Critical Challenge in Science

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BSc., University of Victoria, 2002
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ABSTRACT

This Critical Challenge in Science unit is designed to engage students in critical thinking skills about Science Technology Society and Environment (STSE) issues. It is designed for the Science Five curriculum in British Columbia, specifically the Natural Resources unit. This action research project involved students constructing knowledge through experience and then applying that knowledge to answer critical thinking questions about the environment. The central goal of this project was to increase students use and application of critical thinking skills. This unit also revealed the power of the action research process, particularly the benefits of reflection that lead to new action.
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Chapter One:  
Introduction, Purpose, Context, Rationale and Significance

Introduction

Davis-Seaver (2000, p. 10) stated that critical thinking is “purposeful thinking that uses the skills of problem solving, decision making, evaluation and metacognition to resolve conflicts, arrive at solutions and understand in depth. It is that part of the creative thinking process that analyzes the appropriateness of logicalness of the creative process or outcome.” This study examined the effectiveness of such critical thinking skills embedded in the elementary school science curriculum. Specifically, this project investigated the development and use of critical thinking skills to determine if students are better able to understand the content material presented to them in the science curriculum. There is a great need for students to use and apply critical thinking skills not only to gain a better understanding of science content knowledge in the school curriculum but also to help empower them to become future literate citizens, who are be able to rationalize, evaluate, challenge, examine and reason about real world issues (British Columbia Ministry of Education, 2005). The importance behind the need to embed critical thinking skills in the science curriculum is central to the achievement of scientific literacy and general literacy (Ford, Yore & Anthony 1997).

This assumption involved looking at the traditional science goals, classroom practices, and resources and comparing them to current goals of the science curriculum. Therefore, the discussion needs to establish how critical thinking skills provide an appropriate, if not
necessary, means of meeting the goals of the current science curriculum that being scientific literacy and fuller participation in the public debate about science, technology, society and environment (STSE) issues.

Purpose of the Study

The purpose of this study was to investigate if students are able to gain a better scientific understanding consisting of science knowledge, practical application and skills when they are given the opportunity to think in a critical way. Will students’ understanding about STSE issues be increased when given the opportunity to apply critical thinking skills and to reflect on their learning? It is speculated that engaging students in a curriculum designed to promote critical thinking will facilitate transfer of knowledge and skills to other areas and issues. Students may be more likely to think critically about other issues within the same topic and apply these critical thinking skills to other issues within the science curriculum, to other curricular areas and to debate about STSE issues in the world around them.

The central assumption of this study is that children come to school already able to think critically. Davis-Seaver (2000) suggested that young children are quite capable of thinking deeply and critically about the problems which erupt within their lived experiences and that this level of thinking need not cease when children walk through the classroom door. Critical thinking cannot be seen as an add-on to the curriculum and it cannot be seen as something that can be taught when students are developmentally ready—it is a central feature of contemporary disciplinary literacy. Critical thinking must be seen according to the constructivist approach, an approach that assumes that all children can think deeply and that it is this in-
depth thinking that brings about meaningful learning that is applicable and transferable.

“Children learn to think critically when they have opportunities and reason to think in critical ways; when they see (or hear) others engaged in critical thinking; and when they are admitted into arguments, challenges and debates based on respect rather than power or exploitations” (Smith, 1986, p. 107). This study investigated how student learning changed and understanding was developed when students were given the opportunity to use their pre-existing abilities and intellectual resources to think critically. When students are admitted into arguments, challenges and debates they are empowered and given the chance to work/grapple with knowledge they have gained. This is in contrast to the memorization of knowledge as seen in the traditional science classroom.

