Programs.

Sharon reminisced on her high school decisions and the subsequent consequences of them.

> ...but when I was in grade eleven I took chemistry and I took almost until the end of the semester and then I decided I don't need to take this so then I dropped out of the class. My chemistry teacher looked at me and said "you're going to regret this someday." Here I was how many years later in your chemistry class learning it all over again. But, ya, I didn't think, like they say, "you need to know this,' when you go get into hygiene or get into any of those classes, and I still thought,

> nah, and then I got into dental materials and that's all mixing different things. You absolutely have to know why things react the way they do and how to you know just to add the right amount. Absolutely. That's important.

Gary entered the Medical Radiation Technology program after Pre-Health and recognized the importance of understanding chemistry. He stated:

> Chemistry… organic, yeah. It does pop up once in awhile, so it's kind of good to have that knowledge. That, and the physics too. It was really tough for me. I don't use too much of that really. The other one I use all the time, so I'm getting used to it now.

Sharon completed the Dental Assisting program and also saw the importance of chemistry during her education and now in her career. She explained:

> Well, it helps, lots, just by, well, even when you try to figure out, like, mixing things, say, like with chemistry you learn how to mix things together to get a certain product. Well I can look at even with working, like in a dental office, certain things we have to mix together, bases and catalysts.

Chemistry for Jayce was essential for his learning during the Paramedic program. He described learning chemistry:

> It (chemistry) is really good, because you learn the chemicals – like putting molecules and stuff together, and then it's great when you learn your pharmacology because then you learn how drugs – their structure. Then you learn how they break down.

Jayce also expressed the importance of a biology background for the paramedic field and articulated clearly the essence of a person going into shock and how cells are related.

> Definitely the cellular section of biology because you learn about – like you hear about shock all the time and you learn how shock, like it happens at the cellular level and you really have to understand how to reverse that. And then you learn that when someone does go into shock, you learn the stages of shock and you see the destruction of the cells and you realize how fragile the body is; and you can only take that type of stress for so long and you understand why it gives out.

Connor believed the chemistry prepared him well for the nursing program he entered at university, but was displeased with the general topics of biology that didn't relate to health science. He explained:

> The chemistry totally prepared me for university. It was very general (biology) – yeah. Very general, where I would have preferred to have the focus on anatomy and physiology at the college level.

Connor was in the stream of students that took a higher level of chemistry in Pre-Health so that they would be accepted into university. That meant he did not have room for an elective such as anatomy, and had learned only the topics taught for an Ontario grade 12 university level biology which does not have a wealth of health science content.

Unlike Connor, Emma was able to fit in an elective anatomy class and expressed her appreciation for learning it, as well as how chemistry related to it. Emma also wanted to pursue nursing, but at the college level that didn't require the higher level chemistry.

> Okay, for me, going into the Practical Nursing Program, I had to know a lot about… I guess the most important thing would be the chemistry class and my anatomy classes were really beneficial, to understand how chemicals and different things affect the human body, how they work.

Emma was also pleased with learning terminology that she would use in further health science education. She explained:

> I think it's helped me in my direction, career-wise. It's helped me get a terminology that I've never used before and let me kind of feel a little bit higher on the spectrum than I felt two years ago.

Carrie recognized how chemistry and anatomy would benefit her learning within the Dental Hygiene program and explained:

> I need to have a chemistry and biology background. I think the anatomy and the cells, Periodic table because it's all under drugs and this and that – pharmacology and all that stuff, to me it's all intertwined and it all made sense, because it's all intertwined and everything else.

Applicability in society

All participants except one expressed a more active role in society concerning science related issues. The environment and the issues that surround it were mentioned by many of the participants.

Sharon expressed the need to find a balance in using our planet.

> Well, I think, one way I think of it is like, with the environment. If we continue to put things, like, into the atmosphere, air, for instance water, we're going to have to constantly be figuring out how to balance it, like the earth, and putting that stuff in, but making it last, you know what I mean, if that makes sense.

Emma and Gary talked about recycling needs and their participation with it. Emma stated:

> I think global warming, I believe, has made me now change everything completely from previously. I never used to recycle. I never used to. Now, with everything glass, plastic, paper. So I believe global warming and the world – I think we have to take care of it. So I think that's the thing I'm most concerned about now with science.

Gary felt that Pre-Health helped influence some of his environmentally friendly habits and explained:

> Sometimes I'm cautious in how I do things and more aware of what I do leaves an imprint somewhere. Actually, after doing this (Pre-Health), I recycle more – just things like that. And energy – I try not to waste too much energy. It's just made me more conscientious about the environment and my surroundings. I try to take care of things a little bit more.

Connor expressed his concerns with personal health and the chemicals that are accessible and potentially harmful.

> I want to get into nursing, possibly physiotherapy later on, so understanding pathophysiology – like the reason why things happen to the body and what happens is obviously important in my every day life, like not mixing two cleaners together. You know? You're cleaning the oven and… (laughs). I mean, you have pesticides and you have something – the chemicals that are out there.

Jayce's interest in nature and outdoor activities prompted him to act on his frustration when he read an article that lacked scientific research to support claims.

> I wrote to a newspaper once when they said – basically it's some guy that's been working at the newspaper for like 20 years or whatever, so he gets his weekly

> column. Anyway, he wrote something about the moose with the brain worm. He basically wrote this one page article about it's just a big myth. So that was the only time I actually wrote into the editor and just vented. I mean, you can find so much research to support and there's a reason.

Lifelong learning

Participants expressed their lifelong learning with science as well as the participation with others that evolved from it.

Gary found himself reading science as a personal interest and challenged himself to learn new things.

> And then, actually a lot of pathology I've been reading up on, drugs and stuff like that. If I see anything interesting mechanically or something like that if there's something new that they're trying to figure out and I don't know what they're talking about, I think, "No, you can keep that". Or, you know, follow it up.

His time spent learning science in Pre-Health gave him confidence in learning and trying new things.

> Now I feel like I'm more literate in science, where before I had an understanding of it. Now it's like, "Okay, I know how things work". You don't have to be a rocket scientist. It's something – when you know a little bit, it's not as scary. You know you can do it basically, so why not try it?

Television science programs were mentioned by many participants as a favourite pastime. Carrie enjoyed watching Discovery Channel with her boyfriend and stated, "I love the Discovery Channel. Like he's (boyfriend) really into them. Well, he's doing a Bachelor of

Science too, eh?" She did not watch it before Pre-Health and learning more about science. She added, "Like before it was, 'Turn it off. That's boring'. That was me before. And now I get interested when we watch it." She also enjoyed the conversations that evolved from watching the programs.

> Oh, yeah. When I'm with him, we'll talk about it the next day. Because it has to do with, everything else around you. But I never realized it or I never, I guess, got involved in a conversation. But I can now. I feel like I'm a part of everything, because I know what going on!

Emma also enjoyed Discovery Channel and explained:

> Discovery – that's my favourite channel. I watch that almost every day. So I guess I would watch Discovery. I like to watch medical journals – things that would come on. Anything to do with medical and science, I'm usually watching it.

