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Pre-service teacher perceptions of and experiences with the implementation of inquiry based science teaching

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PRE-SERVICE TEACHER PERCEPTIONS OF AND EXPERIENCES WITH THE IMPLEMENTATION OF INQUIRY BASED SCIENCE TEACHING

by

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ABSTRACT

For many years, students have experienced passive learning in an environment where teachers instruct by lecturing information. Using open ended semi-structured interviews, this study investigated pre-service science teachers' perspectives of inquiry based teaching and their experiences with implementing it. The majority of the teachers interviewed were not familiar with inquiry before they began their bachelor of education, yet all participants' perceptions were initially or grew to be very positive regarding this style of teaching. Due to a lack of familiarity and time, teachers attempted this route to develop positive student experiences with consistent barriers and lack of support. Findings from one interviewee who had learned through inquiry show that exposure through one's own education can ease the implementation of inquiry based teaching. This indicates a need for more support from all levels of education and earlier implementation so that developing teachers will eventually have learned through inquiry.

DEDICATION

This is dedicated to my daughter Vivian who motivated me along my thesis journey as I watched her grow in her first year of life. Your milestones and smiles motivated me to work with great focus so that I could spend the remainder of each day joyfully with you. It is amazing to watch your natural inquisition as you grow and I look forward to always nurturing your desire to find out why and how.

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CHAPTER I: INTRODUCTION

Science education has the power to facilitate the development of critical thinkers and independent learners. This however, has not typically been the outcome of science schooling in the history of its existence. To be literate in science is to have the ability to make sense of how the world works and to have a genuine understanding of scientific principles. The American Association for the Advancement of Science as well as the National Research Council share a common goal of making all science learners scientifically literate (AAAS, 1989; NRC, 1996). These two professional associations have been pushing education reform towards inquiry based science programs for over two decades now, but relentlessly, efforts face the reality of challenges in the successful implementation of such programs.

As stated in the National Science Education Standards, inquiry is a 'multifaceted activity that varies in structure and guidance (NRC, 1996). It is characterized by five essential features, including the engagement of learners by questioning, evidence for proof, the development of subsequent explanations, evaluation of alternative explanations and justification of findings (NRC, 1996; Kazempour, 2009; Varma, Volkmann & Hanuscin, 2009). This learning cycle holds experience as a central strategy for teaching science and is fuelled by the abilities to identify, develop, revise, plan, conduct, communicate and defend (NRC, 1996). Before further exploration into inquiry based teaching, it is important to understand why the push for educational reform has been so strong.

Text books have traditionally focused on memory and learning answers rather than exploration and critical thought. The ability to argue with evidence and understand the nature of science, are beneficial skills to be carried into adult life. In light of the need for reform, time was

highlighted as a major resource to facilitate exploring, taking wrong turns, testing, collecting and doing things over rather than simply covering curriculum (Nelson, 1999).

Before the 21st century, US high school students scored the lowest in science and math knowledge out of 41 nations, at the Third International Mathematics and Science Study (TIMSS) (Nelson, 1999). This international study of education is considered to be the most important in the 1990s, and the only comparative survey of education on such a large scale. The goal of TIMSS was to identify what leads to high achievement by thorough analysis of textbooks, curriculum guides, teaching practice and student results (Notices of the AMS, 1996). The low American scores only proved what had been known for quite some time already, creating a renewed push for the progress of educational reform.

The AAAS founded the Project 2061 in 1985, to help educators focus on important knowledge for the next generation. It outlines the knowledge, skills and attitudes that facilitate the development of scientific literacy in its foundation report, Science for All Americans (Nelson, 1999). As a companion to this report, in 1993, Benchmarks for Science Literacy was published to provide guidelines for what students should be able to do in science, math and technology from k-12. These are the foundations of Project 2061's continual efforts to reform instruction and assessment (AAAS: Programs, 2011). They are not proposed curriculums, but rather guidelines to help write or improve existing curriculum.

The vision of Project 2061 is philosophically backed by two educational perspectives. First is to structure science teaching and learning around knowledge, skills and attitudes that students should master by the end of grade 12. Second, is to create a student centered and student initiated inquiry based learning experience, with varying degrees of guidance. Meaningful

connections are made through the union of these two perspectives, facilitated by the careful approach of the teacher (AAAS: Blueprints Online, 1998).

A focus on teachers' work in the implementation of inquiry based learning is important to maintain. In order to get students to take ownership of their learning and acquire an inherent interest, a teacher's beliefs, background and pedagogical skills need to be in line to facilitate an effective reasoning process in students. The teacher must first have strong comprehension of scientific content and practices. This background can then be transformed into meaningful activities and instructional strategies, where relevant knowledge is available to students. Instruction and evaluation can advance understanding and guide facilitation of student learning. Reflection should be an ongoing aspect of teacher involvement and can help to improve self efficacy. This process can lead to new comprehensions of teaching and learning and encourage an overall shift to successful implementation of inquiry based learning (Shulman, 1987).

Understanding pre-service teachers' ideas about and experiences with implementing inquiry based teaching is crucial, since these are the teachers that will lead the future facilitation of scientific literacy. Many new and experienced teachers did not learn through inquiry, but rather through passive learning (Friesen & Jardine, 2010). As one has the natural tendency to do as one was taught, it has proven to be a challenge for teachers to shift to facilitating inquiry based classrooms (Potvin & Dionne, 2007). Ideally, this experience should start in one's elementary years, but the reality is that our education system is faced with preparing teachers to implement inquiry learning, who have had little or no such experiences. Adding to this issue, is the loss of interest that students experience with the traditional way in which science is taught (Batagiannis, 2007). In order to engage them and bring them into the learning process, inquiry based science teaching needs to be implemented successfully.

Many qualitative studies (Nelson, 2001; Kazempour, 2009; Berns & Swanson, 2000; Church, 2010; Palombi & Jagger, 2008; Panasan & Nuangchalerm, 2010) have been conducted on inquiry based teaching and its effectiveness, but taking an in depth look at direct experiences of pre-service teachers can help to identify what can be done differently to ease its implementation.

The purpose of the proposed project is to understand how pre-service teachers experience inquiry based science teaching in high school, and to identify how this experience could potentially be improved. Since inquiry based science teaching has been promoted by a number of science associations, but not been well implemented in the classroom, it has become a significant issue in teacher preparation (Kazempour, 2009; Church, 2010; Sadler & Klosterman, 2009; Richardson & Liang, 2008; Ruiz-Primo, Li, Tsai & Schneider, 2008). Future teacher's ability to implement inquiry based science teaching is important and therefore the investigation of pre-service teacher's experiences is a valuable action.

Research Questions

1. What are pre-service teacher's perceptions of inquiry based teaching in the high school science classroom?
2. What are pre-service teacher's experiences with implementation of inquiry based teaching in the high school science classroom?

This study will provide participants an opportunity to reflect upon their developing teaching practice, which is an important aspect of personal growth. The findings from this study will be informative to all teachers since they can learn from this study about the implementation of inquiry based science teaching. The findings will also be informative to teacher education

program designers as it will provide feedback on teacher's experiences with implementing inquiry based teaching.

Theoretical Framework

Constructivism is the theoretical framework which drives the importance of this qualitative study. It is essential for students to take an active role in their learning by having teachers identify what they already know through inquisition. This in turn can lead the direction of learning and instruction. Teachers ideally become the facilitators of learning as students build their own understanding through experience and reflection (Kazempour, 2009). The constructivist theory gives meaning to learning environments by starting lessons off with identifying what students know. Both project based and inquiry based learning encourage students to construct knowledge through problem solving and experimentation. This helps students to build belief in themselves and their ability to be independent learners. As students take more initiative in their learning, they are more likely to take initiative in other areas of their life (Hodson, 2008).

Historically, science education development was backed by behaviourism, where educational systems for the first half of the 20th century were largely influenced by Edward Thorndike's Transfer of Learning theory. This theory was not intended by Thorndike to be applied to the classroom, but was done so by others. Thorndike believed "that behaviour could be learned as long as the task was practiced enough and the learning had positive consequences" (Llewellyn, 2002, p.41). A continuous cycle of teachers as products of the educational system has allowed the work of early behaviourists to dominate ideas behind classroom instruction for the greater part of the 20th century, creating a challenge to the shift towards constructivism.

Informed educators have been trying to change the way that science is taught for many years now. Learners are more likely to construct an idea that builds on prior knowledge rather than agree with the view point of the teacher. The strength of prior knowledge discourages the view that learning is transmission of knowledge and encourages that view that learning is conceptual change (Roschelle, 1995; Kazempour, 2009; Varma et al, 2009; Panasan & Nuangchalerm, 2010).

The core ideas that are the foundation of constructivism have been clearly stated by constructivists Dewey, Piaget and Vygotsky. Reflective experience, development of schemata and social interaction are the three areas which drive the historical perspectives of constructivism and link them to support for inquiry based teaching (Roschelle, 1995).

John Dewey (1859-1952) believed that a learner involved in a challenging experience can by the action of inquiry, transform prior knowledge. Such a transformation can restructure thoughts and perceptions of the way the world works. For inquiry to occur, time and space are necessary provisions, in order to allow for pondering and explorations (Roschelle, 1995; Concept to Classroom, 2004). It is not something that takes place in one's mind, but rather through direct engagement with the world and others.

Jean Piaget (1896-1980) proposed that learners' knowledge moves through four stages of maturity, including sensi-motor, preoperational, concrete operational and formal operational. As children move through the stages, each step up provides more constructs with which the learner can make sense of new experiences. Prior knowledge is considered to be structural schemata and is reformulated to constitute knowledge as one moves through the stages of cognitive growth (Roschelle, 1995; Llewellyn, 2005).

Vygotsky (1896-1934) emphasized the role of social interaction in the transformation of prior knowledge. He wrote about how structure came from culture and how learners have the ability to imitate and model through observation. With negotiation and provision of support to promote learning, experienced individuals can guide learning. These supports can be gradually removed as students develop their own learning skills and knowledge (Daniels, 1996). Vygotsky's Zone of Proximal Development (ZPD) identifies two levels of student ability to solve problems. Students have some skills to perform tasks independently and lack some skills that can only be learned through assistance from another student or adult (Llewellyn, 2005).

Each of the three constructivists, Dewey, Piaget and Vygotsky focused on a particular aspect that together, make up the theory behind inquiry based teaching. As an implication to the constructivist learning theory, the learning cycle is a key teaching strategy.

This five stage cycle is a teaching strategy consistent with constructivist theories on how learning can unfold. The first stage sets out to generate student curiosity and interest by engaging students by science questions. This questioning is meant to encourage responses which reveal what students know or think about the topic. In Stage two, through exploration, students work together, interact and act as consultants to one another as they receive redirection from the teacher where needed. This stage leads to evidence that will direct them in their next step. In the third stage students are encouraged to explain concepts and definitions based on their exploration and in their own words. In the elaboration stage, students identify alternate explanations, and apply learned concepts and skills in new situations. Finally, through evaluation, students communicate and justify their findings with an opportunity to assess their own learning and group process skills (Llewellyn, 2005; Varma et al, 2009; Hammerman, 2006).

The learning cycle is directly related to understanding how we learn and provides an example of a careful thought out process that can be facilitated for the successful implementation of inquiry. The learning cycle is therefore relevant to the topic studied as it provides a guide of the steps that need to be carried out in order to lead a student to an inquiry learning experience. Following the guided steps in the learning cycle does not ensure that inquiry will be successfully implemented, however the steps do demonstrate the application of the constructivist learning theory to this method of teaching. Constructivism is composed of the transformation of prior knowledge, cognitive growth through construct building and the importance of social interaction in the process of learning. The components of this framework, alongside the learning cycle, emphasize the strategic approach that needs to be taken in inquiry based teaching. It is not a simple process to bring a student through these stages, and there are many variables that make each student's journey unique and challenging. The goal of this research is to find out if and how pre-service teachers were able to bring the constructivist learning theory into their classrooms. Through interviews, the researcher can identify whether steps toward constructivism and inquiry based teaching were evident in the pre-service teachers' classrooms. In order to ultimately identify what could be done to better facilitate the implementation of inquiry based teaching, it is important to look at pre-service teachers' perceptions of and experiences with such implementation.

CHAPTER II: LITERATURE REVIEW

Collaboration through Inquiry and Argument

An educational approach driven by learners' questions describes the starting point for inquiry based teaching. Focus on a process of sense making, rather than attaining the right answer is the key aspect involved in movement towards this type of teaching. For many years, students have commonly experienced passive learning in an environment where teachers instruct by lecturing information. This does little for the development of cognitive, technological and social skills which are necessary for scientific literacy in 21st century science.

Any teacher who has really tested his or her effectiveness by checking students' understanding of concepts faces a startling dilemma. Teaching science in a constructivist mode is slower and involves discussion, debate, and the recreation of ideas. Rather than following previously set steps, the curriculum in a constructivist classroom evolves, depends heavily on materials, and is determined by the children's questions. Less 'stuff' will be covered, fewer 'facts' will be remembered for the test, and progress will sometimes be exceedingly slow. It is definitely a process of uncovering rather than covering (Watson & Kopnicek, 1990, p.10).

Inquiry. Inquiry is an approach that needs to be well thought out and carefully administered. There are many different perceptions of inquiry based learning and teaching in existence in the reviewed literature. Booi (2011) associates inquiry based learning with critical thinking and the development of active and responsible students. This responsibility transcends in the classroom as well as in society and is accompanied by an ability to effect change in an individual's community. When a student has the ability to think creatively and critically in a

school setting, they are more likely to bring these skill sets to their own lives, separate from school.

Gibson's (2011) perception of inquiry based teaching emphasizes the importance of making student material relevant to them. In certain science topics, it is possible to achieve this through outside education. Provision of this learning environment not only helps students to connect to their learning, but also encourages the development of collaborative work. Successful inquiry based teaching produces students who are confident, connected and actively involved in their learning. The implementation of inquiry based teaching can help to promote student interest and facilitate existing student interest for the positive growth and development of student attitudes and values (Stotter & Gillon, 2010).

Teacher flexibility and the ability to adjust teaching according to student needs are highlighted as important parts of implementing inquiry by Nielson, Triggs, Clarke & Collins (2010). A thought out plan is helpful for teacher strategies, but the many variables that can occur need to be considered beforehand. A teacher's willingness to adapt to both expected and unexpected occurrences is helpful in successfully implementing inquiry based teaching according to these researchers.

Inquiry is a discovery process that both the student and teacher become involved in. As a teacher facilitates a student in identifying, reasoning and building on prior thoughts, the process of inquiry has begun (Goodenough, 2004). This is a process that occurs naturally in young children and should continue to take place with lifelong learners (Annonymous, 2009). Teachers who hold expertise in their subject area have an easier time encouraging this student experience to continue. Chorney (2009) identifies the importance of this expertise in the implementation of inquiry based teaching. It is with such expertise that a teacher is better able to recall, apply and

transfer knowledge in both common and challenging situations. Expertise is associated with experience but should also be related to the tendency to search for new methods of teaching familiar topics. Teachers with less confidence in their subject matter will be more likely to create a passive learning environment lacking in probing questions.

Appropriate questioning can provide instructional scaffolding to advance student thinking to assist them in climbing the "cognitive ladder" (Chin, 2007, p.837). This movement towards higher levels of knowledge and understanding can be encouraged with affirming teacher responses and reiteration of student comments. These approaches, as well as feedback are important parts of guiding a learner to higher thought level (Chin, 2007). It is important for teachers to have a solid understanding of subject matter in order to ask appropriate probing questions to facilitate integration of a student's concepts into the larger picture. Developing an understanding of how the world in science works requires critical thinking, logic and reasoning skills. These actions can lead to explanations based on evidence from activities and an understanding of the work that scientists do (Hammerman, 2006).

Research has shown that problem solving and reasoning are processes that are much more effectively played out in collaboration rather than individually (Branch, 2003; Chin, 2007; Church, 2010; Kazempour, 2009; Meister, 2010; Nelson, 2001; Palombi & Jagger, 2008; Wakelyn, 2008; Zhou, Xu, & Wu, 2006). If there is an issue to resolve, naturally if possible, more than one person involved in addressing it would be beneficial. Many societal systems are based on people working together to result in a greater collection of intellectual and material resources. Inquiry as well as argumentative discourse, provides an individual with the experience of hearing others' ideas and perspectives.