In summary, this project provided a basis in which to allow students to engage, refine, and apply critical thinking skills as they relate to a science unit in the area of natural resources and the associated STSE issues subsumed by such topics. This unit demonstrated that when students are immersed in worthwhile challenges that require critical thinking, their knowledge and understanding of the topic is increased and enhanced. Moreover, the intention of this project is to demonstrate the need to give students the opportunity to be engaged in critical thinking skills in order to grapple with STSE issues within the science curriculum, but more importantly, an opportunity to apply these skills now as it is these students who will be the problem solvers for the future. It may not be possible to predict the kinds of problems students will be faced with in the future but it is certain that they will face problems. If students hone in and refine their critical thinking skills now then they will may be better equipped to face the challenges that the future holds.
Context and Rationale

This action research study is based on adapting and integrating established instructional goals and approaches into existing science curriculum and programs. The context, rationale and importance behind doing so is centered on embedding critical thinking, common in social studies, into the current science curriculum. A brief description of how science has been traditionally taught and past goals of science will be presented to preface the current goals of science education as defined by the British Columbia Ministry of Education. Discussion will then turn to critical thinking as a means of meeting current science education goals, and a way of meeting current considerations for science education, scientific literacy and STSE issues.

The Traditional Science Classroom

“Currently literature, mathematics, history, and science are often seen as separate disciplines unrelated to the life of the learner. And much of what we presently accept as teaching is based on the mistaken belief that students can be taught reading and writing as separate from meaning and purpose, and that somehow what happens in the classroom is unaffected by the real world children and adults inhabit” (Caine & Caine, 1991, p. 4). All too often, people are reminded of the science classroom where students are guided through tried and tested experiments in order to get the same conclusive results. This image is so unlike authentic science and real life. Students are given step by step instructions which are followed through, un-questioned results are obtained and written up following the linear lock-step scientific method. Following the lesson a discussion, more likely a teacher presentation, may ensue about the theory, model or explanation as to why the results came back the way they
did. Students would then be expected to memorize these ideas and retrieve them for a test or a quiz before moving onto the next experiment.

Although there are many problems with this view of science including inaccurate views of the nature of science, lack of constructivist learning with such a curriculum and instructional approach, the focus will be on two major problems that arise in teaching science in such a way. Firstly, this kind of science education leaves science in the science classroom disconnected from the world, nature and naturally occurring events. There is little room for discussion as to how theories, models, ideas and findings relate to students and the world in which they live. There is little time (or room) for discussion around connections to be made. For instance, earlier curricula did not encourage connections to society, to the environment and to technology. If students are unable to make connections, learning can become irrelevant and lost easily. Making connections is “a matter of finding out how what is being learned relates to what the learner already knows and values and how information and experiences connect” (Caine & Caine, 1991, p.4). Secondly, the traditional curriculum assumed tabula rasa – a student as a blank slate; one that comes to the science classroom with no prior knowledge and a deficit in background and intellectual resources. The student is seen as an empty vessel to be filled that encourages a ‘transmission’ instructional model. This type of curriculum focuses on drill and practice, programmed learning, and the transmission of facts and principles rather than a constructivist approach that facilitates personal construction of understanding. This long-established traditional view of science is focused around the traditional goal of science being cultural assimilation for all students (UNESCO, 1994). Snively and Corsiglia (2001, p. 6) stated “the definition of science is a de facto ‘gatekeeping’ device for determining what can be
included in a school science curriculum and what cannot.” Not only does such a goal not consider the prior knowledge of students it also does not take into account prior knowledge of diverse ethnic groups who have made long-standing, reasoned statements to define and make sense of the world around them. “In most science classes around the globe, Western modern science has been taught at the expense of indigenous knowledge” (Snively & Corsiglia, 2001 p. 6). Such assumptions and practices overlook or reject many of our students who come to our classrooms with preconceived notions about how the world around them is constructed.

Teachers must respect, value and use these preconceived notions and to allow these students an active voice in our classrooms. It is also important to allow students to see, contrast and evaluate different ways of knowing and then allow them to construct their own knowledge once they have seen other possibilities.