Sharon watched educational programs along with Discovery as she described, "Absolutely, I watch the Discovery Channel and shows like, lots of education programs, absolutely." Connor liked the science within the CSI show and explained:

> A couple of my favourites – not even the news – it's more fictional. I mean, one of my favourite TV programs is the CSI, like "Las Vegas". Grissom – genius. Okay? And when I hear them talking about certain things and, of course, it's science based and science related, and I understand what they're talking about, then I want to listen and see what else he has to say and what I know about.

Jayce also enjoyed watching Discovery Channel as well as the news channels as he explained:

> Oh, that's... actually lately I've been just watching the news a lot more and I always keep it on CNN or CTV. I watched a cool thing on lightening about mega-lightening, and they didn't know about it until just a few years ago. Well, it's still a lot of electricity, but now this mega lightening that they found, so a lot of electricity up there. So that's kind of neat. And I like watching the Discovery Channel and things like that.

The newspaper was spoken about as well. Jayce explained his interest:

> For a newspaper, it's always cool when you're flipping through and you see how science has unlocked the key to a specific genome, and you understand and stuff. I was always interested in that.

Emma also expressed her interest with science in the newspaper and explained:

> Actually, just the other day on the front of the newspaper about that thing in the water. Did you read that? It's this snake thing that they found in the Great Lakes and it's become a problem and scientists are trying to – it's like a snake thing.

The science learning for Emma had been shared with her family on occasion and she explained how adamant she was with sharing her science understanding.

> Well, for example, today we were sitting here with family and they were talking about their – I can't remember exactly what it was – they were talking about...something about science anyway. It had to do with cancer research or something, and they were wrong. And I knew it, but I didn't want to start hollering at them, so I just kind of sat down and I got out my books, and I just showed them – because I've done projects and I've done, you know – on science and health science. And I think it's helped me educate others, the different aspects of science.

Sharon expressed her lifelong learning in science and described it as such:

> I think science, allows that we continue to learn about our surroundings and why things are the way they are, cause, if we knew, then, what else would there be? I don't know, like it's a learning thing, like, constantly – about the environment, about anything. There's just stuff constantly for us to figure out.

Science awareness

Carrie, Connor and Emma articulated their awareness of science in their surroundings. Carrie stated, "I'm more aware of everything that's going on in the world, because I'm more aware of this and I'm more aware of that. I feel more intellectual, but I know when I'm actually watching a science-related movie that I understand what's going on."

Connor recognized his science understanding had changed as he learned more science and described his thoughts on it.

> I can wake up in the morning and kind of look around, and you see science in everything. You see a plant growing. You see a tree or a plant wilting, and you know it's going to need water, and you go, "Oh yeah, this is starting to shrink". You know? And it's funny, because I sound like a geek when I talk like that and I'm thinking, and I'm going, "Gees, don't tell anybody or they're going to think you're nuts!"

Emma spoke about her garden and the life within it that she interacted with as she worked in the garden.

> Yeah, definitely, when I'm outside in the garden. Different wildlife, different insects. Different things crawling on me and biting me. The soil. The things I

> find. Sometimes I find things I dig up that are old things, like nails, that might be from the old days. Every day, science is everywhere. It's true.

Science education for everyone

Four participants expressed the importance of everyone having an education in science. Gary felt everyone should have the basic understanding of science and explained:

> Yes, I think they should have a little bit of science background, like even like... actually biology, because it touches on chemistry too and it's not so much the physics parts, but the biology touches on a little chemistry and actually it starts from the beginning. That would be a good thing for everybody to take is a little bit of biology just so they have a better understanding. That's like the chemistry... it's really interesting and everything, but you're not really going to split atoms or anything.

Emma shared her belief that everyone should learn science so that they could take better care of themselves as well as their environment.

> Definitely. It's very important that everyone... and I think that science is the biggest part of everyone's life and I think people should be more aware of our surroundings and what can happen and how it happens and why it happens. And I believe that if they knew and were more aware of science, you know, they would be more open to the ideas of maybe eating healthier and taking care of themselves, and taking care of the environment, and being more conscious of their surroundings.

Having a more science-educated society was also important for Carrie and she explained:

> So the world is more knowledge of what's going on, for anything. Like, for example, pollution. People don't realize what it's doing to the earth, but they keep doing it anyway. And just stuff along the same lines as that. Yes, so I think everybody should be educated in science. Definitely.

Sharon also agreed with everyone having a basic education in science as well as a few particular topics.

> I think, like, the basics, like, with biology like I said before, like the theory of life and evolution, and like how we got here and in chemistry just like your basic elements and what a proton, neutron and electron are. You don't have to go very in depth with it but everyone should kind of have an idea what it is.

She further articulates the importance for learning about cells, "You shouldn't have to name every single part of it but you should know that plants and animals have different cells."

Emma felt everyone should learn science and gain the ability to make educated decisions. She explained:

> Well, I don't think you have to be in a science field career or health career to know that science is important. If they learn something today, maybe they'll go home and they won't do that or they'll start doing something better – and that's a start.

Summary

The findings from this research study have indicated that the participants had shared similar perceptions of their science education experiences. The ten themes that were revealed through the analysis of the data were: (a) negative high school science experiences; (b) negative college science experiences; (c) college needs; (d) positive high school science experiences; (e)

positive college science experiences; (f) education in health science; (g) applicability in society; (h) lifelong learning; (i) science awareness and; (j) science education for everyone. These themes are consistent with some of the issues reported in the science education literature.

CHAPTER FIVE

... but when I was in grade eleven I took chemistry and I took almost until the end of the semester and then I decided I don't need to take this so then I dropped out of the class. My chemistry teacher looked at me and said "you're going to regret this someday." Here I was how many years later in your chemistry class learning it all over again. (Sharon)

Discussion

Introduction

This chapter will discuss the findings in relation to the research questions. The implications for theory, practice and research will also be addressed in regards to the study's findings. The end of the chapter will include a conclusion based on my personal experiences during this research study.

Discussion of Findings

In working through this research, there is an overwhelming sense of the need to develop science curriculum that provides a meaningful education for all students, whether they intend to enter the science field or use it within their everyday lives. A better understanding of how the participants perceive their science education can provide information on how the science education has influenced them.

In the following section, the discussion will be organized by the themes discussed in chapter four.

Negative high school science experiences

The findings indicated a sense of disconnection to science classes for high school students. Participants expressed disinterest to the science content as well as problems understanding the content.

The participants of the study described their disinterest as the product of their being lazy, immature, and bored with their science education. Generating student interest in learning science is important. Policymakers argue that Canada's economy will need a science education that develops student interest in science (Council of Ministers of Education, Canada, 1997; Science and Technology Division, 1991). This is not happening according to Hodson (2003) who has stated that student interest in science is not being met and that students are dropping out of science. One participant in my study, Sharon, mentioned that she had dropped out of a chemistry course in high school because she felt she didn't need to complete it. Connor stated that he had no interest in learning science and felt that he did not need science and would never use it. Millar and Osborne (1998) believed that revisions to the science curriculum should be made or else it would be at risk of becoming irrelevant to the younger generation. Research done in England through the ROSE project found that students believed that science education did not improve their interest to pursue science careers (Jenkins & Nelson, 2005).

Aside from the disinterest that participants felt, some participants also felt that the science content was too hard and technical to grasp. Carrie mentioned that she found learning science too hard and further expressed that she hated science. Hodson (2003) noted that students have difficulties using scientific knowledge effectively and get confused about the nature and methods of science.