Argument. In the scientific world, argument is the main component of scientist's work. Arguments between scientists have the power to change ideas. These arguments exist through publications, conferences and informal occasions (Zhou, Xu, & Wu, 2006). Scientists themselves have internal arguments as they change their ideas based on theories, new evidence, personal insights and thoughts. This process of argument fuels the creation of new frameworks in place of old frameworks in science development and therefore takes a 'central position' (Zhou, 2010). Through argument, students are required to provide evidence for their ideas and be convinced via evidence before accepting new ideas proposed by other students and teachers. This approach places the student and the teacher at the same level, a relationship characterized by persuasion for acceptance of new ideas. This requires collaboration and takes time to understand others' ideas while remaining readily able to changes one's own opinion if felt necessary. This parallels the goals of constructivist science teaching with reconstruction of knowledge by students through presenting and defending ideas (Kuhn, 2005).

The differences in student preconceptions provide opportunities for argument, similar to the experience of scientists with different ideas. This process of conceptual change begins with a question or a problem. The initial approach of the teacher is very important as it helps to identify where students are at and allows the teacher to move forward after realizing student preconceptions. Once student ideas are probed, students need the opportunity to predict results or interpret available information. This can be done first independently and then in groups. It is up to the teacher to then create cognitive conflict. In this stage of argument, students become clear on their own ideas and begin to wonder about other students' conceptions. Pointing out limitations and the inability of some ideas to be applied to other areas of science can encourage openness to changing one's perceptions

Through experimentation and inquiry based activities the construction of student scientific notions is facilitated by the teacher. Allowing students to come up with notions leads them to a more genuine understanding than a direct explanation would give them. Following experimentation, students are more likely to challenge notions as they have been a part of the discovery process. This is accompanied by thorough discussions to enhance student understanding while providing the opportunity for them to defend their ideas. Finally, evaluation encourages acceptance of the outcome and the ability to apply ideas to new problems (Zhou, 2010).

This process facilitates the teachers attempt to break down students less acceptable ideas in a socially interactive environment and replace them with new visions in the establishment of scientific notions (Zhou, Xu, & Wu, 2006). Students come to school with their own ideas and it is through collaborative inquiry and argument that teachers have the best chance of identifying those preconceptions (Nelson, 1999). Identification of prior thoughts, whether or not accurate, is the key to beginning the process of implementing inquiry based science teaching across North America as well as internationally.

Global Movement towards Inquiry

Creating inquiry based learning opportunities takes time, patience and risk, while helping students to develop skills needed for life. The benefits of learning how to cope with problems and deal with changes can help to develop adult scientific literacy across all nations. Branch (2003) emphasizes the importance of reflection in the inquiry process and its ability to lead to the development of lifelong learners in the province of Alberta. Many of the studies reviewed (Windschitl, 2003; Windschitl, Ryken, Tudor & Koehler, 2007; Sadler & Klosterman, 2009; Marks & Eilks, 2008; Palombi & Jagger, 2008; Church, 2010) support the implementation of

inquiry based teaching in North American school systems. Osbourne and Dillon (2008) identify the same focus in Europe, to develop more inquiry based science teaching. Projects have been developed to:

> provide secondary school teachers in Germany with tools to change their pedagogical approach to science teaching in the secondary school. The focus of these projects has been primarily on pedagogy and not on transferring the content itself. Such inquiry based approaches are seen as providing children with opportunities to use and develop a wider range of skills such as working in groups; more extended opportunities to explore their written and oral expression; and more open-ended, problem solving experiences all in the belief that it will enhance student motivation and attainment. Some evidence does exist that these have been effective and it is these projects which are central to the recent report calling for a transformation in the pedagogy of science teaching in Europe (Osbourne & Dillon, 2008, p. 22).

On a global level, the International Baccalaureate (IB) is an educational foundation that strives to develop intellectual, personal, and social skills to live and learn in this fast changing world. The IB high school diploma program is offered in 140 countries and is rooted in the process of inquiry. IB science aids in the development of cognitive strategies such as critical thinking skills, intellectual inquisitiveness and interpretation (International Baccalaureate, 2011). It is a requirement of each 2 year IB science program (Biology, Physics, Chemistry, Environmental Science) that each student throughout grades 11 and 12 carries out a set number of self designed investigations. These investigations are inspired by classroom discussions and questioning periods, and supported by the provision of numerous materials so as to not limit the students' inquisition, within reasonable limits.

The Educational Policy Improvement Center completed a study to show that Students around the world who complete the IB diploma high school program are better prepared for success in colleges and universities due to development of cognitive skills. Conley lead the study and concluded that "it's not enough for students to study content in isolation; they must use their content knowledge to solve problems, make conjectures and inferences, and think deeply about the big questions of the disciplines" (International Baccalaureate, 2009). The IB program is continuing to develop in many international schools around the world due to its success in aligning the development of scientific strategies to the way that real scientists work, thus preparing students for success in the advancing 21st century.

Approaches to Inquiry Based Science Teaching

Inquiry software. The use of technology has been an added resource in aiding students and teachers in the development of the expertise of inquiry. Reflective assessment is a main focus in the Web of Inquiry website that was created for teachers to share and evaluate implemented inquiry assignments, and for students and researchers to complete and reflect on science inquiry projects (Shimoda, 2006).

Studies have shown that the introduction of software which incorporates models of inquiry processes to assist students in research can facilitate metacognitive development (White, Frederiksen, Frederiksen, Eslinger, Loper, & Collins, 2002). Understanding how one learns can lead to greater success in learning through the constructivist approach. While the four key processes to metacognition for successful learning are planning, reflecting, revising and monitoring, the importance of reflective self assessment on learning outcomes is emphasized in research regarding inquiry based teaching implementation (Branch, 2003; Eslinger, 2002; Marks & Eilks, 2008; Nelson, 2001; White, Shimoda & Frederikson,1999).

Inquiry Island, a group of software 'advisors', was created to help students with research projects. Advisors such as Investigator, Reflector, Reviser, and Assessor, suggest goals and strategies to guide students in understanding their learning process and reflect on and improve their work. This software has been successful in helping students learn about inquiry and self reflection (White et al, 2002; White et al, 1999) and goes hand in hand with connecting science, technology and society (STS).

Making connections with science. Science, technology, society and environment education (STSE) is necessary for education to produce literate citizens. Scientific literacy can be described by the ability to make decisions and take an active part in discussions about new and ongoing developments in science and technology and their possible impacts. Science lessons, especially chemistry, have the tendency to be highly content driven with minimal personal relevance and achievement in higher order cognitive skills (Marks & Eilks, 2008). In the absence of relevance, low motivation in students is likely to arise.

An 8 year participatory action research project to implement STSE oriented teaching proved to be successful by an increase in student interest, communication, reflection and evaluation of controversial issues (Marks & Eilks, 2008). An example series of STSE lesson plans used in this action research project, are on the topic of shower gels, detergents and fragrances. Their scientific properties were identified and the social controversy of artificial musk fragrances was addressed, as they are hormone-activating and possibly carcinogenic. The potential health effects of these products create social and environmental concerns, increasing student tendency to relate to these lessons. The health effect issues point to a need for change that technology could assist in. Students that were part of this STSE action research tended to be

more openly critical as they found it relevant to human lives, promoting scientific literacy overall.

The greatest province wide attempt at changing the focus of learning in science from concept knowledge to the ability to understand science in relation to technology and sociology (STS) took place first in Alberta (Blades, 2000). A greater emphasis was eventually placed on environmental impacts, creating a push for science, technology, society and environment education (STSE). Blades (2000) reports that re-orienting science education toward a STSE approach presented many challenges as teachers were used to delivering information from a set curriculum or text book. Some of the challenges that arise come from the need for a multidisciplinary approach. Collecting information that is historical, economical, political and environmental takes time and resources, two aspects of teaching that are not naturally plentiful (Pedretti & Forbes, 2000). Without teacher background in delivering an STSE approach in science, these challenges will arise, but regardless, the benefits persevere.

This approach to science education encourages students to become connected to societal issues, inspired by current resources, while developing decision making skills. Understanding the impact of science on everyday life encourages students to become responsible citizens who have the ability to problem solve when addressing issues. Blades (2000), Jenkins (1992) and Smith (1993) support that in order to achieve these student abilities, science education needs to go beyond the learning of theories and facts. It is much more valuable to learn about weather patterns in the context of global warming than to be presented with facts of how weather is produced. Science though an STSE approach provides a more meaningful learning experience while encouraging the development of critical confident thinkers who have attained well grounded knowledge.

A balance between content and process. There is an ongoing debate as to which is the most effective approach to teaching, a focus on content or a focus on process. Inquiry based science teaching is characterized by a change in emphasis relating to this debate. A greater emphasis needs to be on guiding students, continual assessment and providing opportunities for discussion. This change in emphasis does not omit the necessity of content coverage, therefore a balance of the two needs to be attained. Science teaching requires on one end of the spectrum, knowledge gained by readings and lectures, and on the other end of the spectrum exploration through inquiry. A shift in emphasis towards inquiry has been in question for many years, as described by Watson & Kopnicek:

> Do we cover the material, knowing full well that what we cover will be understood superficially at best----- accommodated, but not assimilated? Or do we forget about coverage and work to help children test their untutored conceptions against the real world through challenging questions, predictions, and experiments, knowing that we will be sacrificing breadth for the sake of depth? (Watson & Kopnicek, 1990, p.11).

Effective inquiry based science education aims to achieve the understanding of concepts, learning the process of inquiry, and the development of independent, responsible learners. This achieved balance of content and process varies with each unique teacher and his or her own methods. This variable is accompanied by the diversity of learners, communities and whole school systems (Foundations, n.d). Educators need to understand their own learning processes and the needs of their classrooms in order to work towards consistency in the implementation of inquiry based science teaching.

Achieving teacher consistency. Construction of explanations is an essential aspect of inquiry based instruction, but it is not constant across scientific inquiry classrooms. Not all

classrooms that strive to be inquiry based are successful (Foundations, n.d). Beyond student engagement in activities and thinking processes, there needs to be an 'epistemic goal' where one understands their acquisition of knowledge and some part in the nature of science (Ruiz, Li, Tsai & Schneider, 2008). Ruiz et al (2008) found in their analysis of students' written explanations that instructional inquiry practices varied greatly from teacher to teacher, leading to a clear inconsistency of student results. They highlighted a need to find ways to improve teacher practice in the implementation of inquiry based science teaching. Although beneficial to improve this practice at any point in ones career, it would be most ideal to begin this improvement at the pre-service teacher level. Science educational reform has been aided by the development of inquiry software, incorporation of society and technology in lessons, a shift towards an emphasis on exploration and the goal to reach more teacher consistency. There is a common purpose to all of these approaches, which is to facilitate positive experiences for all students.

The Enhancement of Student Experiences Through Inquiry

If a student has learned about time management, independent learning and group interaction skills, they have experienced science in a positive way. Palombi and Jagger's (2008) research reports that these experiences cause changes in student attitudes to learning science. Experiencing inquiry based science learning can lead to enthusiasm, bringing students in touch with the wonder that science is. A student from Palombi and Jagger's research describes this well:

> I enjoyed this lab. It allowed us to apply the knowledge we have gained about the nature of cells to design our own experiment. This knowledge gave us better understanding of what occurred in our experiment. This lab made us think about what we were doing and understand it. We weren't given a road map. Typically in

> labs we get step by step instructions of procedures so it's easy to thoughtlessly follow directions. With this lab, the instructions were our own; therefore we had to understand why and how every step was to be taken. We learned responsibility in this lab. We learned to rely on each other (Palombi & Jagger, 2008, p.31).

Traditional science labs do not help students understand what real scientists do. An end result is expected, and a correct answer is sought out (Nelson, 2001). With inquiry based learning, there is less concern about the end result and data and interpretations can be right or wrong. The traditional student focus on finding the right answers needs to incorporate the fact that hypotheses in the scientific world are often wrong, leading to further questioning and investigation. Getting students closer to this process delivers a more authentic scientific experience.

When students have an active role in their learning process where teachers tap into their prior knowledge through questioning, students are set up to construct their own understanding through first hand experiences (Kazempour, 2009). Developing curiosity about the natural world is aligned with human nature's inclination to wonder why.

Spending time with children from infancy and beyond is a strong reminder of this natural curiosity. Their tendency to touch, listen, ask, and explore are examples of the inquiry that brings us all through many years of development. Learning through inquiry provides students with the opportunity to make decisions on their own, including what questions to ask, what materials to use, how to organize data and whether or not to accept a conclusion (Dyasi, n.d.). This process leads to feedback from their own investigation and from their teacher and peers (Chin, 2007). With each new inquiry based science learning opportunity, students gain more knowledge and expertise of how to approach this more independent way of learning. As knowledge and skills

are gained, students can better use inquiry for their development. The cognitive scaffolding that teachers provide through questioning and guidance becomes less and less necessary as students gain more confidence in their own abilities (Dyasi, n.d.; Chin, 2007). This outcome is very transferable to a student's life outside of the classroom and a key characteristic of an adult who is scientifically literate.

Not only does inquiry contribute to learners' intellectual development, but also to their social development (Meister, 2010; Dyasi, n.d.). The collaborative approach provides experience that is also very applicable to success in adulthood. The skill of working well with others leads to the ability to work positively with family, friends and coworkers. Such interpersonal skills are invaluable to the scientifically literate adult. Facilitating this experience

> means creating a rich physical and social learning environment in which new questions, explorations, and investigations can arise, and in which every step is not dictated. In such contexts, he or she allows the children time for trials, repetition, and mistakes, and creates a balance between adult guidance and time for children to be guided by their own questions, predictions, and explorations (Dyasi, n.d., p 30-31).

Inquiry based teaching is consistent with the nature of science and ideal for student cognitive development, but its implementation does not occur without challenges.

Challenges to the Implementation of Inquiry Based Teaching

There are a number of barriers to the successful implementation of inquiry based science teaching. Kazempour (2009) pointed out in his study of 3 science teachers taking part in a 2 week inquiry based professional development workshop, that there is a general perceived lack of time to implement inquiry based teaching. There is a great deal of pressure on teachers to

prepare their students for exams, and therefore a push to cover all material. At the fault of these barriers, Kazempour (2008) identifies a lack of support at the colleague and administration level, a lack of resources and of flexibility.

Administrators need to play an active role in encouraging a shift in emphasis towards inquiry learning rather than a focus on content coverage. At the colleague level, a common interest in inquiry based teaching can be fostered by sharing ideas, discussing frustrations, obstacles and successes in its implementation (Meister, 2010; Berns & Swanson, 2000). Sadler and Klosterman (2009) studied the evolving perspectives of beginning science teachers and their experiences with inquiry, to find very few teachers who could implement inquiry based teaching effectively. One teacher in particular, Oscar, stands out in their study as he was significantly successful in this endeavour. This teacher had colleagues and an administrator who also valued inquiry based teaching, expressed a strong commitment to self improvement and experienced positive effects from mentoring.

There is a general lack in North America of teacher familiarity with and ability to implement inquiry based teaching. Although there is a large drive for reform, the fact that many teachers did not encounter this type of learning in their own education, makes it more difficult for them to bring it into their own practice (Kazempour, 2009). Not only do these barriers exist at the teacher level, but they may also exist at the student's level.

When students come to class with misconceptions, it can be challenging to work them beyond a way of thinking that they may have had for many years. Watson and Kopnicek (1990) report on a common stubbornness in students with inaccurate preconceptions. Students will refuse to admit their errors in thinking and will look for ways to adjust old ideas before assimilating new ones.

A new way of thinking alongside new vocabulary can present an even greater barrier. Students vary in terms of memory, skill acquisition and reasoning ability, all factors that may affect their capacity to incorporate new knowledge to existing ways of thought. A teacher can promote new ways of thinking by making connections that allow students to identify with the material (Watson & Kopnicek, 1990). The greater the teacher's science expertise, the greater his or her ability will be to make a variety of connections, reaching a greater number of students.

The Importance of Teacher Knowledge and Professional Development

Teachers' knowledge about science, the learning process, students and effective teaching all influence their classroom instructional practices. In order to engage students with inquiry, teachers themselves must have a clear understanding of the processes in science and the way real scientists construct knowledge. Nelson (2001) describes three categories of teacher knowledge that are important in order to be scientifically literate, and thus an effective teacher. First is disciplinary content knowledge and second is knowledge about teaching and learning. Third is pedagogical content knowledge which is a combination of the first two. As teachers gain experience, they deepen their level of pedagogical content knowledge, characterized by a greater understanding of facts, concepts, organizing principles and of the nature of science. Teachers with less content knowledge naturally have less confidence in the classroom. These teachers tend to be more controlling, question less and stick more to the textbook. In order for students to have an authentic learning experience with opportunities for questioning, designing and being critical, a teacher with a strong background in the discipline who is up to date on current research is better prepared (Nelson, 2001). A better prepared teacher in this sense will be more positively influenced by effective professional development.