The Current K-7 Science Curriculum

Current goals and considerations for the British Columbia Ministry of Education (2005) science curriculum address the two major problems of traditional science classroom and traditional science goals; connections among society, environment and technology and the importance the prior knowledge that students bring to classes especially when that prior knowledge is indigenous in nature. One of the goals of the Ministry of Education states that students will develop an understanding of the nature of science and technology, the relationship between science and technology, and the social and environmental context of science and technology (British Columbia Ministry of Education, 2005). Science Technology Society and Environment (STSE) issues are embedded in the current science curriculum and allows for a focus on all four of these aspects (science, technology, society and environment). A
curriculum that focuses on all four components simultaneously is one that will prepare students for the future. Furthermore, focusing on the connections between and among these four fundamental aspects allows science to take place beyond the classroom and will allow science to exist in the realm of students’ real world, past histories and lived experiences.

The current curriculum explicitly recognizes the importance of alternative interpretations of nature and naturally occurring events and the informal experiences learners have with nature. Maddock, (1981) proposed “that science and science education are cultural enterprises which form a part of the wider cultural matrix of society and that educational considerations concerning science must be made in the light of this wider perspective” (p.10). Although not stated as a goal, the Ministry of Education recognizes that science exists in a wider cultural matrix of society by making an important considering for Traditional Ecological Knowledge and Wisdom (TEKW) (British Columbia Ministry of Education, 2005). The Ministry of Education now suggests a model where Aboriginal and Western understanding exists separately, yet side by side in partnership with one another. More often, TEKW is now being given a voice in classrooms. TEKW takes on a holistic view of the world, one which sees the world as interconnected and humans are not more important than nature (British Columbia Ministry of Education, 2005). A classroom which presents Western and Aboriginal understanding in this type of model allows for an enriched learning environment where values are honored and all students have the opportunity to make meaning in a variety of contexts.

Critical Thinking within the STSE Context

STSE and TEKW are two main considerations for a science curriculum that is relevant, valued and respected among all members provides the context for thinking critically about
knowledge claims, evidence for these claims and the explanation of these events in nature.

“We must put to use the good critical thinking that students already use outside of school in the classroom so that students will examine the world around them critically in order to enhance the quality of life for the whole planet” (Davis-Seaver, 2000, p.98).

Case and Daniels (1999, p.xiii) stated “critical thinking involves thinking through problematic situations about what to believe or how to act where the thinker makes reasoned judgments that embody the qualities of a competent thinker.” Students who are introduced to problematic situations that involve STSE issues have an opportunity to think critically about the world around them. However, critical thinking involves much more than posing problematic questions. Critical thinking also involves teaching the tools required of a critical thinking and then allowing student the opportunity to apply the tools in life situations. The use of this Critical Challenges in Science unit will provide the opportunities for teachers to infuse explicit instruction and for students equipped with the tools for critical thought, to pose problematic situations and to apply the tools in order to look for meaningful solutions to worthwhile problems. Critical thinking in science will allow students to discuss and debate science issues in this unit related to the natural resource of salmon. Students will be able to establish connections that can be made to lived experience, to prior knowledge, to society and to the environment. Embedding critical thinking into the learning about salmon as a natural resource, will make learning active, meaningful and consequential. Furthermore, students will be able to voice their prior knowledge and to hear the prior knowledge of other students about relevant West Coast issues. The ethnic backgrounds their ways of knowing and understanding nature, naturally occurring events, and related concepts will be presented. Critical thinking, a central
and essential component of the fundamental sense of science literacy will allow students to make connections to the world around them and will allow their prior knowledge a voice where in the past that voice may have been silenced or a mere whisper.

**Significance**

Presenting students with an opportunity to think critically about science content knowledge is essential in meeting current science curriculum goals and producing scientifically literate students. Critical thinking in science also has a bigger role; that of producing learners for the future. These learners for the future will be capable of entering into arguments and debates, will challenge opinions of others in respectful and productive ways, and will look at problematic situations with a critical lens in order to find best possible solutions.