Negative college science experiences

There was a disconnection to learning science during college and participants expressed frustration with the science content and lack of applicability towards their future health science career.

Participants expressed concerns with the need to memorize 'facts' and doing repetitive things. Millar and Osborne (1998) and Fensham (1985) describe the science curriculum as one that expects too often for 'facts' to be memorized and learned instead of placing more emphasis on the interests of young people.

One participant felt that the content did not apply to his needs for further education in health science. Though other participants expressed the importance for everyone to learn about science, this participant was more focussed on how science was enabling him and felt that he needed to learn more about human biology. Wellington (2001) stated there is a conflict of goals when science education tries to encompass both science learning for future scientists as well as for future citizens. Curriculum must be able to meet the needs of students or else it will be seen as irrelevant (Millar & Osborne, 1998).

College needs

There was a strong response for the need for labs at the college in this study, as well suggestions for hands-on learning and outings. Participants expressed a sense of loss for not being able to learn science content different from regular classroom teaching.

In a study by Little (2001), students were found to have a more positive perception of science when they were actively participating. This study also found that students suggested there be less memorizing and more hands-on learning. Ornstein (2006) stated that students need

to be allowed to learn in a student-directed manner with lots of hands-on activities. Students also need to learn science in an environment that holds numerous opportunities for experiential science learning (Appelbaum & Clark, 2001).

Positive high school science experiences

Three participants spoke highly of the opportunities given to them through labs in high school. They were fascinated by the science brought into class, such as a cow's heart, and considered these moments of science education very important as well as interesting.
The Council of Ministers of Education, Canada, (1997) believes that students should have learning experiences that develop their inquiry and problem-solving skills as well as their interest in science. They also suggest that these experiences provide a relationship between science and technology with their everyday lives. Participants remembered what came into the class and where it came from (i.e. a farm, the Neurology Division at University of Toronto). This helped students to relate science to their everyday lives. Appelbaum and Clark (2001) believe that students would be more interested in science if they were to have a classroom full of items pertaining to science allowed to interact with them and, while doing so, learn about science. They believe that students would be more motivated in learning science when it is done experientially and in a student-directed environment.

Literature also suggests a more inquiry-based lab where students approach science learning like a scientist (Hodson, 1999). Hodson suggests that students be allowed to generate their own science question and then work towards answering that question through their own research design. This is an excellent way to keep science from becoming irrelevant to students (Hodson, 1999).

Positive college science experiences

During college, the participants felt connected to science because they recognized the importance of learning it and they also had positive experiences when activities involved participation. Since these participants had chosen to obtain the prerequisite science courses so that they could gain entrance to Health Science Programs, they had already vested an interest and were determined to learn the science, get good grades, and move on into the Health Science Programs. The participants expressed their desire to learn science and were connected to it because they recognized its importance for their future education. High school science, as found from the ROSE project, did not create student interest in pursuing science careers (Jenkins & Nelson, 2005). Now, as adults, the participants had decided to pursue science careers but did not have the science education to enable them to get into science programs.

There was an importance placed on participating during class by some participants, such as during debates. Roth and Stuart (2002) articulated the importance of practicing science literacy through conversations. They also suggested it helped to bridge the gap between school and everyday life and promote life-long learning.

Millar and Osborne (1998) believed that teaching important social concerns, such as proper health, diet and lifestyle, helped to promote more participation through debates on those issues. They also felt that teaching these things created excitement about science and learning science. It can also help to create a scientifically literate public that is better prepared to address and participate in science issues in society (Roth & Stuart, 2002). Osborne, Erduran, and Simon (2004) argue that high school students improved the quality of their argumentation skills by practicing them. Regular science classes often do not have the opportunity for discussions

(Watson, Swain, & McRobbie, 2004). Kelly (2005) believes that science should be focussed more as a social activity and that there should be more time allotted to students for debates and dialogue.

Education in health science

All of the participants recognized the value of learning science before entering the Health Science Programs and articulated science topics that were important as they continued into health science programs.

The Council of Ministers of Education, Canada, (1997) stated that the goal of science education should be to provide students with a science education that enables them to continue with higher levels of science education, as well as prepare them for science-related careers. For these participants, entering health science fields dictated that they have a strong science background to support them as they continued studying science. There is a need towards finding the balance between science content and science literacy (DeBoer, 2000). Wellington (2001) believes that when both aspects to educate future scientists as well as future scientifically literate citizens are encompassed in one curriculum, there becomes a conflict of intended goals.

The Canadian economy needs a science education that develops student interest in science (Council of Ministers of Education, Canada, 1997; Science and Technology Division, 1991). Countries that have scientifically driven and knowledge-based economies will be the most successful (Knox & Schmidt, 2006).

Applicability in society

The participants expressed that they played a more active role in society concerning science related issues once they had attained more science education.

Osborne and Collins (2000) articulated the need for science education to develop a scientifically literate society due to the growing significance of societal issues that were science related, such as global warming, food safety, etc. Participants described activities, promoted by their science learning, such as recycling, pollution reduction, saving energy and personal health maintenance, in which they were beginning to increasingly engage.

Hodson (2005) believes that it is very important for people to interpret scientific information and recognize its reliability and validity. One participant, Jayce, wrote to a newspaper editor, questioning the validity of an article and suggested scientific research to back up claims instead of propagating myths.

Lifelong learning

Participants mentioned activities that displayed lifelong learning with science as well as the participation with others that evolved from it. Television programs, reading newspapers, and debates were discussed by the participants in great detail. These science related activities were clearly an important part of the participants' everyday lives.

Einsiedel (1992) stated that the mass media was a means used by most people as a source of science-related issues. Osborne and Collins (2000) believe that students want to become more informed by socioscientific topics and suggested that science education should incorporate more scientific issues focused on by the media (Osborne & Collins, 2000). The Ontario science curriculum's STSE focus (Science, Technology, Society and the Environment) can enable students to learn the connections between science and their everyday lives (Ontario Ministry of Education, 2000).

The right direction for creating a scientifically literate public, Knox and Schmidt (2006) argue, is the establishment of resources such as national and regional organizations, libraries, scientific and research societies, universities and colleges that provide opportunities for students to become more scientifically aware and literate.

Osborne, Erduran & Simon (2004) believe that the next generation of adult citizens will need to make decisions about socioscientific issues as they are dealt information from media sources. Critical thinking skills and the ability to separate credible information from misleading information should be taught in science education so students can learn how use these skills as a scientifically literate citizen (Elshof, 2005).

The participants, as adult science learners, had become more science literate as citizens and spoke of science activities such as reading, watching television, and conversations with friends and family. What did not develop during high school science education had, in fact, developed during their college adult science education.

Canada does not know the level of science literacy its population of adults possess, or how many could be considered scientifically literate (Knox & Schmidt, 2006). National Science Board (2006) determined that the information sources used most often by Americans, when obtaining science information, are television, internet and media.

Science awareness

The awareness of 'science in our surroundings' was expressed by some participants. It was as though participants were seeing the science merge with everyday life and interpreting the experience in a scientific manner. Plants in need of water brought one participant to a more scientific view of water and plants. Another participant had realized that the show she was

watching on television had included some science that she understood. Having bugs crawl over her made another participant reflect on science being in her garden as well as everywhere.