An individual's knowledge of teaching and learning can be positively changed through effective professional development. Techniques for implementing inquiry based science teaching need to be modelled in professional development programs (Kazempour, 2009). Such teacher involvement in the learning process makes it easier for teachers to implement inquiry based teaching into their own practice, by providing firsthand experience with inquiry based activities and discussion with ongoing reflection.

Kazempour (2009) reports on the importance of professional development occurring over a long period of time in order to change teacher views and practices. Research shows (Baker, Lewis, Watts, Perkins, Uysal, Wong, Beard & Lang, 2009; Wakelyn, 2008) that professional development for the implementation of inquiry based science teaching leads to teachers asking more analytical and interpretive questions, and attaining a greater understanding of the nature of science, which in turn leads to the development of scientifically literate students. Although teachers can benefit from professional development at any point in their career, pre-service education programs are in a position to have a significant impact on teachers in the school setting.

Pre-service teacher education programs that integrate practical inquiry exercises with theoretical study can have an impact on ones eventual teaching. Pre-service teacher self-efficacy is predicted by factors including the length at which science was taught, their education level and is related to a greater ability to engage in activity based instruction (Richardson & Liang, 2008). Through administration of a methods inquiry based course for pre-service science teachers, Richardson & Liang (2008) found that such experience can increase pre-service teacher self efficacy.

Other research (Sadler & Klosterman, 2009; Varma et al, 2009; Church, 2010) supports that prior research experience, observations of project oriented classrooms, collaborative relationships in schools and ongoing reflection can all attribute to a pre-service teacher's transition to a successful first year of implementing inquiry based science teaching.

The incorporation of guided inquiry into educational environments builds critical thinking skills and a sense of purpose, leadership and service. Scientific inquiry has only recently become highlighted as having an important role in pre-service teacher preparation. Because of this, training teachers' understandings of inquiry based science teaching is not clearly known. It is valuable to 'dig deep and find out what is going on' (Varma et al, 2009) with the experience of pre-service teachers to identify what can be done to better prepare future teachers for success in implementing inquiry based teaching.

CHAPTER III: METHODOLOGY

In this chapter, the research approach is described as well as the methods used. This section is organized first under the subheading of research design. Following this is a section on participants and then coverage of the process through which data was recruited. Ethics concerns are then addressed and the data collection and instrument are explored. The approach to data analysis is explained and finally the scope and limitations of the study are presented.

Research Design

This study was guided by exploratory qualitative research, to investigate and understand pre-service teachers' perceptions of and experiences with the implementation of inquiry based science teaching. One of the major reasons that researchers do qualitative studies is to gain understanding and familiarity with a phenomenon one is interested in (Berg, 2001). When a researcher has exposure to a topic before approaching existing literature, the approach is likely to better allow one to formulate their own ideas about why or how something is happening. The researcher in this case, has taught science in 4 different high school settings, ranging from a comprehensive school to a privileged school. In the latter school, the International Baccalaureate program was taught, which takes on an inquiry approach. These opportunities in teaching have given the researcher a personal background of experience related to the research topic, better enabling the formation of ideas.

Qualitative exploration provides an opportunity for a researcher to access 'unquantifiable facts about the actual people researchers observe and talk to (Berg, 2001, p.7). Berg goes on to describe that 'exploratory qualitative techniques allow researchers to share in the understandings and perceptions of others and to explore how people structure and give meaning to their daily

lives' (Berg, 2001, p.7). Researchers using this technique are able to examine how people make sense of themselves and of certain situations.

There are advantages to using qualitative exploration because of the benefits of using open-ended questions and probing. Both of these techniques give participants the opportunity to respond freely without any influence. Exploratory qualitative research has the ability therefore to find answers that are meaningful to the participant while being naturally rich in personal experience. The researcher also has the ability to probe participant responses to attain deeper and more explanatory responses. It is the researcher's task during exploratory research to listen carefully during data collection, so that they may ask the appropriate questions to encourage elaboration. These methods lead to an overall greater pool of data for the researcher to analyse and explore.

Following transcription of data collection, the exploratory design is characterized by data analysis steps of coding to create a picture of what is going on. Initial coding is the development of categories by segmenting information attained through qualitative data collection. Secondly, a main category can be brought to the center and emerging subthemes can be identified for each category. Finally, identifying interrelationships of all categories helps to develop the discussion, leading to a significant conclusion

This procedure provides researchers with clear steps to follow in analysis of their data and is commonly used in education. The constructivist design targets the views, values, beliefs, feelings, and assumptions of participants rather than attempting to describe actions. By identifying emerging themes in the qualitative data, a close look can be taken at reoccurring challenges in the implementation of inquiry based science teaching and what could be done to overcome them. The semi-structured interviews conducted with pre-service science teachers

help to get qualitative data for an in-depth understanding of their thoughts and experiences with inquiry based teaching. The reason for choosing this design is that qualitative interviews allow the researcher the unique opportunity to directly address the issues under investigation and the participants to share their perspectives.

Participants

The study was conducted at the Faculty of Education in a Canadian comprehensive university. Any students registered in its physics, chemistry or biology teachable classes could take part in the study. Teacher education in Canada requires that each candidate has two subjects that they can teach at the intermediate/ senior level. They are prepared to teach these two subjects in high schools after taking a sufficient number of related courses in their undergraduate degree. At the point in which 10 volunteers came forward to take part in the study, there were at least two students per teachable science class. Of the 10 people involved in the study, there were three females and seven males. There were six individuals with a physics teachable, four with a chemistry teachable and two with a biology teachable. As shown in Table 1.0, nearly half of the participants have completed a masters degree in the area of their undergrad, creating a pool of very intelligent and motivated participants.

Table 1.0 Participants

Participant	*Sex*	*Science Teachable Class(es)*	*Undergraduate degree*	*Masters degree*
Jeff	M	Physics	Physics U of Windsor	Physics U of Windsor
Alex	M	Physics	Electrical Engineering, coop U of Waterloo	
Amelia	F	Physics	Industrial Engineering U of Windsor	
Vincent	M	Physics	Civil Engineering U of Windsor	

Charles	M	Physics	Mechanical Engineering Overseas	Mechanical Engineering Overseas, repeated at McGill University
Anthony	M	Physics	General Science U of Windsor	
Matt	M	Biology and Chemistry	Biochemistry, Bio specialization U of Western	
Jay	M	Biology and Chemistry	Biochemistry with Thesis U of Windsor	
Laura	F	Chemistry	Biochemistry with Thesis U of Windsor	Biochemistry U of Windsor
Wendy	F	Chemistry	Biochemistry Overseas	Biochemistry U of Windsor

Recruitment Process

The objective was to recruit pre-service teachers who could report on their perceptions of and experiences with the implementation of inquiry based science. The appropriate professors (of physics, biology and chemistry teachable courses) were approached by the researcher and permission was sought out to visit their class for the recruitment of participants. During these visits at the end of scheduled classes, the researcher introduced inquiry based teaching and the research objective to identify what could be done to improve the success rate of its implementation in high school science classrooms. Class members were asked to volunteer for this study by participating in guided interviews. They were ensured that due to the involvement of human subjects, the researcher had received approval from the research ethics board to go forward with the project. The pre-service teacher recruitment script was administered and included a brief outline of the push for educational reform. The script provided details of the approximate length of the interviews and important information to inform a potential participants' decision. This included that the interviewee would be asked about his or her ideas around inquiry teaching and experiences in the classroom with implementing it. The script

ensured that that the interview would be kept confidential and that students would receive a more detailed letter of information about the project and participants if they were interested in taking part.

Once a student's initial intention to participate in the study was expressed, an interview schedule was set up. Potential participants showed interest in volunteering to be interviewed by emailing the researcher or by offering their email address during the class visit and then responding to an email from the researcher. Pre-service teachers could also indicate their willingness to take part by directly volunteering during the researcher's class visit. Once interview times were set up at the convenience of the participants, interviews took place in an available room, according to the interview time, at the faculty of education, University of Windsor.

Ethics Concern

Since this study involves human subjects, the issue of ethics must be recognized. Although the participants have low vulnerability due to the nature of the study, any risk to them was minimized by maintaining their confidentiality and ensuring they knew that they could withdraw at any point during the data collection.

A consent form for participation and an audio recording consent form were signed just before the interviews started. With the participants' permission, the interviews were audio-taped by the researcher for data analysis. The initial interviews took anywhere from 20 minutes to 55 minutes, averaging approximately 30 minutes. The seven follow up interviews averaged 10 minutes. Although the interview participants exposed themselves to the researcher during this time, their identification information was removed in the transcription of interview data and once the project was complete all data was destroyed and audio tapes were erased.

Data Collection and Instrument

Data were collected through semi-structured individual interviews with pre-service science teachers. The goal of this was to explore their perceptions of and experiences with the implementation of inquiry based teaching in their placements. The pre-service teacher interview guide assisted the researcher during the initial interviews in exploring the participants' educational background, work experience and perceptions of inquiry based teaching. It went on to identify how the participants themselves learned in high school, if not through inquiry. The second half of the interview aimed to discover how the participant approached the implementation of inquiry based teaching in their practicum. Specific examples were sought out and assessment of whether or not they were successful was discussed. This was followed by discussing challenges that students faced and what could be done differently in their own education for a future improvement in the implementation of inquiry based teaching. Participants were first interviewed after their second teaching placement, so they were provided with some time to get familiar with inquiry based teaching.

Follow up interviews were conducted, where possible, to identify any changes in perceptions or new valuable experiences after the student's third placements. New examples of how they implemented inquiry based teaching were asked for and whether or not they were successful was discussed. The interview guide consisted of ten set open-ended questions, allowing the participants to respond freely, without influence of the researcher's ideas. There were 7 participants out of 10 who took part in follow-up interviews. Only 6 of the questions were applicable to these interviews, some of which focused on a change in perceptions and experiences rather than direct descriptions.

Data Analysis

Interview data collected from the semi-structured interviews was analysed according to the systematic design strategy as set out by Strauss and Corbin in 1990 (Creswell, 2008). After transcription of the audio-taped interviews, the researcher looked at all data collected and formed categories of information pertaining to pre-service teacher perceptions of and experiences with the implementation of inquiry based science teaching. These include own educational experiences, perceptions, evidence of inquiry effectiveness, challenges and improvements. This open coding sets the stage for the second phase of coding, where the researcher chose subthemes to be discussed, which occurred within each category. Finally, by selective coding, the researcher identified existing relationships and emerging patterns between the categories and subthemes. This qualitative data analysis process was ongoing from the point of the first interview and beyond the last interview until the researcher was able to extract ample meaning from the data.

Scope and Limitations

Since pre-service teachers were interviewed regarding their practice in the classroom, the results are based on participants' word rather than observed actions. There are reported inconsistencies between what new teachers say they do and what they actually do in the classroom (Sadler & Klosterman, 2009). Similarly, participants in this study may have tended to report more or less success of their implementation of inquiry based teaching, because they may either desire a greater experience or feel modest about their success. This could in turn create inconsistencies in the emerging themes. Another limitation is that this study examines pre-service teachers' perceptions of and experiences with inquiry based teaching within the context of the university where this study took place in 2011. It is important to not over generalize the results, making clear that qualitative interviews with pre-service science teachers from this

University do not speak for all pre-service science teachers from other universities. However, this study will provide an avenue to attain a greater understanding of what is going on with the issue at hand.

CHAPTER IV: FINDINGS

This chapter provides a complete presentation of the findings that have been obtained from the collected data. This chapter will begin with the full description of one pre-service teacher's experience with inquiry. Each pre-service teacher will be reported on according to five headings. These headings include their experiences with education, their perceptions of inquiry based teaching, evidence of inquiry's effectiveness from practicum experience, common challenges to its implementation and areas for teacher and faculty program improvement.

There were a total of ten pre-service teachers participating in this study who were interviewed after their second placement. Interviews were then conducted for 7 out of 10 participants following their third placement, at the end of their program.

Having a clear vision of pre-service teachers own educational experiences can create an easier understanding of their ideas and experiences with inquiry based teaching. How these teachers learned connects to how they would tend to naturally teach in their own classrooms. Although there are similar experiences among the interviewees, unique challenges arise with each teachers attempt to implement inquiry based teaching. The findings of this study show that a variety of educational experiences and challenges can be explored to attempt to identify what can be done differently for the future growth of inquiry based teaching in the high school science classroom.

Jeff

Educational experiences. Jeff is a teacher candidate for both physics and math. He completed his undergraduate and masters degrees in physics at the University of Windsor. After completing eight months of a PhD, he decided to switch into the bachelor of education program. His most relevant work experience to teaching is his current tutoring of math high school

students. Jeff had never seen inquiry based teaching before his experience at the faculty of education. He learned through what he refers to as 'chalk and talk', and was provided with a few lab experiences per course. A typical lab would provide the students with a direct list of instructions and lead them to a distinct conclusion. As a result, he explains his high school experience in the following way, "I can count [the labs we did] on one hand. They were like just do this, write down these and you didn't really understand what you were doing."

Perception of inquiry based science teaching. Jeff's first impression of inquiry based teaching was very positive. He has viewed it from his first exposure, as an opportunity for students to come up with their own solutions by critically looking at problems. He expressed his pleasant surprise in implementing inquiry in his own teaching placements by stating, "it is surprising to see what the students can do sometimes. You'd think there is no way they are going to get this but then they do, so it's kind of good."

Evidence of effectiveness. Jeff found it particularly useful to try inquiry with the optics unit of physics, which he was responsible for teaching during his second placement. His school had an abundant supply of optics kits which provided the students with hands on discovery to keep them engaged and allow them to independently come up with laws of refraction and reflection. Jeff realized through his placements that inquiry takes time to implement in order to get it right. A teacher's expertise and approach proved to be very important to him:

> At first I realized I had to give more guidance than I was giving. You do have to especially with the grade 10s, push a little more. Like ok, try first trying this beam and see what happens. I found it worked pretty well based on the fact that they tended to get the laws. If I asked, "what does this depend on?" someone would be able to tell you and

> it's like the very first law, there it is. It kind of surprised me a few times that they actually got exactly what it was.

Challenges faced while implementing inquiry. Although Jeff's impression of and experiences with inquiry based teaching were both quite positive, he did not proceed without the common challenges of lack of student interest, classroom management, and not having enough time to teach through inquiry.

> There is no way we can do it. In any practical classroom, it is a great idea especially if they can learn more. I would love to do it but I simply can't spend four days dedicated to something that could normally take 15 minutes or I will never get through the curriculum.

Jeff also pointed out the significant challenge of an associate teacher's pre-existing notion of inquiry based teaching. In his first placement, his teacher encouraged him to explore any kind of teaching he wished. His second placement consisted of lower level classes, causing his associate to stay close to the structure she had developed.

As a new teacher, Jeff seemed fine to tolerate some chatting and minimal distractions while attempting to implement inquiry. Long term, this tolerance may decrease and classroom management may stand out as a greater challenge.

Improvement: both personal and suggestions for the faculty. Jeff attributes his increasing competence at implementing inquiry throughout the education program to more practice and growing confidence. He only learned about inquiry in his physics class, where it was modelled, and feels as though the pre-service teachers could benefit from seeing this method

of teaching in other classes as well. Based on his overall positive experience with inquiry based teaching, Jeff reflected on his experience in classes at the faculty:

> They could mention [inquiry] more. Again, physics was the only one that showed me anything with it. It was useful because he actually showed examples and he had us try and do it which I thought was great. Even some of the other classes talking about it would be useful. For me it is difficult to think of how I would apply it to something like math, I am not as confident.

Alex

Educational experiences. Alex completed an electrical engineering cooperative education degree at the University of Waterloo. Following this, he went straight into the bachelor of education program in Windsor. His teachables are in physics and math and he has had a variety of field experience through his engineering degree and his high school engineering coop placement. A typical day in science for Alex class consisted of a lecture with notes, questions from the textbook and a possible lab to follow up and confirm the information that Alex had been taught. He explained this well:

> There were experiments but it wasn't true inquiry based learning. It was more, you can do this experiment but it is all very leaded. There is only one way to get the answer... you already know because you have done the lecture first, what everything is. They set you up with the knowledge and then you are supposed to verify it as opposed to working on it and then verifying it. I can't even recall a time when they really used inquiry. It was more teacher centered rather than that discovery. At the end you show

> your understanding, this is what I should have got, so this is why what I have done is good or bad, so there is that verification of knowledge.