A curriculum that is embedded with critical thinking enables students’ to foster, refine and apply critical thinking skills at an early age. This should allow students to be better equipped to deal with issues and problems that they are presented to them in school but also encounter outside of school in the real work and engage in the public forum. More importantly, “critical thinking is also important to the survival of a democratic way of life. If the people in a democracy do not make reasonable decisions in voting and the conduct of their everyday public lives, then the democracy in which they live is threatened. We have a public responsibility to try to make reasonable civic decisions---that is, to try to think critically in civic matters and to help other do so as well” (Ennis, 1996, p.xvii).

The development and refinement of critical thinking skills must begin at an early age. Davis-Seaver (2000) feels that allowing critical thinking in the classroom at an early age is
essential to the empowerment of students who will begin to become aware of possibilities, will challenge what is presented as given or absolute, will demand to look at the evidence and examine reasons, and finally will take their places as full participants in a global society that must learn to treat its humblest citizens as it does the most powerful.

**Design of the Study**

This Critical Challenge in Science project is designed as action research about an instruction innovation utilizing a mixed-methods approach (pre-test, post-test, one-group case study, with collection of artifacts and reflections). A series of lessons were developed and used by a teacher who is teaching the natural resources unit of the grade five curriculum. The unit and lessons were designed to allow children of this age (9-11 years old) to be engaged in critical thinking while learning about science and a STSE issues. Each individual lesson is composed using the Smart Framework (Close, 2004) and is focused on science content knowledge specified by the curriculum and developmental appropriate critical thinking skills while posing deep thinking questions in the form of a worthwhile challenge.

Specifically, students will focus on learning that is centered on use and conservation of natural resources in British Columbia. Students will focus on salmon as a natural resources and will look at the fish farming versus commercial open water fishing debate. Each lesson ends in a critical challenge involving an STSE issue. The unit plan for this study is composed of six lesson plans; two background lessons and four critical thinking lessons, each of which poses a critical thinking question. The Smart Learning approach provides a framework for learning composed of nine steps that allow learners to activate and build background knowledge, process information, transform their learning into a product that shows what they know, and reflect on
their learning (Close, 2004). Structured talk and assessment as and for learning are carefully woven into the process to build a thoughtful context for learning and to advance the thinking of all learners. The unit will culminate with a challenge that looks at two main forms of harvesting salmon; fish farming and commercial open-water practices. Students will synthesize their learning about natural resources, critical thinking as well as the important process of learning that have been the focus through the Smart Framework in the final critical challenge.

In this unit, students explored how BC’s living and non-living resources interact and are used. They will identity methods of extracting or harvesting and processing BC’s resources, analyze how the Aboriginal concept of interconnectedness of the environment is reflected in responsibility for and caretaking of resources and describe potential environmental impacts of using BC’s living and non-living resources. At the same time, students will be invited, encouraged and asked to practice critical thinking skills such as forming an opinion, supporting an opinion and considering an alternate point of view about what to believe and actions to take that can be openly justified.

**Setting**

The instruction was intended for students and the study takes place in a typical multiage, integrated 21st century grade five classroom. Classrooms commonly seen today in the public education system have a wide range of abilities, which often span over several grades. Classes are often composed of ESL, low incidence students such as autistic and intellectual disorders as well as high incidence learners spanning from a variety of learning disability and gifted students. Teachers must ensure that the needs of all learners are considered and
addressed. The lesson plans in this project were differentiated in order to meet the various needs of students in a classroom and can be successfully implemented by other generalist teachers. Success being that each student is able to learn the science outcomes, develop and apply critical thinking skills, and reflect on that thinking and learning.