In a study done by Little (2001), past students expressed their memories of 'doing things' in science class and felt that they should have had more time to be able to analyze, interpret and apply things in science.

The participants in this study were analyzing their surroundings and interpreting them by applying their science knowledge. In such a natural way they were 'doing science'.

Science education for everyone

Participants expressed the importance of everyone having an education in science. The suggested science content was the 'basics' of science, such as personal health and environmental sustainability. Also articulated was the need to provide everyone with scientific understanding so that they could make informed decisions.

Osborne, Erduran & Simon (2004) believe that science education needs to create curriculum that encourages science understanding for everyone. Science issues, such as maintaining a sustainable environment, need to be addressed by citizens that are scientifically and technologically literate (British Columbia Ministry of Education, 2001). A scientifically literate society is needed to address scientific issues and make well informed societal decisions (Knox & Schmidt, 2006; Millar & Osborne, 1998).

Revisiting the Research Questions: Conclusion

The research problem is aimed at better understanding college adult science students' perceptions of their science education and how it relates to their further education and science-based societal participation. From this problem comes the five research questions:

1. **How did the science education during secondary school and Pre-Health Sciences prepare the students, now enrolled in a Health Science Program, as citizens in society?**

All participants indicated that science was a part of their everyday lives. Three of the participants described reading science for personal interest. Five discussed their favourite science television programs. These activities would also prompt discussions with family and friends about science topics. Five participants noted that they were more concerned with environmental issues. Personal health was also mentioned as an important part of their lives.

Five participants were able to recall their secondary school experiences (Gary could not recall his high school experiences). There was no indication from their experiences that their secondary school science education necessarily prepared them as citizens in society. The general perceptions focussed on their disconnection with learning science and inability to engage in their learning during that time. They described themselves as lazy, immature, disinterested, and some found the science too hard to learn. One participant mentioned that, once in college, she found that she put more effort into her learning.

Some participants were able to express that their science related activities in their everyday lives were a large result of the science education they had in Pre-Health Sciences. Things such as recycling, saving energy and generally being more aware of environmental issues were related to their experiences in Pre-Health Science. Maintaining personal health, personal interest reading of science, and choice of science television programs were also related.

Though there was a wealth of information indicating Pre-Health Science's contribution to their science activities in everyday life, participants did not directly connect a specific educational moment to a specific everyday activity. They did, however, remark on their appreciation of debates that occurred in Pre-Health Sciences. Debates were continued into their

everyday lives. Some participants could relate their ability to understand science as they read or watched television and that their science education had given them that confidence as well as a foundation to be able to better appreciate what they were reading or watching. The biology course in Pre-Health Sciences has a unit on the environment and environmental issues. The time spent learning this unit may have helped contribute to their environmental awareness in their everyday lives, but participants did not mention the environmental unit directly.

a. How do the students perceive their secondary science and Pre-Health Sciences course as relating to scientific literacy?

All participants needed an explanation of what scientific literacy meant before expressing their thoughts on it. Although they didn't state that their actions displayed science literacy skills, they supplied multitudes of information that pointed to them actually practicing it in their everyday lives. Their actions through discussion with others about science as well as their general everyday activities that evolved through learning science had displayed science literacy.

Some participants noted that as adult learners they had acquired interest in science related activities. These activities portrayed science literacy in action. There was an emphasis on watching television programs related to science, such as the Discovery Channel. Reading science related topics also was mentioned by some participants and they expressed their enjoyment of learning new things pertaining to science. Conversationally, science literacy was also expressed well. Some participants spoke of enjoying conversations with friends and family about science issues.

2. How did the science education during secondary school and Pre-Health Sciences prepare them for their Health Science Programs?

Secondary school science essentially did not prepare the participants for Health Science Programs. For the most part, participants did not identify career choices at that point in their lives and thus did not place importance on their science education at that time. It does not necessarily mean that the science education was the root of the problem. Participants had typically described themselves as lazy, immature and bored during their secondary science education and that could negatively impact their level of motivation and interest in learning science. Science labs in secondary school were remembered fondly and, incidentally, would be useful towards a Health Science Program. The issue lay with their lack of interest in learning science. They felt that it was not imparted onto them strongly enough that science credits would be important. This problem was exacerbated by the fact that the students felt that the science classes themselves did not captivate their interest enough to give them an intrinsic reason to learn science.

Pre-Health Sciences did help to prepare the participants for Health Science Programs. The content of the science courses are essentially the same as in the senior secondary school science curriculum documents so content itself is not entirely the contributing factor. Their readiness to learn science was a strong factor and they learned a lot of science that benefited them as they entered Health Science Programs. Specific content that was described as very important was anatomy of the human body. Incidentally, there is only a little content set aside for the human body in the equivalent grade 12 university biology course that they took. The Ontario curriculum for the grade 12 university biology course has other units besides the human body and must divide the course into these units. The Pre-Health Science Program recognized the need for students to obtain a foundation in anatomy, so students were able to learn it in an elective class called Human Biology. This class was very important to the participants as they

progressed through their Health Science Programs. Also mentioned as important were the basics of chemistry, and biology content such as learning about cells. There was a little frustration by one participant that the non-health science topics were irrelevant and not useful to learn and took time away from learning content that would be useful.

a. How do the students perceive their secondary science and Pre-Health Sciences course as relating to their career choice in the Health Sciences program?

As stated previously in question one, secondary school science did not encourage the participants to choose a career in Health Sciences. Their lack of engagement in learning science contributed to this and they did not articulate any desire to enter a health science career at during that time. For the most part, at this stage in their lives, they did not have a particular career choice in mind to pursue so science education as well as health science careers were not a priority to them.

Pre-Health Sciences was perceived by the participants as their way of entering the Health Science Programs. Participants articulated their desire to learn science in Pre-Health Science as a necessary component to gain entrance to a Health Science Program. There was recognition of how the science learned in Pre-Health Science had given them a better foundation to work from when they progress through their respective Health Science Program.

3. What aspects of their science education do these students perceive were the most beneficial for them in terms of scientific literacy and as health workers? Why do they hold these perceptions?

The aspects of their science education that the participants perceived were the most beneficial to them were the debates that they experienced as well as the development of environmentally friendly traits. Though only two participants articulated their enjoyment of

having debates occur in their science education, many participants spoke of the debates they have with others about science issues in their everyday lives. Many participants discussed their environmentally friendly activities and some distinctly expressed that Pre-Health Science had encouraged these new habits.

From a health worker perspective, these participants recognized the importance of having a firm understanding of topics such as anatomy, chemicals and chemical reactions, and cells as they applied that understanding to the new knowledge they were learning in their Health Science Program. Some also articulated how that knowledge would be directly applied in their health science career choice.

4. **What aspects of their science education do these students believe were the least beneficial for them in terms of scientific literacy and as health workers? Why do they hold these perceptions?**

Since the participants had difficulty expressing their understanding of "science literacy", they did not refer specifically to science literacy. The aspects of their science education that they did consider the least beneficial were the tasks of memorizing facts and repetitive activities. Some participants felt that the high school science content was too difficult to understand, and expected to cover so many topics of science that the pace of learning became too rushed for both high school and Pre-Health Sciences.