Alex managed to learn well through this teacher centered style, always remaining at the top end of the class. He discussed that later in University individuals have more of an opportunity to discover how they truly learn best, as there is more responsibility that must be taken on as a learner. For him, he continued to be successful with the way he had learned all through high school, but recognizes that if he had learned through inquiry, he might have been even better at that style of learning.

Perception of inquiry. According to Alex, it is very important to mention student responsibility when discussing his perception of inquiry based teaching. This teacher candidate expressed a liking for this method of teaching particularly because of its shift in learning responsibility from teacher to student. He spoke of the needed balance between content coverage and inquiry in order for teaching to be effective. This balance can't be attained if students are always being told exactly what to do, leaving less chance to discovering a student's potential.

> A lot of it has to do with putting the ownership of learning on the students. So what you are doing is it's almost like a guided tour but you are letting them make the discoveries. They are making the leaps of using data and experiments and things like that to be able to see the difference of how things in the world work. You are essentially setting up a guided tour so that they look in this direction but they make that leap to be able to do it. It's always great at the end to reinforce it and make sure they have the right ideas and they are making the right connections but like I said, allowing them to make the connections first and going from what they think they know, looking at and analysing something and then creating that, that leap of knowledge.

He identified inquiry as an avenue for students to build knowledge themselves by seeing a problem and figuring out what all aspects mean, with appropriate guidance.

Evidence of effectiveness. Alex discussed with his class, the concept of acceleration in grade 12 college physics. He wanted them to come up with a way of measuring acceleration by dropping a marble. They discovered that dropping a marble was too difficult to time and as a result came up with the idea as a class that using a ramp would work better. They were able to time the marble rolling down the ramp, providing overall, more consistent results. When they completed the actual calculations, they were able to see that acceleration due to gravity is supposed to be constant. They had already been exposed to the true value of $9.81 m/s^2$, but this activity provided a practical experience of allowing them to discover that acceleration due to gravity is constant, while helping them understand that stated value. This was the first physics class that these students had taken, so Alex had to begin with definitions of speed and distance. Taking this into consideration, he was particularly happy with how this approach to teaching acceleration turned out.

Challenges faced while implementing inquiry. With a teaching placement, experience with different material is limited, since you are only in the class for a short period of time. This created a slight challenge for Alex as he feels that not all units are equally easy to implement inquiry based teaching with.

Alex tolerated chatter and slight distractions, but didn't report that to be a significant challenge. He stated that "kids are still going to text, they are still going to be jabbering about what they are going to do on the weekend so you still have to be active."

In both interviews with Alex, he discussed time as being the greatest challenge and describes it as follows in his first interview:

> Because of the amount of things you have to cover with curriculum you have to be really good at setting up your lesson so it hits several parts of the curriculum in order to have that amount of time, 2 days, 3 days consecutively to do these full on experiments and inquiry based style of learning. That is the real difficulty. They have to have breadth, and hit a lot of curriculum because of the amount of time you are going to spend on it, but still be simple enough that they should be able to reach the logical conclusions that you are hoping to get from them. That is the hardest part.

Improvement: both personal and for the faculty. Alex felt he improved with each placement in his ability to try and implement inquiry based teaching. He does not attest this to anything in particular he learned at the faculty, but rather purely to more experience and greater confidence to deal with a lesson if it did not work out, and not be afraid to try again. He discussed the ability of an associate to facilitate a training teachers' likeliness to take risks and try new things such as inquiry based teaching. All of his associates were supportive of his interests in teaching. For his third placement, he stated that "it was definitely easier to try and implement this time round. I had more confidence and was willing to try everything."

Alex feels that there was a great amount of repetition in his classes at the faculty in terms of the teaching of lesson plans. "If teachers did not overlap so much and we had more time on placement, we would learn more." He feels strongly about this because his undergrad was an engineering coop program, where his most valuable learning was through each 4 month work term.

The majority of his exposure at the faculty of education to inquiry based teaching was in his physics class. It was mentioned in some other classes, but no examples were modeled, as in physics. "It seems we have a lot of theory and a lot of the ideas, we just need more chance to try them out and do those live experiments."

Amelia

Educational experiences. Amelia was the only female interviewed that was a teacher candidate for physics and math teachables. She completed an industrial engineering degree in Windsor followed by three years off to work before returning for her bachelor of education degree. Amelia can recall one high school project in biology where students had the option of coming up with an experiment that had to be approved by the teacher before conducting it. Her experiment compared the bone structure of cats to rabbits. Although this wasn't completely inquiry based learning, it was the closest experience she had to more independent learning. Otherwise, her high school science lessons consisted of lectures and labs with written out instructions.

Perception of inquiry. Amelia views inquiry based learning as a very natural way to learn and one that is very helpful for student understanding. "It is the way we learn from birth right, play with your toes or fingers till you figure out what they are." She described inquiry as a teacher setting up his or her students with the right amount of materials and information so that they will be able to figure out a problem or concept.

Evidence of effectiveness. Amelia reported doing a number of labs, but most of them were from the text book and therefore guided. Her best experience with inquiry was in her second placement, a grade nine math class. In this class, she conducted an activity that guided three different groups to come up with an exponent law by identifying patterns on a work sheet.

Each group had to then teach the other two groups about their method, resulting in all students knowing all three laws. This proved to be successful, leading Amelia to further believe in inquiry based teaching, although she felt she was limited in implementing it.

Amelia provided an example of successful implementation of inquiry based teaching outside of her classroom experience:

> I just think inquiry based learning is really helpful for student understanding when they teach themselves in a way. I was looking at the lab school in Toronto. It looks really interesting. They start from a really early age there, letting the children discover everything for themselves, even if it is playing with dirt or frogs, they learn the world through themselves.

Challenges faced while implementing inquiry. It is clear that Amelia recognizes the value of learning through inquiry, seeing as it is a natural approach to the world. However, she sees the lack of this kind of learning earlier on in school as a major challenge to its implementation in a high school science classroom. Because of this unfamiliarity, experienced teachers are not necessarily keen to try out inquiry based teaching. This was the case with Amelia's first and third placement associate teachers. They both liked to do physics labs, but did not feel comfortable straying from the traditional cook book style in textbooks. This created a major obstacle for her in trying to implement inquiry based science teaching.

In both interviews with this pre-service teacher, she spoke about time being a major challenge. She expressed that it is difficult enough sometimes just to get through the material, without incorporating a more time consuming method in which to teach it. She also finds the planning aspect of these kinds of lessons very time consuming, since as a teacher you need to be

organized and ready for all scenarios. Finally, she shared some frustration that she even experienced with academic classes:

> There is a group that really gets off task and I don't want to be babysitting. I found this with all of my placements. I had classes that were academic but there was still that group of students that almost just wants to play. You give them materials and they are not really focused on what they need to do.

This comment was not in relation to inquiry based teaching, but to teaching as a whole. With an increase of inquiry, she suspects a greater need for classroom management.

Improvement: both personal and for the faculty. Amelia feels as though her time at the faculty did help her to become more comfortable in her placement, but the largest contributing factor to her improvement was practical experience in the classroom. In her first interview she expected her third placement to be even better due to more practice, and she reported that her expectations were met in the final interview. Amelia's second associate teacher provided a lot of feedback daily to her, which she found very helpful for day to day improvements.

Amelia feels as though there should have been more modelling of inquiry based teaching at the faculty, along with some informal discussions of how to implement inquiry. She would have preferred this along with less of an emphasis on structured lesson plans.

> A lot of the program feels like we are doing a lot of the same things over and over again...Maybe just run through ideas of how you can implement inquiry a little bit easier in more classes, not necessarily huge things you have to hand in and write up that are just really time consuming. In physics we actually looked into it and had to write up a lesson

> that was inquiry based so he really covered what inquiry based learning was and why it is so important. The other classes may have just mentioned it.

She continues on to discuss that the faculty does teach a lot in the bachelor of education program, but that the focus is "maybe a little bit off".

Vincent

Educational experiences. Vincent completed his degree in civil engineering at the University of Windsor, qualifying him for a teacher candidate of physics and math. His most relevant work experience to teaching has been tutoring math and science for the previous two years. Vincent did not learn through inquiry at all in his secondary education. His classroom environment was teacher centered and any labs were guided with distinct instructions. "It was largely little note lectures, do an example, do the problems, next day take it up, do another note, do the examples, same thing every day."

Perception of inquiry. Vincent found that his perception of inquiry had changed over the course of the education program. Initially, he didn't see inquiry as the well thought out and planned teaching method that it is, but rather as a method allowing students too much freedom, with tendency for classroom chaos.

> When I first heard of inquiry based teaching, it was the first thing we did in physics, and I just thought it was useless completely because I was like we are paying teachers to teach, they should be teaching, not sending us off on wild goose chases. But as I saw it work, it is actually pretty good. I realize now it takes a lot more planning to get the activity to work out the way you are hoping it will. You have to create a lesson that allows you to basically give students a very minimal amount of information or a minimal amount of the equipment they are going to need and then they take that and use that to develop their

> own understanding of the topic that you are teaching. So basically you give them the opportunity to develop their own perceptions and then you take those perceptions afterwards and you mould them into what they should be basically.

Overall, he grew a greater liking to inquiry as he was faced with opportunities to implement it in his practicum.

Evidence of effectiveness. In Vincent's grade nine science class during his second placement, he questioned the students about their knowledge of electric circuits. He provided materials for them to build their own and circulated throughout the class to guide students with questions as needed. By the end of the lesson the class was able to see that if you break the circuit in some way, the electrons can't flow and the light is going to go off.

In another grade nine science class, in his first placement, he set up stations so that students could find out the difference between static and kinetic friction or to see how factors like weight would affect friction. Although this lesson was guided for the students, he still provided them the opportunity to figure out the concepts for themselves, instilling that discovery aspect of inquiry into their learning.

Challenges faced while implementing inquiry. Vincent came across student resistance to learning in a new way. Students claimed they didn't have the proper background for certain activities, and therefore seemed to lack motivation and interest.

Vincent's associate teachers were very experienced, open minded and happy to see their student teacher try new things. Vincent recognizes that he was lucky in this area as he was given the freedom to attempt to implement inquiry based teaching however he felt necessary. In doing so, he found classroom management to always be a slight challenge.

> It is a little more challenging, especially because I had a large classes. Because they don't know what they are doing, it is easier to have students drift off, but once they started to figure out what was going on, it was a lot easier to control and it also helped obviously having an associate in the room so there are two people.

Improvement: both personal and for the faculty. Vincent attributes his success in trying out inquiry based teaching largely to his associate teacher.

> My associate was teaching for 18 years, but she was good and has been taking classes now to try and incorporate technology and incorporate all that stuff. She was excellent like that. it was because of her that I was pushed to use these kind of techniques cause honestly when I first heard of inquiry based learning, it was the first thing we did in physics, and I just thought it was useless completely.

Vincent was able to try out inquiry lessons and whether or not they were successful, his associate was supportive and provided constructive criticism. With more practice and experience in the classroom, he felt a significant improvement in his attempts to implement inquiry based teaching. In his third placement, he had a second chance to teach the same unit in grade 11 university physics. He made changes to things that didn't work well the first time around, resulting in an overall more positive teaching experience.

As for the faculty of education, Vincent recognizes a need to talk less about inquiry based education and provide more modelling of this teaching method. He would however like to see more discussion of the in depth planning that is required for inquiry based teaching in order to help minimize behavioural issues.

Charles

Educational experiences. Charles completed his undergraduate and masters degrees in mechanical engineering overseas and worked in this field before coming to Canada. He then worked for 12 years in the automotive industry in the United States before repeating his masters in mechanical engineering in Montreal, as his was not accepted in North America. This participant then decided to take his expertise and variety of valuable experiences to the classroom himself.

Charles learned through inquiry and shared of the experience of having to construct knowledge with little guidance. His educational experience was not based on memorization and given information, but rather on critical thinking and discovery through questioning.

> It was common to produce knowledge over a blank sheet of paper. Ok you get the question and you start from scratch. You derive your own formulas and this is where you have to understand and that makes you have this inquiry quality about you because you can't remember and retain knowledge over the long term unless you really understand how this came about.

Charles's exposure to inquiry in his own education was not inclusive of a variety of materials for student interest. That depended on the personality of the teacher and how interesting he or she could make the lesson. Since Charles was educated outside of Canada, through genuine experience he is aware of how education systems can vary greatly from country to country.

> My education dates way back and it was overseas in a different setting and I went through a high school where I chose physics already as sort of a high school major. I had a lot of physics and eight different subjects. I can tell you now it is really impressive when you go overseas and see what people are doing. Because people are struggling and they think that education is the ticket to success, they brought physics into grade six

> elementary with teachers who have a bachelor degree in physics. So you have subject teachers with physics in grade six. It is incredible.

Perception of inquiry. This participant expressed his opinion of inquiry based teaching by recognizing its positive points, but is not able to imagine it in full working form in our school system. He discussed that with inquiry based teaching, we have to assume that students are interested, otherwise the inquisitiveness that is needed to fuel such a method of teaching, is missing. This assumption is hard to maintain with the variety of learning styles and student achievement levels that exist in any one school.

> It's a very noble idea to have students go through a logical thinking process of discovering physics. I don't believe it is very practical though. It is easy to relate to. To a certain extent it sort of makes an assumption that you are not able to explain well enough so you have to put them through these exercise of finding it out for themselves by doing something first hand, some kind of lab or something. But in fact I believe if you really know physics you should be able to explain it in an interesting enough way so they should be able to grasp the concept to begin with because you can retell a lot of these experiments and fortunately enough you have technology now you can show a lot too. It's much easier than 15-20 years back when they were dependent on a still picture. Now you can play a little movie. But to put them through the whole exercise or putting a set up together and then with even minimum guidance have them wander around and come up with a logic of their own of how to steer the activity to discover something... I don't think it is very practical.

Although it is a great idea in theory, this participant feels that the practice aspect of inquiry does not quite match up.

Evidence of effectiveness. Charles did not attempt inquiry based teaching in its full form, as he found it very easy to lose student engagement through providing any lesson that was not completely guided.

Challenges faced while implementing inquiry. Although he did not implement inquiry based teaching, one of the main reasons was due to limited time. He "just didn't have time for it." Charles went on to discuss that the schools he had practicum in typically had lab materials that were not maintained, requiring him to collect or buy his own materials. This was another factor in taking up time for lesson preparation.

The greatest challenge overall, in his view, is that this thinking process needs to be nurtured from an early age. Otherwise, teachers are going to continue to have the ongoing common issues of implementing inquiry based teaching into classrooms such as lack of student interest and motivation. Charles expressed his feelings about this issue:

> If they are not brought up to think and to find out for themselves, you can't make them. They are just going to wander around waiting for instructions because that is what they are used to. Now you are flipping the table on them, you want to change the whole education system round and say ok now, this is novel, this is going to result in a different quality of knowledge and you know, they are really going to understand and they will be able to make so many more connections and they will be able to retain this knowledge over a long period of time, yes, that is all true. But then you have to start bringing inquiry based stuff into kindergarten and from there on so by the time they come to high school they are your, you know, students to have for an inquiry based class.

He then talked about how knowing content is much more than putting it up on the board. Teachers need to be experts in their subject area in order to be able to teach inquiry effectively

and he sees this as a challenge to the implementation of inquiry since not all teachers have major degrees in their subject area.

Improvement: both personal and for the faculty. Charles did not have a follow up interview and did not report any significant personal improvements in teaching in the first interview. He did however share that he feels the faculty of education is doing the best that it can in preparing pre-service teachers for implementing inquiry based teaching. He saw a few examples over the course of the year of what inquiry should look like, but he feels that the faculty needs to make this connection with the school board and schools. The only way he sees this possible is if there were a gifted school with which they could try and implement inquiry with a portion of the curriculum. After seeing how and if this could work, growth of inquiry could slowly follow. Although this would be a long way from making it work in a college level class, it would be a start in the direction of more implementation of inquiry based teaching.

Anthony

Educational experiences. This teacher candidate with teachables in physics and math, started off in an electrical engineering program at the University of Windsor. He eventually switched to College and then back to University to complete a degree in general science. He has been tutoring for over nine years at institutions such as Sylvan learning center as well as being self employed. This work experience encouraged his pathway to teaching.