Summary

In conclusion, the purpose of this action research study was to evaluate the implementation of an instruction innovation and determine if students are able to gain a better understanding of scientific knowledge when they are given the opportunity to think about that knowledge in a critical way. The implementation was in a regular classroom with a normal group of students for the host school. The instruction allowed students the opportunity to think critically, permitted them to bring to the classroom knowledge they have already constructed, to compare that knowledge against new and different knowledge and to make connections to the world. Critical thinking allowed students to see alternate viewpoints, defend their judgments and gain new knowledge. All of these are ‘critical’ if students today are to be the future citizens and leaders. This study focused on elementary students in an intact grade five classroom with a diverse range of learners. The study assumed that by immersing students into critical thinking at an early age, that they will have more opportunity to refine and apply their critical thinking skills as they move through the education system and eventually into the bigger context of society.
Chapter Two: Literature Review

Introduction

“Education is not in the ‘business’ of providing human resources to industry and commerce. Education implies a seeking to understand, the preparedness to approach difficult problems – problems of significance to human beings” (Davis-Seaver, 2000 p.29). The fundamental goal of education is to ensure that students of today will be prepared to face the problems of tomorrow. Students today will be the future leaders, decision makers, educators and citizens of tomorrow and as such have a great responsibility bestowed upon them. Although we can predict and forecast what we feel the future may hold, no one can be certain as to the exact challenges humankind will face in the future. In order to prepare students for the future it is necessary to make sure students are equipped with the proper tools. Preparing students for the future means providing them with a toolbox that would be filled with a number of tools, strategies, abilities and habits of mind that students would be familiar with and effective at applying. Just as a sledgehammer may be used to tear down a wall or a wrench may be used to fix a leaky pipe, students would select a cognitive tool and apply it to a particular situation. One of the most important and well-used tools in this toolbox would certainly be critical thinking skills. Students would make use of this tool to seek truths, to create informed decisions and look for solutions.

The use of critical thinking skills in adults will only happen if introduce critical thinking skills and their key function at an early age. Ideally, this would happen for students as early as elementary school and would continue throughout their schooling. It is important to note that some believe education as preparation for adult life denies the inherent curiosity children bring
with them to school and removes the focus away from students’ present interest and abilities to more abstract notions of what the future holds (Brooks & Brooks, 1999). Keeping this in mind, giving students the opportunity to practice critical thinking skills at an early age must be done in a way that taps into their present curiosities in order to excite and engage students toward critical thinking. Brooks and Brooks believe that schools can “successfully prepare students for their adult years by understanding and honoring the dynamics of learning; by recognizing that for students, schooling must be a time of curiosity, exploration, and inquiry, and memorizing information must be subordinated to learning how to find information to solve real problems” (1999, p.9). Therefore embedding of critical thinking skills into the curricula should be viewed as an opportunity to promote, not as a denial of, youth. In order to achieve this we must engage students’ excitement for learning, interests and skills and allow them the opportunity to participate in meaningful challenges and situations that require them to think critically.

In 1993 the Critical Thinking Consortium (CTC, 2008) was formed in British Columbia to promote critical thinking skills. The consortium has grown from a small group of committed individuals to an internationally renowned model whose popularity is due to the way in which it embeds critical thinking into school curricula making it more accessible to teachers worldwide (CTC, 2008). The CTC has embraced the notion of embedding critical thinking skills into school programs such that it honors the nature of student learning (2008). Their philosophy and effort have not yet received widespread acceptance in schools, however The CTC has created and verified a model for the inclusion critical thinking skills into all classrooms.

The consortium has produced teacher-developed resources to support critical thinking
in the classroom that are centrally concerned with nurturing students’ ability to make sound judgments and they feel that it is their educational directive to teach and assess the intellectual resources for sound thinking (CTC, 2008). Furthermore, the consortium believes that critical thinking should not be taught as a single unit of study like decimals in mathematics, instead it should be infused in everything that students do in a class. Critical thinking needs be modeled and lived continuously in the classroom. An important dimension of this approach is learning to nurture a classroom community of thinkers where the norms and practices of thoughtful reflection are reinforced. The consortium is just one example of a group or community committed to infusing and embedding critical thinking skills in a holistic way across the curriculum. Although their commitment to the cause (and that of others) is commendable it has not caused a widespread institutional shift in the way schools and classrooms are run. In order to reach a tipping point where critical thinking skills are embedded in each lesson of each class in all schools, deeper understanding, commitment, use and practice of critical thinking skills must take place.