5. **What do they perceive needs to be incorporated into, or removed from, the science curricula that would benefit them in terms of scientific literacy and as health workers? Why do they hold these perceptions?**

Participants expressed the importance of having labs. Those who had experienced them in high school were adamant on how it created interest and felt that experience with labs was

important. During Pre-Health Sciences, participants described the lack of labs and outings as a problem that took away from their ability to learn science in a different way, instead of always regular class lectures. They wanted labs available to them and felt they needed to be incorporated into their science learning. More hands-on activities were also mentioned as a needed component for Pre-Health Sciences.

Participants also wanted to spend less time memorizing facts and doing repetitive tasks, as well as spend more time to learn the content instead of having such a rushed pace.

Implications for Theory, Practice and Research

Implications for Theory

There is a great deal of research being done on how best to deliver an effective science education to students. For science education to be effective, Keeves and Aikenhead (1995) believe that everyone should learn science, scientific inquiry and scientific literacy should be emphasized, and it should encourage lifelong learning. Students should be encouraged to participate in discussions about science and practice their science literacy skills (Roth, 2003; Roth & Stuart, 2002). Effective science education also needs students to practice argumentation skills and critically evaluate science information (Osborne, Erduran, & Simon, 2004). The practice of debate and dialogue should be incorporated into science learning and display science as a social activity (Kelly, 2005).

The traditional approach to science education that teaches the scientific manner and process often alienates many students from science education (Aikenhead, 2005). Aikenhead believes that a science education that focussed more on personal and societal science issues would have a more positive effect on students.

Changes to the science curriculum over the decades have been influenced through different groups, sometimes government influences, sometimes science research and scientists' influences, and sometimes societal influences. These changes in science curriculum have also been influenced through written literature gained from research that was inspired by researchers in the educational field. For instance, the introduction of STS (Science-Technology-Society) into the curriculum was to create a more societal perspective (Aikenhead, 2003).

Whenever science curriculum changes are made, it is important that the effects of those changes be studied. An understanding of how students did, or did not, benefit from those changes are needed so future changes move in a positive direction. Educational research helps to clarify what is happening in the classroom with curriculum changes. For example, Osborne, Erduran and Simon (2004) found in their study that students were able to improve their argumentation skills through practicing them in the classroom.

The participants who were adult students generally showed interest in learning science. They chose to enrol in science due to a personal career choice and the need to get the prerequisite science courses for their Health Science Programs. That could be a contributing factor to their interest in learning science. During high school, these participants did not know what their future career goals were, so science education did not have a strong intrinsic value to them and that may have contributed to their loss of interest in science. Literature supports the issues involving high school students and the problems they experience while trying to decide on a future career. Code et al. (2006) found that high school students had trouble choosing and committing to a career choice and were frustrated about their indecisions. Bloxom and Bernes (2003) believe that there needs to be more specialized counselling available to students to help them find career choices that suit them. There is also a need to supply high school counsellors

with post-secondary school program material so that they have the proper information to support these students (Bloxom & Bernes, 2003). Research may benefit by looking further into how high school students relate their science education to possible career choices. A clearer understanding of the counselling process that means to support and guide these students, and the influences it has on them would also be beneficial.

One important issue needing to be corrected with high school science education is the problem with students dropping out of science courses, as well as not choosing to take them. Changes in science curriculum to address this problem have been made to a certain degree. Ontario science curriculum has incorporated the STSE (Science, Technology, Society and the Environment) framework to ensure that students are connecting science with their everyday lives (Ontario Ministry of Education, 2000). Agencies, organizations and institutions are offering environments in which students and the general public can gain a stronger science awareness and scientific literacy (Knox & Schmidt, 2006). This encourages more interest in science and may generate student interest in choosing science courses as well as keeping them from dropping out of science courses. Researchers need to continue to study this area and note any changes that occur with students as they experience science learning with the new curriculum.

There is also the question of whether science education should be the same for everyone. More research in this area would provide a better understanding of the needs students have based on their future educational and career aspirations, and whether these needs are being met in the current science curriculum.

Literature in the area of science literacy impresses the importance of students gaining the ability to be science literate and lifelong learners with science. Based on this study's findings,

participants had grasped the basics of science literacy and were practicing it in their everyday lives. Roth (2003) believes that science educators need to give students the opportunity to learn science through discussions in class about science issues in their everyday lives. This, he further states, allows students to improve their science literacy skills. These skills could then be applied as scientifically literate citizens as they participate in conversations about science issues in society (Roth & Stuart, 2002). Practicing argumentation skills and critically evaluating science information is also important for students (Osborne et al., 2004), and more focus should be placed on science as a social activity (Kelly, 2005).

The National Science Board found that adult Americans use television, internet and media most often when obtaining science information (National Science Board, 2006). Falk et al. (2007) argue that science education does not play a large role in establishing long-term public understanding of science. More research into better understanding the differences between adult learners and high school learners could help shed more light on how students are obtaining science literacy during their science education.

Implications for Practice

Based on this study's findings, science education for students can be both stimulating as well as boring depending on how they're being engaged with it. Students also respond more positively to learning science when they have established the importance for learning it. Science education needs to continually generate curiosity and interest. Appelbaum and Clark (2001) believe that science education should be student-directed and allow students to learn science experientially in a classroom full of science-related things that they can interact with. This, they further argue, would help students be more motivated to learn science.

When students are interested, they tend to learn and remember science better. The findings of this study point toward student connectedness with learning science when they are engaged with science. Science education needs to have plenty of activities where students can participate and learn through experiencing science. Ornstein (2005) believes there should be more hands-on science activities as well as student directed inquiry. Labs should be a large component in both high school as well as college level learning. Students should perform labs as 'scientists' where they are able to learn the process of science by practicing skills in planning, conducting, analyzing, and reporting their science investigations (Hodson, 1999). Hodson also believes that students should have the opportunity to create their own authentic science question so that they are more motivated in learning science as they try to answer their question. Fieldtrips incorporated into the science content are also important for sustaining interest on the part of students while learning science.

Based on this study's findings, students have charged science curriculum with being overloaded in content and feel that the pace set to cover all of the topics can become overwhelming. Teachers need to be aware of this and make an effort to let students enjoy science while they learn it. Memorizing facts instead of participating in an activity to learn science causes students to lose interest. West (1996) believes that the United States science and math curriculum has too much content so the depth of the material studied becomes minimal and students do not learn many details within the content. It would be easier to find time in the classroom to place more emphasis on science literacy if there was less emphasis on learning so much content (DeBoer, 2000).

The potential consequences for students when attention is not given to meeting their needs are a loss of interest in learning, frustration in trying to learn, and even simply just dropping out of science class.

Implications for Research

This study provides further support for the issues surrounding science education that were identified in the review of literature. These issues are: students losing interest in learning science; problems with curriculum content size and expectations; implementation of science inquiry; and implementation of science literacy. Even though the study was small and the number of participants was limited to six, this research may be useful to other researchers who are interested in studying the issues pertaining to student motivation in learning science, as well as the positive and negative experiences with learning science as both high school and college learners. It also provides some understanding of the science literacy that these adult students developed, and their lifelong learning with science.

One aspect of this study that would benefit with further research is the area of career decisions, especially within the Health Sciences field. Determining the career choices that students develop during high school as well as during Pre-Health Science would provide a better understanding of what motivated them to pursue, or not pursue, a science education.