Anthony expressed thankfulness that he had genuine interest in learning, especially in the sciences, when he was in high school. He typically completed labs to solidify what he learned in class, and otherwise learned from a book, handout or lecture. He did have the opportunity to take a course on building circuits and residential wiring, which drove him initially into the electrical engineering field of studies. He was attracted to the hands on but found it hard to find a balance

of practical and theoretical courses in both university and college, switching finally back into university to complete a science degree.

Perception of inquiry. Along with many of the other participants, Anthony described the benefit of inquiry being that students have to critically look at problems and find answers themselves.

> Inquiry based learning to me means that the students are actually involved in formulating their own ideas about what a given topic is so they are not being told directly, this is what this topic is, this is how you analyse this circuit, this is how you do something. You let them work through trial and error, design their own way of learning or way of testing to see if their thinking is proper. They are very involved and it is very student directed, they can do whatever they want pretty much, as long as they are learning.

He showed in his explanation that this discovery approach can help to develop thinking skills and aid students in the solving of problems.

Evidence of effectiveness. Anthony was able to implement inquiry based teaching with the topic of acceleration due to gravity in his grade 11 university physics class. His inquiry lesson unfolded as the topic began:

> One of the students had noticed that things speed up when they go to the ground, they don't fall at a constant rate. So I decided to allow them to figure out how fast does this speed up. I just let them have free rein and say ok, bring in something that you can drop, like on the floor. So they knew that they were going to be dropping something, they were going to be calculating something, but I didn't specifically tell them what to do. I allowed them the first 10 or 15 minutes of the class as a group to come up with a procedure. I let them write it up and I had to okay it.

Anthony went on to explain how the class became quite inventive with what to drop, from where and from what height, leading to some very accurate results. They designed and carried out their own experiments and wrote up their findings. Anthony made it very clear that he was not focused on the right answer, but rather wanted to focus on what they came up with and what the sources of error were. Proof of this labs success was the great understanding that was shown on the communication part of their test. Overall, Anthony thought that the students felt like they were really involved in the process and therefore would ideally retain more of the knowledge they had gained.

Challenges faced while implementing inquiry. In order to truly implement inquiry based teaching, Anthony reported that "it's a lot of planning." It takes a great deal of time to plan properly and prepare oneself for the right kind of questioning in order to lead a lesson with inquiry. The need to ask converging questions requires teacher expertise and with some topics, a great deal of background knowledge for both student and teacher. Anthony learned this in his grade 11 university physics class while trying to teach the graphing unit. Students asked many unexpected questions and he had to be well prepared to steer them in the right direction. On a couple of occasions, the students lead the class in a different direction than where he wanted to go.

Improvement: both personal and for the faculty. As Anthony proceeded in his teaching placements, he became more confident with time and practice. That same nervous feeling that resided so strongly with placement number one, eased considerably with each additional placement. In his second placement, Anthony discussed feeling more comfortable to take risks, and again in his third placement. As this willingness to try new things increased, so did the amount of facilitated group work and inquiry based learning in his class.

Anthony only reported having to do an inquiry based lesson plan in his physics class. He therefore does not feel that the faculty of education did a sufficient job in preparing students for this kind of teaching. He did not hear about inquiry in any other class, and therefore was very limited in seeing it modelled. He felt like the classes at the faculty of education were very repetitive, covering "the exact same thing in every class about what a lesson should have from everyone's perspective." He expressed concern for the lack of inquiry based learning both presently and in the future.

> If you have a science classroom that is not in an inquiry model at least partially, then kids are never going to want to pursue it further and that is why you see declining enrolment in science. You see a lot of Psychology, a lot of Sociology, because you can see that they are going to help people one day. Here, it's like ok, what is science. I am good at math I am good at science and that is why I go into it. It is not usually because people have passion.

Matt

Educational experiences. This teacher candidate completed a biochemistry degree at the University of Western Ontario. He finished with a specialization in biology which requires four more courses than a major, and a minor in chemistry. He therefore is a candidate for teaching biology and chemistry. He began tutoring grade seven and eight students for his 40 hours of community service in high school. He continued to tutor throughout his undergraduate studies and volunteered at a resource center to help kids with their homework.

Matt expressed a keen appreciation for the way that he was taught and its suitability to his learning style.

> We would walk in, sit down and he would write on the board this is your note for the day, write it down, homework from the book and that was it. I love that... we can't teach like that anymore but that is how I learned and I am fine with that.

Whether his success in high school was because this was an effective way of learning, or simply a method he had to get used to, this student regardless took his positive experience and pursued a science degree in university.

Perception of inquiry. This participant views inquiry based teaching as a situation where students want to know how something works and them building towards that knowledge with the help of the teacher. As time went on at the faculty of education, Matt began to like inquiry based teaching more. He didn't see the way that he learned as a problem, so he initially was not too interested in inquiry based learning. After realizing that not a lot of students learn well in the way that he did, he became more interested in the concept of inquiry based science teaching.

Evidence of effectiveness. Matt taught an everyday science class in which there were no tests, quizzes or notes. They used only hands on material for discovery of concepts and issues affecting our everyday lives. Through this inquiry based style of learning, the students were able to grasp the main concepts in the course.

With his grade 12 university chemistry course, he tried out a strategy that incorporated a balance of both inquiry based learning and theory from the textbook. For the topic of properties of solids he assigned half of the class to create a model and teach themselves concepts from the textbook while the other half of the class did lab based activities to actually find the properties of the solids. The second day, he switched the groups around and felt that it worked quite well.

"Some kids like the lab more and some kids that are just like me, analytical, they want to sit and read the text book, know it and be done."

Challenges faced while implementing inquiry. This participant finds it much harder to engage students with chemistry than with Biology. "To teach a kid ionic bonding is more difficult than if I were to teach them viruses because they care about it less." Overall, the challenge of student interest exists with any subject. Inquiry based teaching can be better implemented when students are curious to know about how something works. Matt taught an essentials level grade 10 science class and on any given day, only half of the students were present. This lack of student motivation and interest made it very challenging for him to cover any material without gaps from absenteeism.

As a result, Matt found classroom management a reoccurring challenge. He had behaviour issues in at least one class in all three of his placements. As a learning teacher, this made it a lot more difficult to try and implement inquiry, since classroom management issues often go hand in hand with lack of interest.

Finally, this participant found his associate teachers to be a large obstacle for the implementation of inquiry based learning. "The first problem is always going to be, how does the teacher teach before you get there?" He taught in a grade 12 university class, where the teacher put up an overhead from 10 years ago. The students wrote it down and recorded the textbook questions for homework. Having to teach like this as well, Matt covered material nearly five times faster than other colleagues in the bachelor of education program. From his experience with associate teachers, some simply "teach the same way they did 10 years ago and they are going to keep doing that."

Improvement: both personally and for the faculty. Matt feels he would have been better prepared to teach through inquiry during his second placement, but because of his associate and his challenging classes, he was unable to. His classes during his third placement had severe attendance issues, so again he was not able to see his own potential in inquiry based teaching.

Matt shares a common feeling that the faculty of education courses are repetitive and not entirely practical. He is not alone with his feelings of what changes could be made.

> Maybe there could be more examples of an inquiry based lesson. For instance the chemistry class I was in ... I don't really think... I mean, we were told what inquiry based learning is and we were told when we were making our lesson plans to make them inquiry based but we weren't given really any examples to go from.

Jay

Educational experiences. Jay completed an honours undergraduate degree in biochemistry with a thesis, making him the second male participant with biology and chemistry teachables. The methods of teaching through which Jay learned were not reported to be exciting and engaging, however, he still managed to learn well with the way he was taught. He decided earlier on that he did not benefit from note taking, but rather from listening alone.

> There were a lot of times where we would be listening or watching a presentation and writing down a lot of notes. For me that is not how I learned so I didn't get much out of the notes. I did get a lot out of the labs and a lot out of the speaking.

Perception of inquiry. Jay views inquiry based teaching as a discovery approach to learning, allowing students hands on experiences where they become involved in what they are finding out.

> Inquiry based learning to me would mean that students have to build the knowledge themselves by seeing a problem and trying to be able to think about exactly what all the aspects would mean. So as an example, talking about gas laws...having students see what happens when you change the temperature, the effect on the pressure and volume of different gas containers.

Evidence of effectiveness. Jay did not complete a follow up interview and only reported one example of where inquiry seemed effective in his classroom practicum experience. The following was with a biochemistry unit in his grade 12 biology university class.

> I did an experiment with eggs where we dissolved the shells off using vinegar and then we would put it in different solutions to see what would happen to the volume of the egg. The students would have to think what must have happened, what must have left there, based on what they already know about membranes and just the volume changes in the egg.

The students were provided with materials and had enough background knowledge to lead their learning in the direction that Jay intended.

Challenges faced while implementing inquiry. Jay found it difficult to implement inquiry with certain topics. In his first placement, he taught the beginning of the chemistry unit for a grade nine science class. It was a lot to do with models of atoms, which he didn't find leaves too much room for inquiry based learning.

His inexperience created a challenge as he was very nervous during his first placement. He became slightly more comfortable the second time out in the field, with anticipation that this would continue to get better. An increase in confidence allowed Jay to be able to focus more on teaching and less on survival.

He brings up the issue of time at three different points in his interview, viewing it as the biggest challenge to the implementation of inquiry based teaching. Part of the time factor is creating activities that will engage the students and bring their level of interest up, another pressing issue that Jay noticed, with inquiry based teaching.

Improvement: both personal and for the faculty. With an increase in confidence and practice, Jay was better prepared to attempt to implement inquiry based teaching.

At the faculty of education, Jay would have liked to have seen more modelling of inquiry based teaching, for the development of a better idea of what it would look like in the classroom. He suggested having all students partner up and create an inquiry based lesson to be administered in presentation form, as if the classmates were students in high school. This would give the pre-service teachers a chance to recognize true inquiry based teaching with discussions, and collect some resources that may be used later on in their teaching.

Laura

Educational experience. Laura is only the second female of the participants and completed an honours undergraduate degree in biochemistry with a thesis. This was followed by attaining her two year masters degrees in biochemistry. Her teachables are in chemistry and math and her most relevant work experience is tutoring and grad assistantship during her masters degree.

Laura had one teacher in high school that was trying to implement inquiry based teaching and likely motivated by his interests in working in the board or administration. Otherwise, aside from labs to sometimes confirm what was learned in class, her learning was “largely little note lectures, do an example, do the problems, next day take it up, do another note, do the examples,

same thing every day." Although this wasn't very exciting, Laura was engaged enough to go on to complete her undergrad in biochemistry with an honours thesis.

Perception of inquiry. Laura's last teaching placement helped to develop her perception of inquiry based teaching:

> It is having the students discover theories and stuff. Actually in my last placement, my teacher always tried to do that. He would start off with a question for the students to kind of present them with a sort of dilemma and then we would work through problems to see if they would notice a pattern to eventually get to a theory. So that was actually pretty good and the best I have ever seen it modelled, but it was in math.

Evidence of effectiveness. This participant was able to model her math associate teacher and also implement inquiry based teaching in math. She reports that the students were very engaged and were able to tell her what to write. In her grade 10 science class, she found it difficult to bring inquiry into the biology unit. During her follow up interview, she tells of the closest she was able to get to implementing inquiry based teaching.

> I did this constructivist approach where they had to trace the path of oxygen, from inhalation. They were all on task, there were no students sitting doing nothing. I really should have given it more time. That wasn't really inquiry, but it followed the constructivist approach which is sort of getting closer to inquiry. That was the best lesson I had the entire time. If I could implement stuff like that I for sure would do it in the future, it is just how to get the students on track with that sort of thing is the most difficult obstacle.

Challenges faced while implementing inquiry. Laura found it challenging to keep students on track when allowing them a little more freedom in their learning. Through speaking

with other experienced teachers in her placements, she found that this was common. When she taught a grade 12 university chemistry class, the teacher wanted her to stay close to the curriculum and focus on covering the concepts rather than trying out inquiry based teaching. Laura didn't hesitate to follow her associate teacher's suggestion however, if she wanted to implement inquiry based teaching, she didn't feel as though she had a clear enough idea of how to do it in chemistry.

> Math is more intuitive so I found it easier because they have those basic skills but in chemistry kids are already kind of shaky on it... it's kind of a harder subject to wrap your head around it... so it is difficult to implement.

Other challenges that became evident to her were lack of student knowledge, interest and limited time. If an inquiry lesson did not accomplish what it was meant to, a teacher would end up having to teach the concepts a second time.

Improvement: both personal and for the faculty. Laura was successfully able to implement inquiry based teaching in her math practicum which she attributes to her associate teacher modelling it well. She did not feel like she saw enough examples of chemistry inquiry based teaching in her placements nor at the faculty, therefore leaving her unsure of how to really do it.

> Some more concrete examples would be nice of what I could actually use because I would love to do it... I just you know.... in my placement for math I could do it because I saw him do it. I understood what he wanted me to do. That definitely helps a lot for me.

Wendy

Educational experiences. The third female and final participant in this study completed her degree in biochemistry overseas, followed by several years of working in that field before coming to Canada. She completed her masters in biochemistry once arriving in Windsor and is a candidate for teaching chemistry and math.

This participant shared an experience of having to produce knowledge with little guidance. Her educational experience was not based on memorization and given information, but rather on critical thinking and discovery through questioning.

> Inquiry was very much a part of our learning. We were not allowed to regurgitate information. We had to solve tones of problems... on a daily basis. Every single day in chemistry we had to solve problems as well as listen to lectures, do our homework, we had to come up with problems. We were asked to design our problems and share them in class.

Wendy learned with exposure to inquiry based teaching through education overseas. With her genuine experience in education both overseas and in Canada, she holds the opinion that education systems can vary greatly from country to country. She goes to the extent of saying that "the education system here is delayed," providing details of how multiple choice does not exist in undergrads nor masters programs in her home country. Multiple choice assesses "lower level thinking skills, but you need more than this to succeed in university and beyond."

Wendy's experience of learning physics and chemistry was very rigorous, while biology was a little more relaxed.

Perception of inquiry. Over the course of the year, Wendy stated in her follow up interview that she grew to feeling even more positive about this method of teaching. She feels it is important for students to have an opportunity to develop thinking skills and work more

independently towards solving problems. She feels inquiry based learning can provide this experience for students. Wendy expressed that "otherwise they are just copying notes and would be able to reproduce whatever you told them in the classroom, but this is just regurgitation, not thinking and asking themselves questions in order to better understand the knowledge provided for them."

Evidence of effectiveness. Wendy implemented inquiry based teaching in her chemistry classes by first discussing related concepts and identifying student misconceptions. To introduce her metal reactivity lab, she linked it to ionization energy, since she had previously covered that topic. Students were responsible for coming up with which metal is more reactive than the other metals based on working with the provided materials. Wendy "always use[s] the students to help by putting questions up on the blackboard. They really seem to like to be involved." Based on the metal reactivity, the students could deduce which compounds were ionic or covalent. She felt that even reluctant students were interested, engaged and took responsibility for their learning. Above all, they understood the concepts and they arrived at that comprehension through discovery rather than listening to the teacher.

In biology, Wendy came up with an activity to teach natural selection with a creative collection of materials.

> I brought different kind of beaks and I used long straws for long beaks and short straws for short beaks. I gave them a mixture of seeds and they had to mimic how they could pick them up and based on that they had to record their results and they would see very clearly that in an environment where they have to feed on hard seeds, they have to develop a strong beak and from there they were able to realize exactly how the natural selection took place.

She continued on by having the students come up with a hypothesis regarding sexual selection, and followed up with a discussion session to identify the weak and strong points of their hypotheses. The students ended up with a deep understanding of this unit.

Challenges faced while implementing inquiry. Wendy experienced some student reluctance in the beginning of trying to implement a different way of teaching. She dealt with this mostly in her inner city grade 11 university biology course, as the students wanted to be given information and expected multiple choice questions on the test. Wendy made it very clear she wasn't going to do this. As students proceeded, they began to warm up to new ways of learning.

Wendy's second placement with a grade 11 university chemistry class in the county, presented her with less classroom management. These students were responsive and collaborative from the beginning, showing her the variation of schools that exist, potentially depending on location.

Although she had to carry some lessons onto the next period, she does not feel as though time presented a challenge for her. She related this to her own educational experiences in saying "I never felt restrained. I had no problem with it. I think this might be connected to my experience in high school... having inquiry modeled to me."