As a way of getting at how critical thinking skills can become embedded into the school curriculum, it is important to have a more in-depth and well cultivated understanding of what critical thinking is by looking at some of the many definitions and interpretations of critical thinking. Then in order to gain a better understanding of the definition of critical thinking used for the purposes of this project, it will be important to look at the theory of constructivism and how this theory can evoke change and empowerment through praxis.
Critical Thinking Definitions

Critical thinking has been defined in many ways that range from being very prescriptive and step-by-step to very general and open to interpretation. Definitions of critical thinking tend to fall into three general perceptions; reductionist, developmentalist and constructivist. The reductionist perspective is characterized by people who believe critical thinking can be broken down into manageable skills and that mastery of these sets of skills will result in critical thinking. The developmentalist perspective is dominated by the theories of Piaget and Erikson who believe students will engage in critical thinking skills when they are developmentally ready. According to this perspective critical thinking falls under the umbrella of post-adolescent learners, therefore elementary school children are usually not developmentally ready for critical thinking. The constructivist perspective posits that critical thinking does not develop through practice and repetition of skills in artificial situations or through maturation, but through thinking critically in situations that are meaningful to children of any age (Davis-Seaver, 2000).

The following are three definitions that will be presented as a progression working towards a constructivist perspective definition that will be used in this research. Firstly, the Critical Thinking Co. (2005) believes that critical thinking is the identification and evaluation of evidence to guide decision making. A critical thinker uses broad in-depth analysis of evidence to make decisions and communicate his/her beliefs clearly and accurately. This very prescriptive definition focuses on evidence as a means and basis for decision making. When the thinker has mastered the skill of analysis of evidence then they will be considered a critical thinker. This is synonymous with deBono’s (1985) six thinking hats in which each hat represents a different
perspective, whether it is that of an observer, justifier, critic, optimist, creator or decision
maker. Putting on a particular hat allows one to assume a particular role and take on a different
perspective. Although this makes the role of thinker clear, critical thinking is more than
evaluation of evidence, presentation of an opinion and playing a role. The hats become a
category of thinking and not part of the person themselves. The above definition and metaphor
for thinking does not allow students to construct their own knowledge and also lacks the
opportunity for students to present or use their own prior knowledge, both of which are central
to critical thinking.

Ennis provides a more holistic definition of critical thinking when he states “critical
thinking is reasonable, reflective thinking that is focused on deciding what to believe and do”
(1985, p.45). Again, this definition focuses on the thinker and the decision. However, this
definition implies that there is more to critical thinking than following the steps of analysis and
presentation of a decision. Ennis includes a reflective component to his definition by suggesting
that the thinker brings beliefs and actions to the situation they are thinking about. Reflection
assumes thinking about how one thinks. This definition allows a greater focus on learner and
their prior knowledge and belief systems.

A third definition, provided by Davis-Seaver (2000 p.2) “sees critical thinking as the
process of interacting within the materials and data of a discipline in such a way as to come to a
deeper understanding of the basic ideas that drive the theories of the discipline, that create
new concepts both within and transferred to other disciplines and make relevant to one’s own
life the concepts of that discipline.” Again, as in Ennis’ definitions, Davis-Seaver recognizes that
there is an importance of connecting to someone’s personal history and prior knowledge.
Making knowledge personal and connected to one’s personal life allows education to be seen as a way of life instead of a system intended for the production of workers. Furthermore, Davis-Seaver recognizes that critical thinking begins as soon as students work with and gather evidence as opposed to beginning with the analysis of data. It is when students involved with data and collecting it through experiments and observations that they begin to construct their understanding and begin to think critically about the information. When students are provided opportunities to construct their own knowledge it also provides them with the opportunity to compare and add it to the prior knowledge, history and beliefs. It is this third and final definition that will be used to support the understanding of critical thinking for the purpose of this research project. This definition of critical thinking is based on a constructivist approach, an approach founded on the principle that knowledge is created by people and influenced by their values and culture. The following will present a more in-depth analysis of the constructivist approach in order to gain a clearer understanding of critical thinking as defined in this project.