Another aspect for further study would be to obtain perspectives from students that were not successful in the Pre-Health Science Program. Considering that this would technically be a second round at obtaining science credits for these students, it would be very interesting to understand what obstacles they experienced during the Pre-Health Science Program.

Reflections

The purpose of my research was to gain a better understanding of how students perceived their science education and how it affected their further education in science as well as their everyday lives. Due to my role as a science teacher for adult students, I feel that it is important for me to better understand my students and learn of practices in science education that I could improve or change that would, ultimately, improve my students' learning, appreciation and application of science. I think that science is fascinating and that my understanding of it enhances my life experiences. I would like my students to have the opportunity to not only learn science, but also experience it the way that I do.

Based on the findings from this study, there are new strategies in the classroom that I mean to establish. One that I knew about before the study, and was subsequently reinforced by the study, is to implement science inquiry that includes student-directed labs and more hands on activities. This is an area in progress for the college Pre-Health Sciences Program and within the year, a lab room will be available for our use and I can supply this element of need that was so adamantly expressed by the students.

Another area that I mean to sustain and hopefully enhance is classroom debates where students can practice argumentation and critical thinking skills while learning and conversing about science. I have had semi-formal debates as assignments through the years, but now, from the findings of this study as well as the literature read about it, I mean to make them a more significant part of my students' learning. Johnson and Johnson (n.d.) describe a particular debate technique called "academic controversy" that would enhance my classroom debates. The academic controversy style has students research their topic and prepare their arguments, refute

and rebut during the debate with their opposing team, and then has both teams reverse their perspectives and debate once again, and finally, the teams work towards a position that both sides can agree upon (Johnson & Johnson, n.d.). This method would definitely enhance my students learning experiences.

And finally, a very important practice that I need to maximize would be the generation of curiosity and interest of science with my students. As the findings established, students do not want to learn science through memorizing facts and repetitive tasks. One way to promote interest in science would be to pull media science related issues into the classroom and apply them to the science topics being learned.

Constant reflection on the progress of these changes will need to occur throughout my teaching years. I also will continue to monitor the literature in science education to keep updated with any new directions that it may take.

This study was very meaningful for me and the journey through it was quite enlightening. Emma had commented during my interview with her about why everyone should learn science. Emma said:

> If they learn something today, maybe they'll go home and they won't do that or they'll start doing something better – and that's a start.

This, in my view, defines such an important element of any education. I see myself in that phrase and mean to use what I learned through this study to 'start doing something better' in my science classroom.

References

Aikenhead, G. (2003). STS education: A rose by any other name. In R. Cross (Ed.), *A Vision for Science Education: Responding to the work of Peter Fensham* (pp. 60-75). New York: RoutledgeFalmer.

Aikenhead, G. (2005). Research into STS Science Education. *Educacion Quimica, 16,* 384-397. Retrieved February 1, 2008 from http://www.usask.ca/education/people/aikenhead/research_sts_ed.pdf.

American Association for the Advancement of Science. (2000). Designs for Science Literacy: Guiding K-12 Curriculum Reform. *2061 Today: Science Literacy for a Changing Future,* 10 (1). Retrieved May 23, 2007, from http://www.project2061.org/publications/newsletter/pdfs/2000tdy1.pdf.

Appelbaum, P., & Clark, S. (2001). Science! Fun? A critical analysis of design/content/evaluation. *Journal of Curriculum Studies, 33* (5), 583-600.

Bartley, A. W., & Orpwood, G. (2005, Fall). Scientific Literacy, STS and Assessment: Lessons from TIMSS. *The Morning Watch: Educational and Social Analysis, 33*(1-2). Retrieved May 24, 2007, from http://www.mun.ca/educ/faculty/mwatch/current.htm.

Bloxom, J. & Bernes, K. (2003). What they need: Delivery of career development to Grade 12 students. *National Consultation on Career Development (NATCON).* Retrieved February 2, 2008, from http://www.contactpoint.ca/natcon-conat/2003/pdf/pdf-03-21.pdf.

British Columbia Ministry of Education. (2001). *Science Curriculum Review Report.* Retrieved February 17, 2007, from http://www.bced.gov.bc.ca/irp/reports/scireview.pdf

Bybee, R., W. (n.d.). *The Sputnik Era: Why is This Educational Reform Different From all Other Reforms?* National Research Council. Retrieved February 2, 2008 from http://www.nationalacademies.org/sputnik/bybee1.htm.

Code, M. N., Bernes, K. B., Gunn, T. M., & Bardick, A. D. (2006) Adolescents' perceptions of career concern: Student discouragement in career development. *Canadian Journal of Counselling. 40*(3), 160-174.

Connelly, F. M., Crocker, R. K. & Kass, H. (1985). *Science Education in Canada, Volume1: Policies, Practices, & Perceptions.* Toronto, ON: The Ontario Institute for Studies in Education.

Council of Ministers of Education, Canada. (1997). *Common Framework of Science Learning Outcomes, K to 12.* Retrieved February 15, 2007, from http://www.cmec.ca/science/framework/

Council of Ministers of Education, Canada, Statistics Canada, Human Resources Development Canada. (n.d). *Measuring up: The performance of Canada's youth in reading, mathematics and science.* OECD PISA Study – First Results for Canadians aged 15: Highlights. Retrieved April 1, 2007, from http://www.pisa.gc.ca/pisa/brochure_e.pdf

Creswell, J. W. (2003). *Research design: Qualitative, Quantitative, and Mixed Methods Approach* (2nd ed.). Thousand Oaks, CA: Sage Publications, Inc.

DeBoer, G. E. (1991). *A History of Ideas in Science Education: Implications for Practice.* New York, NY: Teachers College Press.

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching, 37* (6), 582-601.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84* (3), 287-312.

Eijkelhof, H. (2003). Partners or opponents: The role of academic scientists in secondary science education. In R. Cross (Ed.), *A Vision for Science Education: Responding to the Work of Peter Fensham* (pp. 132-138). New York: Routledge Falmer.

Einsiedel, E., F. (1992). Framing science and technology in the Canadian press. *Public Understanding of Science, 1*, 89-101.

Elshof, L. (2005). Scientific literacy to avoid a 'progress trap'. *The Morning Watch: Educational and Social Analysis, 33*(1-2). Retrieved March 18, 2007, from http://www.mun.ca/educ/faculty/mwatch/current.htm

Falk, J. H., Storksdieck, M., & Dierking, L. D. (2007). Inverstigating public science interest and understanding: Evidence for the importance of free-choice learning. *Public Understanding of Science, 16* (4), 455-469.

Fensham, P. (1985). Science for all: A reflective essay. *Journal of Curriculum Studies, 17* (4), 415-435.

Gallagher, J. J. (1971). A broader base for science education. *Science Education, 55(3)*, 329-338.

Gaskell, J. (2003). Perspectives and possibilities in the politics of science curriculum. In R. Cross (Ed.), *A Vision for Science Education: Responding to the Work of Peter Fensham* (pp. 139-152). New York: Routledge Falmer.

Hodson, D. (1999). Building a case for a sociocultural and inquiry-oriented view of science education. *Journal of Science Education and Technology, 8* (3), 241-249.

Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education, 25* (6), 645-670.

Hodson, D. (2005, Fall). What is scientific literacy and why do we need it? *The Morning Watch: Educational and Social Analysis, 33* (1-2). Retrieved March 18, 2007, from http://www.mun.ca/educ/faculty/mwatch/current.htm

Hogan, K. (2000). Exploring a process view of students' knowledge about the nature of science. *Science Education, 84 (1),* 51-70.

Jenkins, E., W., & Nelson, N., W. (2005). Important but not for me: Students' attitudes towards secondary school science in England. *Research in Science & Technological Education, 23* (1), 41-57.

Johnson, R. T., & Johnson, D. W. (n.d.). *Academic Controversy.* Retrieved March 9, 2008, from the University of Minnesota, Cooperative Learning Center Web site: http://www.co-operation.org/index.html

Keeves, J. P., & Aikenhead, G. S. (1995). Science curricula in a changing world. In B. J. Fraser & H. J. Walberg (Eds.), *Improving Science Education* (pp. 13-45). Chicago: University of Chicago Press.

Kelly, G. J. (2005, February). *Inquiry, Activity, and Epistemic Practice.* Paper presented at the Inquiry Conference on Developing a Consensus Research Agenda, Rutgers University, New Brunswick, NJ.

Knox, K., & Schmidt, B. (2006, November). A wake-up call on science literacy: Canada's future depends on it. *Policy Options.* Retrieved March 18, 2007, from http://www.irpp.org/po/archive/nov06/knox.pdf

Lakehead University. (2005). *Graduate Program Handbook.* Ontario, Canada.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry.* Beverly Hills, CA: Sage.

Little, C. (2001). What matters to students. *Educational Leadership, 59* (2), 61-64.

Marks, L. A., Kalaitzandonakes, N., Wilkins, L., & Zakharova, L. (2007). Mass media framing of biotechnology news. *Public Understanding of Science, 16,* 183-203.

McMillan, J. (2004). *Educational Research: Fundamentals for the Consumer (4th Ed.).* Boston: Pearson Education.

Millar, R., & Osborne, J. F. (Eds.). (1998). *Beyond 2000: Science Education for the Future.* London: King's College London.

Miller, J. D. (1998). The measurement of civic scientific literacy. *Public Understanding of Science, 7*(3) 203-223.

Mullis, I. V. S., Martin, M. O., Beaton, A. E., Gonzalez, E. J., Kelly, D. L., & Smith, T. A. (1998). *Mathematics and Science Achievement in the Final Year of Secondary School: IEA's Third International Mathematics and Science Study (TIMSS).* International Association for the Evaluation of Educational Achievement. Centre for the Study of Testing, Evaluation, and Educational Policy, Boston College, MA. Retrieved April 1, 2007, from http://timss.bc.edu/timss1995i/TIMSSPDF/C_full.pdf

National Science Board. (2006). *Science and Engineering Indicators: 2006.* Washington, DC: US Government. Retrieved February 3, 2008 from http://www.nsf.gov/statistics/seind06/c7/c7h.htm

Olson, J. & Lang, M. (2004). Science and technology and the didatics of citizenship. *Journal of Curriculum Studies, 36* (5), 543-553.

Ontario Ministry of Education. (2000). *The Ontario Curriculum Grades 11 and 12: Science.* Ontario: Queen's Printer for Ontario.

Ornstein, A. (2006). The frequency of hands-on experimentation and student attitudes toward science: A statistically significant relation. *Journal of Science Education and Technology, 15* (3), 285-297.

Osborne, J. (2003). Making science matter. In R. Cross (Ed.), *A vision for science education: Responding to the work of Peter Fensham* (pp. 37-50). New York: RoutledgeFalmer.

Osborne, J. & Collins, S. (2000). *Pupils' & Parents' Views of the School Science Curriculum: A study funded by the Wellcome Trust.* London: King's College.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41* (10), 994-1020.

Papanastasiou, E. C. (2004). Differential effects of science attitudes and science achievement in Australia, Cyprus, and the USA. *International Journal of Science Education, 26* (3), 259-280.

Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods (3rd Ed.).* Thousand Oaks, CA: Sage.

PISA Canada. (2003). *Scientific Literacy in PISA.* Government of Canada. Retrieved March 19, 2007, from http://www.pisa.gc.ca/science_e.shtml

Polkinghorne, D. E. (1995). Narrative configuration in qualitative analysis. In J. A. Hatch & R. Wisniewski (Eds.), *Life History and Narrative* (pp. 5-23). London: Falmer Press.

Robinson, J. T. (1968). *The Nature of Science and Science Teaching.* Belmont, CA: Wadsworth.

Robitaille, D. F., Taylor A. R., Orpwood, G.J., & Donn, J. S. (n.d.). *TIMSS-Canada Report Volume 4: Senior Secondary.* Retrieved on March 31, 2007 from http://www.cust.educ.ubc.ca/wprojects/TIMSS/Reports.html

Roth, W. M. (2003). Scientific literacy as an emergent feature of collective human praxis. *Journal of Curriculum Studies, 35* (1), 9-23.

Roth, W. M. (2007). Moving science classes to the community: A question of social justice. *Education Canada, 47* (2), 46.

Roth, W.-M., & Stuart, L. (2002). Scientific literacy as collective praxis. *Public Understanding of Science, 11*, 33–56.

Science and Technology Division. (1991). *Science Education in Canada.* Government of Canada. Retrieved July 14, 2006, from http://dsp-psd.pwgsc.gc.ca/Collection-R/LoPBdP/BP/bp265-e.htm.

Stewart, J., & Rudolph, J., L. (2001). Considering the nature of scientific problems when designing science curricula. *Science Education, 85 (3)*, 207-222.

Watson, J. R., Swain, J. R. L., & McRobbie, C. (2004). Students' discussions in practical scientific inquiries. *International Journal of Science Education, 26* (1), 25-45.

Wellington, J. (2001). What is science education for? *The Canadian Journal of Science, Mathematics and Technology Education, 1* (1), 23-38.

West, P. (1996, October). *Lacking a Clear Focus, U.S. Science and Mathematics Courses Cover Many Subjects but Provide Little Depth.* National Science Foundation. Retrieved February 2, 2008, from http://findarticles.com/p/articles/mi_pfsf/is_199610?pnum=2&opg=3938375027

Zimmerman, C., Bisanz, G. L., Bisanz, J., Klein, J. S., & Klein, P. (2001). Science at the supermarket: A comparison of what appears in the popular press, experts' advice to readers, and what students want to know. *Public Understanding of Science, 10,* 37-58.

APPENDICES

APPENDIX A

Cover Letter to College

June, 2007

Dear: [redacted],

As part of my completion of the Master of Education at Lakehead University, I have designed a research study that involves students at [redacted] College. The study focuses on the students' perceptions of their science education and how it has impacted them from a societal perspective as well as how it has met their needs as they continued their education. These students are presently enrolled in a Health Science Program and I have taught them in the Pre-Health Science Program. . The study's title is *Adult college students' perceptions on science education: Reclaiming lost ground in science education in preparation for Health Science Programs.*

I would like to ask the College's permission for me to conduct interviews with six students. The interviews would be approximately one and a half hours in length and would be during a time that does not negatively impact their present studies. They would be tape recorded and the interviews transcribed.