Improvement: both personal and for the faculty. Wendy's teaching improved throughout her placements, leading her to a positive experience of implementing inquiry based science

> It was easier for me to use inquiry in placement three, but I don't think it has to do with anything at the faculty. It has to do with the second placement and what I tried to implement. It worked partially and in my third placement I just decided to take my

> chance and I will teach this placement how I want to teach. I participated in a math and science seminar and the guy that organized it inspired me to do that by saying that "you have three weeks of placement left, don't be shy to implement these strategies." And he showed us, he modelled.

With more time and practice, her confidence improved and therefore so did her overall teaching experience.

Like many of the pre-service teachers, Wendy feels as though the faculty could better prepare students to implement inquiry based teaching by modelling the method more and in all classes. Wendy recalls learning about inquiry in many of her classes, but only saw examples of it in English and chemistry. She feels as though there could have been less emphasis on what she calls "busy work", and more emphasis on practical experiences that could be used in the classroom.

CHAPTER V: DISCUSSION

This chapter will begin with discussion of the pre-service teachers' educational experiences. A discussion of the four remaining themes will follow, including perceptions, evidence of effectiveness, challenges and improvements. Comparisons will be made throughout to existing literature while addressing the questions that guided the study.

Educational Experiences

Since pre-service teachers come from a variety of backgrounds and experiences, this study shows that they will naturally develop their own unique perception of inquiry based teaching. Similarly, Marks and Eilks (2008) show that students who have been exposed to open minded learning methods such as action research, are more openly critical therefore promoting scientific literacy. Eight out of ten participants in this study completed their high school and post secondary education in the Windsor-Essex area quite recently. Half of these students went on to complete a masters' degree in their science background before enrolling in the bachelor of education program. The remaining two participants were educated overseas, and completed their undergraduate degrees more than 10 years ago. These candidates went on to complete a masters degree in their discipline once they arrived in Canada. Each group of participants, both those educated in Canada and overseas, experienced different methods of teaching in their secondary education, building for each individual, their ideas of inquiry based teaching.

Those who were educated in the Windsor-Essex region experienced a very teacher centered learning environment in high school. Although each experience is unique, they generally learned through lectures, note taking and guided labs. Jeff carried on each day, "not really understanding what [he] was doing," while Anthony reports learning well "because, luckily [he] was interested." The other six participants describe their methods of learning as a

very repetitive process, containing "the same thing every day," in the words of Vincent. Nelson (2001) describes the typical 'cook book' lab as seeking answers to an expected result, without any understanding of what real scientists do. Anthony in particular, after having learned through structured labs, made it clear that he was not interested in the right answer when conducting labs in his placements. He preferred that the students focused on their process, and why certain things occurred the way they did. This allowed his students to gain a better understanding of how scientists work. The participants' backgrounds of lectures and instructed labs, led to a collective positive view of inquiry based teaching, regardless of their familiar personal learning styles. They tended to see inquiry as an innovative way to engage students and bring back the natural curiosity that science should be associated with.

Of the eight pre-service teachers who were educated in Canada, two reported to particularly learn very well through teacher centered methods. Neither did Matt nor Alex initially find inquiry based teaching to be very useful. They did however experience a changing perspective of inquiry based learning as they had opportunities to implement it in their placements. They began to like it and see it as a positive way to teach the variety of learners that each classroom has. This perspective was not attainable without the experience of being teachers themselves since Matt and Alex both did well with the traditional way of teaching. In their world as students, teacher centered classrooms worked well. The other six students who were educated in Canada managed to do well in high school and accepted that teacher centered lessons were the norm. These individuals did not relate well to this style of teaching and therefore initially found inquiry based teaching to be quite opposite and potentially engaging. Inquiry offered something that they thought could have provided a different learning experience for them in high school and were therefore willing and interested to try it out. Regardless of personal learning styles, all

students educated locally saw, at least eventually, that inquiry based teaching was a method of teaching they would like to bring into their own classrooms. This was not how they learned, but it appeared to be a way to get learners to think for themselves and come up with their own solutions.

Anthony's experience of starting at university, switching to college and then ending back up at university was a result of a search for the right balance of theory and practice in his learning. In discovering that university was far too theoretical and college was all hands on, he proceeded to complete his degree as quickly as possible. With this educational experience, he approached his first teaching opportunity at the faculty of education with a desire to implement this innovative concept of inquiry. He felt that it would help him deliver content with a balance of providing students the opportunity to be involved in formulating their own ideas. Due to his lack of inquiry in growing up and his exposure to hands on in college, he was driven to make this work, but found it challenging to meet the demands of time in preparation and implementation.

The two who were educated overseas, Charles and Wendy, feel they learned very much through inquiry. This was implemented with an expectation that students would take initiative in their learning and solve problems on their own through trial and error. Although Charles didn't experience inquiry through engaging materials, he and his classmates were constantly expected to be independent learners. It was up to the teachers to "explain physics in an interesting enough way." This in turn would set the students up with the right balance of knowledge to be able to design, infer and conclude. Wendy learned more with engaging materials in labs and in her classroom, which aligns more typically with the inquiry based teaching that is being encouraged by The American Association for the Advancement of Science and the National Research Council. Both of these students, who grew up with more accountability for their own learning,

attribute their own success and motivation to their personal learning style. It was not uncommon to fail in their high schools and therefore, without elevated drive and motivation, students would not graduate. In their cultures, there exists a very large emphasis on education being the only way to succeed. They were therefore cultured in a system where student initiative was a necessary aspect of both elementary and high school education. For them, inquiry based learning is a more natural approach than for the other participants who did not learn in this way.

Since Charles and Wendy were nurtured in systems with inquiry based teaching, their personal learning style is best fitted to a student centered environment. Both of these participants therefore recognize that this style of learning is an excellent approach. However, this common belief transcends to different overall perspectives for the two of them. Wendy's perspective of inquiry based teaching is largely aligned with those who were educated in Canada, while Charles' perspective is set apart, which will be discussed in the following section.

Perceptions of Inquiry

Every participant recognizes that inquiry based teaching could be a very effective method in the classroom. Charles, who was educated overseas, believes however, that it is a totally impractical approach for the Canadian education system. Because of his experience in his own education with inquiry based learning, he has been exposed to the keen student motivation that made inquiry successful. Coming from a country where people are generally struggling, they look at education as the only route to success. He expresses his thoughts of how many of his classes in practicum did not have this innate interest.

> I don't think you get that critical mass of interest you know across the whole class to participate and if it is not guided step by step, they are going to just waste time. Even guided hands on labs took a lot longer than I thought they should because they are slow,

> they wander around and talk and you know this is kind of a second to them. To have true inquiry you have to have people interested. Here people have been trained through just the modality of testing from an early age, to have a minimum of creativity if you ask me.

Charles comes from a system where you have to "derive your own formulas" and he claims this is where "you have to understand and that makes you have this inquiry quality about you because you can't remember and retain knowledge over the long term unless you really understand how this came about." His experience of inquiry based education, has developed his perception of the potential effectiveness of such a method while remaining aware of its impracticality in matching up with the way that students typically learn in Canada. He was not therefore even willing to try it out in his placement due to the apparent lack of student interest and the small window of time that he had in each placement.

The other overseas educated participant, Wendy, who learned through inquiry, did not focus on the impracticality of this method in describing her perspective, but rather on the quality discovery aspect of inquiry, which is supported by Goodenough (2004). She recognizes the same difference in the education systems that Charles does, but regardless felt very motivated to try inquiry based teaching. Her success in turn led to enthusiasm for this method of teaching, leading to a higher self efficacy. This is in line with Richardson and Liang's (2008) findings, that a pre-service teacher's self-efficacy is predicted by factors such as a greater ability to engage in activity based instruction. As Wendy became more able to implement inquiry based teaching, she began to believe more in her own teaching skills. The difference in views of Wendy and Charles could be attributed to experiencing different types of classes in their placements. Both pre-service teachers reported having some issues with classroom management and the findings show similar struggles of student chatter and disinterest. According to Sadler and Klosterman

(2009) there are inconsistencies between what new teachers report happens in their classrooms and what actually occurs. Perhaps in reality certain classes were more difficult, leading to Charles' perception of inquiry being impractical.

Since the eight participants who were educated in Canada did not have a successful model of inquiry based teaching to compare to, they had no reason to initially feel that certain aspects of Canada's typical diverse classroom would be an impractical environment. Although each of them did well in high school, several participants would have liked to have learned with more variety in high school, therefore leading to positive outlooks on the potential of inquiry based teaching. The main themes guiding their perceptions of inquiry were discovery, student responsibility, interest and learning from mistakes.

In accordance with Goodenough (2004), seven of the participants framed inquiry based teaching as a discovery approach. This is in line with Chin's (2007) description of the importance of student cognitive scaffolding with inquiry, through teacher questioning and guidance. Collaboration and group work were identified in this study as a helpful factor in encouraging such discovery, as found also by Church (2010) and Branch (2003). These seven participants found out that inquiry based teaching needs to be well thought out and carefully administered. This preparation is the only true way to facilitate a quality student experience of discovering answers to problems and theories independently. This will lead to engagement and an increased responsibility in student learning.

Student responsibility in learning was highlighted by six students as well as Booi (2011) when describing their perception of inquiry based teaching. These six also focused on the discovery approach of inquiry. They highlighted the importance of students being involved in their learning process and the igniting of genuine interest. In order for a teacher to have the

ability to engage students in the classroom and get them asking questions, they need to be well prepared. Teacher flexibility in order to cater to student needs is a key part of being ready (Nielson et al, 2010). Preparedness, coupled with time is a reoccurring theme throughout the findings of this study. As indicated by Chorney (2009), a teacher with subject expertise has the background and knowledge to best deliver well thought out motivating lessons that encourage student initiative

In understanding that inquiry takes time to prepare and deliver, two participants educated in Windsor, emphasized the importance of teacher expertise and preparedness, in successfully implementing inquiry based teaching. Vincent and Anthony's ideas are supported by Nelson (2001) who also found that a teacher's strong knowledge can attribute to scientific literacy and being better prepared for the implementation of inquiry. These particular findings of the participants and Nelson (2001) tended to focus on the teacher's effort in making students responsible for their learning, rather than on student motivation or interest. Perhaps because these students had not seen inquiry based teaching before their bachelor of education, they tended to focus on the responsibility of the teachers to engage students. Although teachers do have this responsibility, there is a degree to which the student dictates whether or not they will choose to show interest.

The necessity of interest from the student was perceived by the two participants educated overseas, as a critical factor for the implementation of inquiry based teaching. This point of view is supported by Gibson (2011) and Stotter & Gillon (2010) who also emphasized that interest is a component of inquiry based learning. Both Wendy and Charles learned through inquiry and therefore witnessed and lived daily at school in an environment where the inquiry method led to success for students. For the students that weren't successful, behavioural issues did not emerge.

Student interest and engagement appeared to be dominant factors for the successful implementation of inquiry based teaching. The educational experiences of these participants therefore shaped their perceptions of inquiry. The concept of interest in true scientific work has been a necessary part of many discoveries that have improved our lives and living standards. In order for students to gain an understanding of the work that scientists do, through inquiry based teaching, Hammerman (2006) as well as these two participants found that student genuine interest must be present. From a desire to question and find out, comes the natural scientific process of making mistakes and identifying what went wrong.

The valuable experience of learning from mistakes was perceived by three participants to be the basis of inquiry based teaching. It is how we learn from infancy, described by Amelia, "play with your fingers or toes, until you figure out what they are." Anthony also mentioned the natural questioning of young children of "why or what is that?" We are inquirers from birth and we learn from trial and error. If we bring this inquiry aspect back into science these three participants as well as Palombi and Jagger (2008) feel as though student attitudes towards learning science could be changed for the better. Anthony described in his words why this needs to happen.

> In science we get to answer those questions, we get to say oh, this is what that is, this is why that happens. It's the most interesting course you could ever be in and students lose that because they are not answering the questions. They analyze situations instead of getting the kids to actually get excited about why and what's happening. And that to me is why inquiry based learning is essential in at least a science classroom.

In accordance with Gibson (2011), as Anthony points out, when students are able to make connections to their learning, this relevance enhances student engagement. This participant found

that negative results in a lab are good results, often leading to a situation where a student can learn the most. Focusing on getting the right answer takes away from the inquisitive process which can teach the most valuable lessons. Once students see they have made a mistake, they have to try and look at the problem in a different way and attempt again to solve it.

Several of the participants mentioned one or more of the four main ideas, discovery, student responsibility, interest and mistakes, in describing their perception of inquiry based teaching. These ideas in collaboration create a very realistic idea of what inquiry based teaching is in practice. It is a discovery process which builds confidence in students by providing enough background and guidance through initial questioning. This leads them along the path of being able to make sense of how the world works, on their own. The potential student initiative can spark the natural inquiry within a learner to want to solve problems and embrace the value of trial and error.

Of the entire study, three participants through their practice ended up with a more positive perspective of inquiry than when they started. This change came from implementing inquiry, regardless of their inhibitions and in some cases a lack of support. Vincent did not have a good first impression of inquiry based teaching. It was a brand new concept to him at the faculty of education and he felt like it took away from the responsibility of the teacher. This perception quickly changed with some experience and awareness of the preparation that inquiry based teaching required. He started to see this new method of teaching as one that could help him reach certain learners as he tried out inquiry approaches in each of his placements.

Matt's change in perception of inquiry based teaching went from feeling unsure about it to realizing its ability. He encountered a lot of teachers in his placement schools that were resistant to inquiry and he realized they were set in the ways they had taught for their whole

career. This was a point of frustration for Matt and recognizing the common use of old teaching habits encouraged him to appreciate inquiry based teaching and its potential even more.

Wendy started off with a very positive view of inquiry based teaching since she had learned in this way through her education. She still however faced some challenges in trying to implement inquiry, but regardless continued to try. This lead to a very positive outcome in terms of her view of inquiry based teaching. Regardless of student resistance, she saw genuine eventual signs of its effectiveness in her classroom experiences, leading to greater enthusiasm for this method of teaching.

These experiences proved to the three participants that inquiry could bring student success while significantly improving their self efficacy, and hence their perceptions. The others reported no change in their perceptions through the course of their studies and their attempted implementation of inquiry based teaching. They had accepted inquiry teaching as a potentially effective way of teaching from the beginning of their bachelor of education program. This was proven to be the case as they progressed through their placements and saw that depending on the circumstances, inquiry could be implemented with minimal challenges.

Evidence of Effectiveness

All participants except for Charles tried to implement inquiry based teaching in their placements. Half of the participants found that student collaboration was a helpful tool in getting students engaged in activity based learning. Although inquiry begins naturally with teacher questioning to discover student preconceptions, it often leads to activities where students work together to solve problems and come to conclusions. The comments of these five participants are supported by Branch (2003), Chin (2007) and Church (2010). These researchers have shown that problem solving and reasoning are processes that are much more effectively played out in

collaboration rather than individually. The ability to work collaboratively is an important skill in adult life, therefore supporting Meister's (2010) idea that inquiry based learning can enhance social development. Collaboration applied in the high school science classroom is usually associated with varying activities and materials in working toward student success.

The comments of the pre-service teachers of this study suggest that materials to support student engagement were helpful for the successful implementation of inquiry based teaching. The only student that did not implement inquiry felt that in addition to time restraints, the schools he was at did not have sufficient lab materials and the available lab materials were not maintained. All of the participants who attempted to implement inquiry based teaching did so successfully only when they had thoroughly thought out the preparation needed for inquiry. They in turn reported a surprising result of students understanding the concepts and showing enthusiasm. Palombi and Jagger (2008) confirm the findings of this study by giving importance to the ability of inquiry based teaching to change student attitudes towards learning science. Providing this opportunity for student discovery with materials is best followed up by debriefing to solidify concepts.

Three of the participants in this study found that discussions following labs and activities provided a chance for students to clarify their remaining misunderstandings while enforcing what they learned. Wendy, the participant educated overseas who implemented inquiry based teaching, pointed out that this provided an opportunity for students to identify the weak and strong points of their hypotheses. Amelia and Anthony also agree that doing this led to a deeper understanding and according to Hammerman (2006), a more similar experience to that of scientists. Following up with a debriefing session to assure student understanding showed the participants that inquiry based learning had been effectively implemented in their classrooms.

Those who were in placement at the right timing of a unit to experience administering tests, were also shown evidence that their implementation was effective.