Confidentiality will be maintained at all times and the students' names will not be disclosed. Instead, pseudonyms will be used for each of them. The college's name will also not be disclosed. There are minimal psychological, physical or social risks involved in this research. The students participating will be notified that they can withdraw at any time during the study and participation will be voluntary.

The students are well acquainted with me because I taught them in the Pre-Health Science Program. This is beneficial for both participants as well as me. The participants will be comfortable communicating with me and I will be able to obtain in-depth information for my study. Due to the nature of their programs, I am no longer teaching them. This maintains a professional distance for the study as well as their personal education.

Data collected from this study will remain confidential and will remain in a secure location at Lakehead University for a period of seven years. My supervisor at the Faculty of Education will receive all of the findings from this study, completed as a thesis. The data and findings may also be presented in conference and journal papers, with all personal identifiers removed.

Any questions regarding this study can be directed to me using the information given below, or Dr. Anthony Bartley, my supervisor, by phone (807) 343-8896. You may also contact the Lakehead University Research Ethics Board at (807) 343-8283 if you have any questions. This letter has been sent to you after the approval of this study by the Research Ethics Board.

Thank you,

Anita Graham
Professor – Pre-Health Sciences
[redacted]
aigraham@[redacted].on.ca
home phone: 768-0023
office phone:[redacted]

APPENDIX B

Cover Letter to Student

June, 2007

Dear Potential Participant:

In order to complete the requirements of my Master of Education, I am conducting a study at [redacted] College for my thesis. [redacted] College's Administration has approved this study. I am interested about your perceptions with the science education you have experienced thus far in secondary school and the Pre-Health Sciences Program. The study's title is *Adult college students' perceptions on science education: Reclaiming lost ground in science education in preparation for Health Science Programs.*

I would like to invite you to participate in a tape-recorded conversation with me about your experiences with science education. The interview may last approximately one and a half hours.

Confidentiality will be maintained for all involved in the interviews. All participant names will be kept confidential and, instead, a pseudonym will be used to identify participants. There are minimal psychological, physical or social risks involved in this research. Participation is voluntary and participants may refuse to participate in any part of the study, decline answering any question, and withdraw from the study at any time. The benefits arising from participating in this study are your own personal reflection on your educational journey thus far, as well as lending valuable information that can be used towards improving the Pre-Health Science Program. A summary of the research results will be provided for you once the thesis is complete.

Data collected from this study will remain confidential and will be securely stored at Lakehead University for a period of seven years. My supervisor at the Faculty of Education will receive all of the findings from this study, completed as a thesis. I may also use this data and findings to prepare papers for conferences or publication. In either case your pseudonym, rather than your real name, would be used.

Any questions regarding this study can be directed to me using the information given below, or Dr. Anthony Bartley, my supervisor, by phone (807) 343-8896. You may also contact the Lakehead University Research Ethics Board at (807) 343-8283 if you have any questions.

Thank you,

Anita Graham
Professor – Pre-Health Sciences
[redacted] College
aigraham@[redacted]c.on.ca
home phone: 768-0023
office phone:[redacted]

APPENDIX C

Consent Form for Participation

June, 2007

My signature on this form indicates that I do agree to participate in a study conducted by Anita Graham on "Adult college students' perceptions on science education: Reclaiming lost ground in science education in preparation for Health Science Programs." My participation will involve one interview.

I have read and understand the research study outlined in the covering letter. I also understand that:

1. I am a volunteer in this study and can withdraw from it at any time.
2. There are minimal psychological, physical or social risks involved in participating.
3. The data obtained will be kept confidential and analysed only by the researcher and I will remain anonymous in any presentation of research findings.
4. The data collected will be securely stored at Lakehead University for a seven year period and then destroyed.
5. I will receive a summary of this research study upon request following the completion of the thesis.

I, _____ agree to participate in the interview.
(Please print name)

_____ _____
Signature of Participant Date

APPENDIX D

Consent Form for Study

June, 2007

My signature on this form indicates that Anita Graham has permission to conduct her study "Adult college students' perceptions on science education: Reclaiming lost ground in science education in preparation for Health Science Programs."

I have read and understand the research study outlined in the covering letter. I also understand that:

1. Participants are volunteers in this study and can withdraw from it at any time.
2. There are minimal psychological, physical or social risks involved in participating.
3. The data obtained will be kept confidential and analysed only by the researcher and participants will remain anonymous in any presentation of research findings.
4. The data collected will be securely stored at Lakehead University for a seven year period and then destroyed.
5. Participants will receive a summary of this research study upon request following the completion of the thesis.

I, _____ have given permission for Anita Graham to perform her study here at [redacted] College.

_____ _____

Signature Date

APPENDIX E

Interview Guide

1. What is your age?
2. What science education have you taken so far?
    a. What level (advanced, general, basic) was this education?
    b. What was your average grades in science (chemistry, biology, physics)?
3. What kinds of things do you remember the most about your experiences during high school?
4. Which science topics do you remember studying in school?
    a. Which science topic(s) were your favourite?
        i. What were the reasons that you enjoyed it?
        ii. What kinds of things do you remember doing that you enjoyed?
    b. Which science topic(s) were your least favourite?
        i. What were the reasons that you did not enjoy it?
        ii. What kinds of things do you remember doing that you did not enjoy?
5. What aspects of learning science did you enjoy the most? Why?
    a. Did you participate in any of the following during a science class?...debates...labs...were they prepared or did you generate the question and lab procedures?...group activities...?
6. What aspects of learning science did you not enjoy? Why?
7. What do you believe science is? How is it different from other disciplines?
    a. What do you believe the nature of science is?

b. What importance, if any, is there to learning about the nature of science?

8. What do you believe science literacy is?

a. How does it apply to you?

Preparation: Citizen

9. How does your science education help you in your everyday life?

a. What kind of involvement have you had with science issues in society?

i. What kind of activities do you do that pertains to science:

1. Reading magazines, books, newspaper, journal articles
2. Watching television programs, news
3. Participation in clubs, organizations
4. Conversations with friends/family
5. Writing/responding to newspapers, magazines, television programs, internet
6. Gardening/yard work
7. Cooking
8. Hobbies
9. Are there any other activities you can think of?

ii. What activities in science class helped you with these activities?

iii. What other kinds of activities would you like to participate in that involve science?

b. What would be some reasons for not participating in science related issues?

10. Do social and cultural values influence science?

a. Explain how it does/does not influence science.

11. What science issue has made the most impact in your life? Why?
    a. What influence did school education have on this?
    b. What influence did everyday life have on this?
12. Is it necessary that everyone in our society learns about and understands science? Why/why not?
13. What do you believe are the most important aspects of science in our society? Why?
14. What do you believe the role is that science plays in our society?

Preparation: Health Science Program

15. What do you feel are the important things to learn in science education:
    a. If you were not entering a science field career?
    b. If you were entering a science field career?
    c. Why are these reasons the same/different?

Further Improvements

16. What outcomes do you feel that you missed during science education?
    a. How has this affected your everyday life?
17. What do you believe could be added to science education that would have benefited you as a citizen and as a student in the Health Science Program?

Additional Comments

18. Is there anything else you would like to add to this conversation that I have not addressed?