There were two participants who were able to test their students following the implementation of inquiry based teaching. In these cases, they reported that students showed "good understanding at test time" and "performed fairly well on tests." Anthony's students who showed a "good understanding" got very inventive in their designing of experiments and carrying them out. Several students came up with relatively consistent results and through discussions in class were able to identify what they had done wrong. Jay's students who performed 'fairly well' seemed confused in class, but the discovery process seems to have left them with a better understanding, according to their test results. Regardless of end performance on tests, the inquiry process requires suitable guidance from the teacher, a balance that the participants of this study had to work to get right.

The ability to guide students through questioning, discussion and provision of materials proved to be effective in the implementation of inquiry based teaching for all participants except for Alex, Matt and Jay. Six of these seven pre-service teachers that guided their students did not learn through inquiry. All seven of them experimented with providing varying guidance with each unique lesson, to find out what worked best. They did this through circulating while students were working, answering questions and addressing issues when necessary. The participants' findings that attaining the right balance of guidance with students is not a simple task, regardless of experience, is supported by Chin (2007), Daniels (1996), Shulman (1987) and the National Research Council (1996). An individual with long term exposure to inquiry based teaching, such as Wendy in this case, may feel more comfortable with this way of teaching, however will still have to work to get that balance right. With more practice, these participants

recognized that they had already and would continue to improve in this area and overall with inquiry, but not without arising challenges.

As each new teacher strives to find that balance of appropriate guidance in their classroom, there are several factors that will guide their actions. In order for inquiry to be effective, a teacher has to take into account that with each group of 20 or more students there is a unique collection of personalities and potential. Each unique group has the ability to make attaining that balance a more or less challenging task. As Anthony explains,

> It is a huge comfort thing I believe because the first time we go out we are nervous. We don't know what to expect in a classroom. I have taught people before in tutoring so I am comfortable with teaching the subject but the difficulty is classroom management. You don't know what the classroom dynamics are of the class, you don't know if it is a very male dominated class or a female dominated class so it could be that a couple males are very loud and talkative and if you put them in a situation it is going to be negatively affecting your class.

Certain classes may present a very challenging environment in which to implement inquiry. This could be the case whether or not one is well acquainted with the inquiry method of teaching.

The individual who felt very comfortable with teaching through inquiry, because she had learned that way, still found it challenging to get students to be willing to take part in a more active kind of learning. She continued to try different things until the students began to open up to her efforts. She felt that her implementation of inquiry based teaching was effective based on student actions, expressions and interest in her activities.

> Even the reluctant students were interested. It was engaging and they took responsibility. The best thing is they figured it out and they like this. I see it and I figure it out rather than just listening to what the teacher is saying.

Attaining student focus is a constant objective in teaching, and can be achieved by presenting lessons that students can make connections to their own lives with.

This study supports Gibson (2011) by showing that presenting students with problems that are relevant to them can get students engaged and involved in their learning experience. This was found by Amelia to be much easier to do in math class than in physics. This participant implemented inquiry based teaching in grade nine math, by having the students figure out how much a certain number of tickets would be for a concert. All factors including number of people, internet charges and taxes had to be accounted for. Making science relevant can be easier in biology than it is in chemistry, but regardless, teacher expertise is important to be able to present connections.

The more knowledge a teacher has on past and up to date science in the news, the more likely he or she is going to be able to catch student interest by teaching in ways that show how science is relevant to them. Students genuinely learn better when they see that there is a purpose to the material and can even get excited about understanding how or why something works as it does. This rejuvenates the wonder and awe that science can naturally bring and can again lead a teacher's hard work to a rewarding situation (Pardhan & Bhutta, 2001). Inquiry based teaching is shown to have the ability to bring forward positive student experiences, and that rewarding experience for a teacher. This may not always be the outcome, but it can always be the fuel that motivates the educators.

Challenges Faced while Implementing Inquiry

Lack of student interest was found to be the one challenge in this study that all of the participants faced. This held true so much for one participant, Charles that he didn't even try to implement it. The absence of student interest was demonstrated by reluctance, stubbornness to get involved and absence of focus. These behaviours were also reported by Kopnicek and Watson (1990) as common challenges to the implementation of inquiry based teaching. The issue with interest and inquiry based teaching is that this method of teaching is dependent on the innate desire to know how things work. If interest and initiative do not exist, it becomes very difficult to guide students to where you want them to go. In addition to this, in the busy life of a new teacher, it often is difficult to take the time needed to plan lessons for effective student engagement especially in the absence of nearby support.

Pre-service teachers have an additional potential challenge over classroom teachers, when teaching in their placements. If their associate teacher has a specific way they want the class to be taught, this needs to be adhered to, seeing as pre-service teacher performance is the basis of their practicum grading. Sanford and Hopper (2000) point out in their research the importance of avoiding power over the pre-service teachers that are being supervised. Rather there should be a focus on finding ways to empower them to develop their own understandings of teaching, share this and question freely in conversations with associate teachers and professors. It is more important to focus on the value of their experiences rather than what they did or didn't do correctly. There are often struggles between associate and pre-service teachers regarding issues such as the pre-service teacher feeling like their associate's expectations are unfair or the associate teachers feeling as though the pre-service teacher was not addressing their concerns seriously. These concerns might include the pre-service teacher's ability to hand in lesson plans

on time or relate to students in the class. Often times, challenges in this relationship are due to lack of communication.

Half of the participants in this study discussed the issue of the associate and pre-service teacher relationship as one that did or could have left them with little ability to implement inquiry based teaching. Some of these pre-service teachers found that their associate teachers encouraged them to teach with whatever method they wished. Others had associates who made it very clear that they should not try to implement inquiry based teaching. Some participants' also encountered resistance to inquiry based teaching in conversations with other experienced teachers in the schools they were placed at.

Although these experiences were reported as discouraging, it wasn't enough to change the interviewee's perceptions of inquiry. For these pre-service teachers, their encounter with resistance to inquiry rather maintained their interest in teaching in this way. Matt was placed with his chemistry teacher from high school who expressed a disinterest in inquiry based teaching. This teacher used the same overheads that Matt was taught with, several years before, administering complete teacher centered lessons. This made it very apparent to this participant that inquiry based teaching was a far better option. Experienced teachers who felt there was no room for inquiry in their classrooms, expressed that they felt this way because of challenges such as lack of time and classroom management issues.

Time was found by nine participants in this study to be a challenge for the implementation of inquiry based teaching. This is supported by Goodenough (2004) and Case and Wright (1997) who emphasize the importance of time for all teachers, in nurturing the critical thinking that inquiry based teaching requires. The only individual, Charles, who did not implement inquiry reported that time was the reason. Over half of the participants mentioned

time more than once and found it to be the most prevalent challenge to implementing inquiry. This includes the time it takes to plan lessons as well as the time it takes to implement lessons.

A lesson that may take half a class to cover in a teacher centered way, may take two full classes through inquiry. The students may develop a better understanding through inquiry, but whether or not it is realistic is in question. The only participant, Wendy, who found that she "never felt restrained," associated it to her own learning by saying, "I had no problem with [time]. I think this might be connected to my experience in high school... having inquiry modelled to me." Although time was not an issue for this participant, she did however experience some common classroom management issues.

According to reviewed literature, classroom management is an area of continuous improvement for pre-service teachers (Wood, Proudfoot, Hagen, Burgess, Gilroy, Riar, Rampuro & Rowlin, 2001; Schulz, 2005). Each of the pre-service teachers in this study faced some form of classroom management with their teaching experience. Seeing as inquiry based teaching does allow more freedom in the structure of learning for students, this study found there to be a greater tendency for distractions such as wandering students and chatter. For pre-service teachers who are learning every aspect of teaching at once, classroom management already exists as a common struggle (Schulz, 2005). Although the incorporation of inquiry based teaching may enhance this challenge, the potential positive outcomes of the method need to be remembered. The participants in this study did the best they could with the resources they had and the backgrounds they came from. As a result, many felt they succeeded at implementing inquiry into at least one of their placement classes and felt positive about facilitating a student involved way of learning.

Implementing inquiry based teaching has been shown to be more difficult in some areas of the sciences than others. The four chemistry pre-service teachers found it more challenging to spark an innate interest in their students with chemistry, than it was for them to do so with biology or math. Students tend to have more interest in a topic such as viruses because they can relate to it, than with a topic such as ionic bonding. Three quarters of these participants found that they needed to see more examples of the implementation of inquiry with chemistry to get a better idea of how to implement it.

The six students who had physics as a teachable found that they generally had success with the implementation of inquiry, other than the individual who did not attempt to implement it. They had seen at least one example of how to implement inquiry based teaching with physics at the faculty of education, but would have preferred to have seen more. One participant taught an introduction to physics and had to teach the concepts of speed, distance and vectors. He found this challenging to implement inquiry with as he felt he had to essentially teach them definitions. Perhaps if he had more experience he would have had a better idea of how to teach this topic through inquiry. In each subject area, there are topics that are more easily geared to inquiry based teaching. However overall, there is evidence from the pre-service teachers of each science that guiding student learning in a desirable direction through inquiry is possible.

Location and type of school also played a factor in how many challenges each pre-service teacher was faced with. Two participants reported that the closer their schools were to the center of Windsor, the greater the prevalence of classroom management. Wendy stated that her grade 11 university chemistry class in the county was much “more responsive and collaborative” in direct contrast to the same class at an inner city school that she was at. Matt expressed his frustrations with attendance at one inner city school, claiming that he was unable to move

forward in the curriculum without each student having major gaps, resulting in disengagement. These participants who taught both near to the center of Windsor and out in the county particularly found a large difference in student behaviour and motivation. They found it more challenging to implement inquiry based teaching in the difficult schools and were faced with more associate teacher and other teacher resistance to inquiry. This conflicted with the encouragement to implement inquiry from the faculty of education. Since teachers do not often have a choice of which schools they will teach at, managing a classroom is a skill that must develop with time and can always improve throughout ones career. Although it is important to look at common challenges that were faced during the implementation of inquiry based teaching, it is important to take a step back and look at the whole education system and the barriers to inquiry that result.

According to Kazempour (2008), a lack of resources makes it difficult to properly implement inquiry based teaching. Charles found himself in agreement, noticing that the schools he worked in were under stocked and the materials that were available were not maintained. This limited his ability to implement inquiry based teaching, not wanting to spend a lot of his own money on supplies, during a teaching placement. Although this is common practice for teachers with their own classrooms, this participant found that with family responsibilities, by the time he had gotten organized for the following day and realized certain materials that could have been useful it was too late to go out and buy them. The fact that in his opinion common supplies were not readily available was a source of frustration for him, as it inhibited his ability to provide dynamic inquiry based lessons.

The two participants educated overseas, Wendy and Charles, as well as two others, Amelia and Anthony, found that students had a hard time with suddenly being introduced to this

type of learning in high school science. They had learned for many years in a teacher centered manner making it more difficult to become engaged and take part in the inquiry learning process. This is supported by Kazempour (2008) who identified this lack of earlier implementation of inquiry as a challenge. The participants who agree with Kazempour feel as though students are typically very used to being told what to do and exactly how to do it. As a result, teachers face resistance when they put expectations on students to try and figure out what to do and why.

Two participants noted that another challenge arising from the education system is that there are teachers in positions without expertise in some cases. This happens very often in schools, where for example one section of grade nine science needs to be filled and is done so by a math teacher. The students of this class will likely learn purely by teacher centered methods, making it more challenging for them to later learn through inquiry. A teacher without subject expertise is not going to have the knowledge to help students 'climb the cognitive ladder' (Chin, 2007). They simply don't have the scientific literacy to be able to identify where students are at and how to get them to the next level.

Participants of this study as well as Kazempour (2008) have identified that changes would need to happen with administration and colleague support for a shift towards inquiry to be fully possible in schools. Several participants felt as if there was a lack of inquiry support in their school system as a whole. This was found at the student, colleague and administrative levels, because of a previous lack of exposure to inquiry. Regardless of the several barriers to the implementation of inquiry based teaching, each participant in this study did experience self improvement over the course of their studies at the faculty of education in Windsor.

Improvement: Both Personal and for the Faculty

Several of the participants attributed their increase in competency for teaching to practice in their placements. With more practice and a greater feeling of comfort in the classroom, comes confidence to try new approaches. With each subsequent placement, the pre-service teachers noticed a significant change in their ability. One participant described a very notable change already by the end of his second placement.

> I was really focused on surviving at the time [the first placement]. I felt a lot more comfortable my second placement. My first one I felt so nervous I was shaking. The second time, I felt I was coming in there, this was my role. I felt a lot more confident.

As the participants of this study tried out different approaches to their teaching, they began to understand why things did and didn't work. Through this period of trial and error, they eventually found successful approaches. Having a greater understanding of managing a classroom comes with time and provides both new and experienced teachers with greater self efficacy. Such avenues for improvement were equally experienced among all the participants, regardless of previous exposure to inquiry. Although they shared in the experience of self improvement, they all expressed a belief that seeing more modelling of inquiry based teaching at the faculty in all the sciences would lead to even greater improvements in their teaching.

According to Wakelyn (2008), exposure to inquiry gets teachers asking more analytical questions, therefore leading them to a greater understanding of scientific nature. This can only transcend in a positive way in their classrooms. All ten participants would have liked to have seen more modelling of inquiry, which is supported by Kazempour's (2009) claim that such exposure over a long period of time is most beneficial to successful teacher implementation of inquiry. Even though perceptions of inquiry among the participants were already quite positive, they identified that an increase in seeing the method modelled could significantly help to put

these positive ideas into constructive motion. Since it was evident to all participants that inquiry based teaching is not wide spread, they realized their ideal position for attempting to bring inquiry based teaching forward.

Pre-service teachers are currently the best way to try and bring inquiry based teaching into more classrooms. They are new to the profession therefore most open to new ideas and methods of teaching. Since newer methods of teaching are most impressionable with pre-service teachers, there is value in the participants' preference for more placement time and less repetition in university classes. This is not possible with the current structure of the bachelor of education program, but in comparison to other programs in North America which include nearly a year of practicum, the three short placements seem hardly sufficient. Although long term training of new teachers to teach with inquiry should not be the only way to introduce inquiry into schools, without full support of the education system, it proves to be effective in the meantime.

According to Ruiz et al (2008) there are benefits to improving the implementation of inquiry at any point in ones career; however it is most ideal to begin this improvement at the pre-service teacher level. The participants in this study who were new to inquiry, have found that first learning of inquiry based teaching at the faculty of education is beneficial, however not enough to truly ease its implementation. They recognize that they would most benefit from a familiarity with inquiry before beginning their bachelor of education degree. This is similar to how students would also benefit from being familiar with inquiry based teaching in general. The only way for training teachers and students to attain this familiarity is to have inquiry based teaching be an engrained part of our education system. Otherwise, new teachers are going to continue to face the challenges that these participants have in trying to implement a relatively newer method of teaching.

Although there has been a push for inquiry based teaching for many years now, it takes a great deal of time to filter into each and every school, especially without consistent support. In the profession of providing education, experienced teachers do not often feel they have the time to incorporate teaching in new ways. A main reason for this is that they don't want to deal with what the pre-service teachers in this study were faced with. One participant described her experience of bringing this newer method of teaching to students who weren't familiar with it.

> I don't know if inquiry based teaching as a whole is maybe a new thing that is going on. I think it will get better as we go along and start students with this being the way to learn when they are younger. A lot of students I feel are almost lost, they don't know what to do when they aren't told what to do.

This presents an issue that goes beyond the walls of the education building at the University and onto the tables of education program designers and upper management in school boards. Seeing more inquiry based teaching throughout high schools and elementary schools would require a large increase in support from teachers, administrators and beyond.

CHAPTER VI: IMPLICATIONS AND CONCLUSIONS

This chapter will begin with an overview of the findings. It will then present implications of the present study for all teachers and teacher education program designers, identifying how the experience of inquiry based teaching could be improved. Finally, it will conclude with what the researcher has learned about the topic and the subjects.

Overview of the findings

The research question, 'what are pre-service teacher's perceptions of inquiry based teaching in the high school science classroom?' is addressed in the findings through the themes of pre-service teachers' educational experiences and perceptions of inquiry. There is a general positive attitude towards the concept of inquiry based science teaching since it is felt to target the development of cognitive, reasoning and interpretive skills. Of the participants in this study, the few that did not push inquiry in their classrooms, did so not because of a perception that inquiry based teaching is ineffective. Rather, because of the variety of challenges implementing the inquiry method, and a feeling that it is not a practical method. Bringing this theory into practice is shown to benefit most from a teachers' familiarity with it and an earlier introduction than high school for students, to this method of learning.

The research question, 'what are pre-service teacher's experiences with implementation of inquiry based teaching in the high school science classroom?' is addressed in the findings through the themes of evidence of effectiveness, challenges and improvements. Based on the analysis of data, it is evident that a pre-service teacher's own educational experiences and perceptions have an effect on one's ability to implement inquiry based science teaching. The challenges that typically arise are lessened as a teacher gains confidence through practice. Pre-service teachers, who have had more practice with inquiry based teaching within their own high

school learning, tend to have an easier time implementing it themselves. It is easier to teach how one is taught, as that is what likely seems natural to them.

All participants that were interviewed reported an improvement in their experience with teaching throughout the program. This improvement was largely attributed to greater confidence from more practice teaching. Although such improvements were made, there is a great deal of work to be done for an overall smoother experience of implementing inquiry based teaching for pre-service teachers.

Implications

Following this study, the researcher has found that the conclusions have left room for more research to be conducted in the area of inquiry based teaching as it applies to avenues for earlier and consistent implementation in elementary and secondary schools. How can our education system filter this method of teaching downward to earlier grades, with the support of parents, teachers, administrators and school boards? If this method of teaching is to be scaled down to elementary and seen more in secondary, a shift in the education system is needed.

Further research could be conducted with research sites that are successfully bringing inquiry into the classroom, to help to identify what needs to be in place to make this possible. The Dr. Eric Jackman Institute of Child Study Laboratory School is an enriched school for ages 3 to 12 in Toronto, which is dedicated to providing an education that prepares students for asking questions and finding answers. Taking an in depth look at what happens at a school like this, might provide insight for future actions across a school board. Although this is a gifted school and doesn't provide a realistic demographic of whole cities, it's worth discovering further reasons to encourage independent learning, since a shift from content coverage to inquiry has been in question for many years.

Many changes have taken place over the course of this time, encouraging related initiatives such as differentiated learning. This is viewed as an ideal way to teach as it is advantageous for unique learners. Differentiation in the classroom gives students their best chance at having their personal learning needs met, however there is little consistency from teacher to teacher in terms of what is being implemented. Encouraging consistency for differentiated teaching, shares some parallels with the initiatives for inquiry based teaching. Inquiry will therefore, regardless be as equally difficult to bring consistently into classrooms and down to elementary, unless there is intervention from education program designers and the entirety of the school boards.

The continued push for education reform by organizations such as the American Association for the Advancement of Science at a minimum brings positive experiences for teachers and students. Schools, teachers and others working in education that have come on board with inquiry based teaching are continuing to bring new experiences to new and old teachers and students. Whether or not attempted implementation of inquiry based teaching is done so successfully, it continues to engage students in innovative ways and encourage them to become involved in their own learning. This brings a variety of learning experiences to each individual student with a student centered approach. Teachers in turn, experience professional growth and development, proving that ongoing encouragement for inquiry based teaching in any way is valuable.

No matter whether this encouragement comes through at the faculty of education in only some classes or through professional development for teachers employed at a board, it is valuable exposure. Although inquiry at the faculty and through professional development seems

hardly sufficient to encourage teachers to suddenly implement inquiry based teaching, it is a starting point.

Teachers would benefit greatly from being exposed to the modelling of inquiry based education more consistently at the faculty of education. Since all teachers in this study saw inquiry based teaching as a positive teaching method, more familiarity with it would help them bring it to the classroom. This does not solve the problem of common student learning styles that create challenges to the implementation of inquiry based teaching, but it minimally prepares a new teacher with the motivation to bring the novel idea of inquiry into their eventual classrooms.

Through a process of many years, if new teachers of all grade levels were consistently taught to implement inquiry through modelling of examples, all students would begin to have exposure to more independent learning. As students grow through elementary school, they will be that much more likely to have less resistance in high school to the implementation of inquiry. In reality, this would require a large push from the Ministry of Education for specific school board initiatives. This would have to funnel down through administration, organizing the provision of appropriate professional development to nurture this initiative for new teachers and provide encouragement for experienced teachers. This would lead to administrative and colleague support, which this study has shown to be lacking, because of assumptions of the time that inquiry takes and the classroom management that it can lead to.

Although it can be argued that inquiry based teaching is more geared to academic level students, regardless, exposure to this kind of learning presents a push for all learners to think more. This push is not going to be successful for all students, especially if they have never been pushed before, but a consistent attempt may bring surprises of student motivation and interest as

it did in this study. This possibility makes inquiry based teaching well worth it, leading to the mentioned points for future changes.

The participant, Wendy, who was educated overseas through inquiry, must be remembered here. She did not feel restrained for time with the implementation of inquiry in biology and chemistry, which she attributes to having learned that way. Since there was only one participant with this experience, there is room for more research to be done specifically with new teachers who were educated themselves through inquiry. This could indicate whether the issue at hand really is lack of exposure to independent learning, or that inquiry really is an impractical approach for all learners.

The above recommendations and suggestions for further research would inform educators, administrators and practitioners of education research with useful insight and knowledge related to inquiry based teaching. Hopefully this study will provide the appropriate individuals with information that can help to continue to work towards nurturing independence, developing critical thinking and improving the experience of all learners.

Conclusions

The purpose of this study was to explore pre-service teachers' perceptions of and experiences with inquiry based teaching, in order to identify how improvements can be made to its implementation. The lack of in depth looks at pre-service teachers ideas of and experiences with inquiry, presented a gap in the existing literature. Pre-service teachers are important to this research because they are the best subjects with which to intervene, in order to try and bring inquiry based teaching into more classrooms. Experienced teachers are often comfortable with the methods of teaching they have found to work for them and are less willing to try new and different things. Newer teachers on the other hand are more willing to incorporate new methods

of teaching into their own personal styles. If we start with new teachers, students over a long period of time will eventually learn to learn in different ways.

A key finding of this study is the relationship between pre-service teachers' experiences with their own education and the challenges and successes faced while implementing inquiry. Most of the teachers in this study were first exposed to inquiry at the faculty of education. They therefore first required some time to feel comfortable with the concept. When teachers are familiar with a method of teaching, they will have more confidence to try to implement it and have a greater chance of success. This exposure to inquiry can come from elementary, high school, teacher training or ideally all areas. If it has come from all areas, as was the case for two of the participants, pre-service teachers will have had plenty of inquiry based teaching modelled to them over time. It therefore would be more of a natural approach for them in their teaching experience in practicum. For this to be the case for most pre-service teachers, there needs to be a consistent move towards inquiry based teaching over a long period of time, so as to allow that exposure to filter down to elementary school for future teachers.

Since all participants in this study held a degree in their main teachable, many of them having completed a thesis or a masters degree, they hold the foundations for expertise in their subject. If they also had previous experiences with inquiry, their attempt at implementation could have been improved. A combination of subject expertise and confidence with the inquiry method of teaching can best prepare new teachers for any questions or redirections that may occur in the classroom.

Time and practice is critical for gaining competence in the implementation of inquiry based teaching. Students themselves could ideally gain some of that time and practice during their own learning through inquiry, and bring that experience forward to be applied to their

studies in the bachelor of education program. As pre-service teachers strive to meet the needs of all learners, challenges will inevitably prevail. This however, is not a reason to move away from inquiry, but rather a reason to be more open to attempting its implementation with the hope that it can reach more learners.

New teachers learning the many aspects of their profession all at once will find it especially hard to implement methods of teaching that are new to them. However, they will always benefit from trying new things by learning what does and doesn't work. This can lead to inspirational professional development and growth in their careers. Such development should be ongoing throughout ones career therefore creating room for more encouragement for the implementation of inquiry based teaching. This study provides insight into the benefits of this style of teaching with its potential to enhance student engagement, motivation and learning. Learning new ways to teach takes time and motivation and teachers need to receive consistent support and guidance from their training and in the communities in which they will eventually teach.

With more support from all areas of education, I believe that over time it is possible for teachers to gain greater competence in the implementation of effective teaching strategies involving inquiry. This can be done so alongside a continued incorporation of content coverage to provide a balanced learning environment. A push for the implementation of inquiry based teaching can continually bring valuable learning experiences to both teachers and students. However, if the education system as a whole does not give inquiry implementation committed support, this method of teaching will have trouble developing into the nationwide success that education reformers envision. Inquiry based teaching, where it is applied, can and will in the

meantime, inspire and motivate students of all levels to ask both simple and compelling questions and to seek out their answers.

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APPENDIX A

RECRUITMENT LETTER

Dear Pre-service Teachers,

Inquiry based science teaching has been promoted by a number of associations, such as the American Association for the Advancement of Science and the National Research Council. Although inquiry! has been promoted, it is not well implemented in the high school science classroom. It has therefore become a significant issue in teacher preparation, as it is important that future teachers develop the ability to facilitate inquiry based learning experiences for their students. This approach to science education will prepare students to make sense of how the world works and to become critical and independent thinkers.

The purpose of this study is to explore pre-service teachers' perceptions of and experiences with the implementation of inquiry based science teaching, and how they feel they can be better prepared from the faculty of Education. This research project has received University of Windsor REB clearance.

You are invited to participate in this study by being interviewed for about 45 minutes following your second and/ or third teacher placements. You will be asked about your ideas around inquiry teaching and your experiences in the classroom with inquiry teaching. The interview will be kept confidential.

More detailed information about the project and participant rights is entailed in the Letter of information. You will be provided a copy of this letter if you have the intention to participate in the study.

Thank-you for considering participation in this study. Please contact me for further information about the study or if you are interested in participating.

Rebecca Reaume

Cook16@uwindsor.ca

APPENDIX B

LETTER OF INFORMATION FOR CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: Pre-service teachers perceptions of and experiences with the implementation of inquiry based teaching in the high school science classroom

You are asked to participate in a research study conducted by Rebecca Reaume (cook16@uwindsor.ca), a Masters student from the Faculty of Education at the University of Windsor. The results will be contributed to her thesis.

If you have any questions or concerns about the research! , please feel to contact her advisor, Dr. George Zhou during the day at 519-253-3000, extension 3813.

PURPOSE OF THE STUDY

To identify Pre-service teachers perceptions of and experiences with the implementation of inquiry based teaching in the high school science classroom, in order to establish avenues for improvement.

PROCEDURES

If you volunteer to participate in this study, you will be asked to participate in a 30 minute interview following your second and/or third teacher placement in the winter term of 2011. The interview will be audio recorded for ease of data analysis and will take place at the Faculty of education before or after your required class for your convenience.

POTENTIAL RISKS AND DISCOMFORTS

There are no potential risks or discomforts associated with involvement in this research project

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Participants may benefit from self reflection and personal analysis of their teaching placement experiences and may apply this reflection to their future practice.

COMPENSATION FOR PARTICIPATION

As a token of thanks for their participation, each participant will get a gift that carries a value of $10

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Your name will not be used in the final report of this research project. You have the opportunity to review the

transcripts of your interview and request to delete or re-word any information that can be used to identify you. Only the research committee and researcher will have access to these recordings and they will be erased when the project is complete. Data will be kept secured in a locked filing cabinet and will be destroyed once the project is complete

On the tapes and transcripts, each participant will be identified by a research participant number. There will be no connection between the interview data and the individual's true identity.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you are free to withdraw from this study at any time before the findings are disseminated without consequences of any kind. Or you can refuse to answer questions you don't want to answer and still remain in this study. The researcher may withdraw you from this research if circumstances arise which warrant doing so.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE SUBJECTS

The feedback to you will be in October 2011. A summary will be published on the REB website.

Web address: www.uwindsor.ca/reb

Date when results are available: October 2011

SUBSEQUENT USE OF DATA

This data will be used in subsequent studies.

RIGHTS OF RESEARCH SUBJECTS

If you have questions regarding your rights as a research subject, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

_____ _____

Signature of Investigator Date

APPENDIX C

CONSENT TO PARTICIPATE IN RESEARCH

Title of Study: Pre-service teachers perceptions of and experiences with the implementation of inquiry based teaching in the high school science classroom

You are asked to participate in a research study conducted by Rebecca Reaume (cook16@uwindsor.ca), a Masters student from the Faculty of Education at the University of Windsor. The results will be contributed to her thesis.

If you have any questions or concerns about the research! , please feel to contact her advisor, Dr. George Zhou during the day at 519-253-3000, extension 3813

PURPOSE OF THE STUDY

To identify Pre-service teachers perceptions of and experiences with the implementation of inquiry based teaching in the high school science classroom, in order to establish avenues for improvement.

PROCEDURES

If you volunteer to participate in this study, you will be asked to participate in a 45 minute interview following your second and/or third teacher placement in the winter term of 2011. The interview will be audio recorded for ease of data analysis and will take place at the Faculty of education before or after your required class, at your convenience.

POTENTIAL RISKS AND DISCOMFORTS

There are no potential risks or discomforts associated with involvement in this research project

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Participants may benefit from self reflection and personal analysis of their teaching placement experiences and may apply this reflection to their future practice.

COMPENSATION FOR PARTICIPATION

As a token of thanks for their participation, each participant will get a gift that carries a value of $10

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Your name will not be used in the final report of this research project. You have the opportunity to review the

transcripts of your interview and request to delete or re-word any information that can be used to identify you. Only the research committee and researcher will have access to these recordings and they will be erased when the project is complete. Data will be kept secured in a locked filing cabinet and will be destroyed once the project is complete

On the tapes and transcripts, each participant will be identified by a research participant number. There will be no connection between the interview data and the individual's true identity.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you are free to withdraw from this study at any time before the findings are disseminated without consequences of any kind. Or you can refuse to answer questions you don't want to answer and still remain in this study. The researcher may withdraw you from this research if circumstances arise which warrant doing so.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE SUBJECTS

The feedback to you will be in October 2011. A summary will be published on the REB website.

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This data will be used in subsequent studies.

RIGHTS OF RESEARCH SUBJECTS

If you have questions regarding your rights as a research subject, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH SUBJECT/LEGAL REPRESENTATIVE

I understand the information provided for the study of Pre-service teachers' perceptions of and experiences with the implementation of inquiry based teaching in the high school science classroom, as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____

Name of Subject

_____ _____

Signature of Subject Date

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

_____ _____

Signature of Investigator Date

APPENDIX D

CONSENT FOR AUDIO TAPING

Research Subject Name:

Title of the Project: Pre-service teachers' perceptions of and experiences with the implementation of inquiry based teaching in the high school science classroom

You are asked to participate in a research study conducted by Rebecca Reaume (cook16@uwindsor.ca), a Masters student from the Faculty of Education at the University of Windsor. The results will be contributed to her thesis.

If you have any questions or concerns about the research, please feel to contact her advisor, Dr. George Zhou during the day at 519-253-3000, extension 3813.

Only researchers can access any type of data collected. All data will be locked in a cabinet and then destroyed once the project is complete. Audiotapes will be erased once they have been transcribed and verified.

I consent to the audio-taping of interviews.

I understand that this is a voluntary procedure and that I am free to withdraw at any time by requesting the taping be stopped. I also understand that my name will not be revealed to anyone and that taping will be kept confidential. Tapes are filed by number only and store in a locked cabinet.

I understand that confidentiality will be respected and that the audio tape will be for professional use only.

_____ _____

(Research Subject) (Date)

APPENDIX E

PRE-SERVICE TEACHER INTERVIEW GUIDE

1) What is your educational background?
2) What work experience do you have?
3) From your own experiences, including your time at the faculty of education, what does inquiry based learning mean to you?
4) As a student yourself in high school, was inquiry based teaching a part of your learning?
5) What is an example of the way you typically learned science in high school?
6) What is an example of how you used inquiry based teaching into your previous placement?
7) Was this method of inquiry based teaching successful? Why or why not?
8) What challenges were you faced with in implementing inquiry based teaching in your practicum experience? Consider the following:
    a. Classroom management
    b. Content coverage with limited time
    c. lack of student base knowledge
9) How can the teacher education class better prepare you for teaching science through inquiry?
10) Do you have any other comments you feel would be helpful?

VITA AUCTORIS

Rebecca Reaume was born in Kitchener, Ontario. She completed her Biology and Social Development Studies degree at the University of Waterloo in 2002. From there she went on to try out teaching overseas in Seoul, Korea. She completed her bachelor of education degree in Windsor in 2006, before returning overseas to teach Biology at a comprehensive high school in Scotland. This was followed by two years of teaching science in Canada and one year at an international school in Dubai, U.A.E. She is currently a candidate for the masters degree of education at the University of Windsor and hopes to graduate in the fall of 2011. The author is married with one daughter and enjoys seeking out the next adventure, whether it is 65ha walk to the park or a move to the other side of the world.