The Constructivist Approach

Davis-Seaver’s definition of critical thinking focuses on the learner constructing their own knowledge, connecting that knowledge to the learner’s life, using that knowledge to make new knowledge and transferring that knowledge to other areas, while they evaluate against evidence and defend in public debate. Students learn to think critically by thinking critically and that the process of critical thinking is endemic to the outcome of becoming a critical thinker (Davis-Seaver, 2000). Furthermore, Paul (1990) believes that higher-order learning, such as critical thinking, leads to greater comprehension and insight that stimulates and empowers the
learner. Unfortunately, much of the lower-order thinking associated with school prevails leading to the perpetuation of misconceptions and misunderstandings since students frequently do not evaluate and defend their conceptions and misconceptions. Students need to form intellectually sound standards for belief, truth and validity (Paul, 1990). Providing students the opportunity to think critically through experience as well as rigorous reflection allows students to become critical thinkers. The following will look at a traditional behaviorist approach to teaching through a narrative, followed by the exploring of the progression from the behaviorist approach to the constructivist approach in order to gain a deeper understanding of where teaching and learning should currently be situated.

Leggo’s (1998) description of a traditional approach to teaching helps provide a better understanding of the need for a constructivist approach to critical thinking.

In my second year of undergraduate study in English literature, I recall a practical criticism course where the professor distributed copies of poems with the poet’s names deleted, and expected me to match the understanding of the poem that he had devised from his successive readings. Not once did I even come close to matching the professor’s response, and subsequently I was awarded a C grade. I could never understand why the poet was deleted, why the socio-political-cultural context was ignored, or why the poem invited only one expert reading. In the course I learned only my inadequacy. I also recall, with shame, that during the early years of my teaching, I expected my students to produce at least shadows of the responses that I carried around with me in the teacher’s guidebook. I perpetuated the practice I had known as a student. (p.186)
Leggo shares an image of himself as a university student and the frustration he encountered from being expected to conform his understanding to a set of pre-determined knowledge. He also shows, as a school teacher, how he expected his students to conform their understanding to that of the knowledge in a guidebook. Far too often teachers are seen as keepers of knowledge that is to be dispersed in small, easily remembered packets in order for students to memorize it and hold onto it to just long enough to reproduce it onto a test.

The science curriculum has seen its fair share of these types of knowledge transmission. Students are not given a chance to construct their own meanings, create their own understandings and engage in debates about their understandings in order to look at knowledge in a critical way. They are also not given the opportunity to challenge and reverse contrary views. The goal for education should not be to produce assembly line thinkers whose ultimate objective is to contribute to the workforce. Instead, we will have to look at including critical thinking informed by a constructivist approach in order to reform education, specifically the science curriculum, in order to make it more meaningful and useful for students today and to create critically reflective citizens for tomorrow.

Sadly, what Leggo describes is often what happens in many classrooms, even today, and a picture that many people hold when they are reminded of their education. The foundation of this image is the behaviorist approach to education; an approach in which knowledge is universal, objective and fixed (Leggo, 1998). The function of schooling is to transfer the body of established knowledge from teachers to students. This approach is characterized by the teacher disseminating information incrementally, demonstrating procedures and reinforcing actions to habits during times of independent practice and the role of the student is to replicate
knowledge transmitted by authorities (Scheurman, 1998). The teacher is seen as a transmitter and students as passive receptors. A typical classroom activity defined by the behaviorist approach would include responding to textbook questions that produce responses that can be termed right or wrong rather than “interpretations that are justified on the basis of critically examined evidence” (Scheurman, 1998, p. 7). It is important to note that the behaviorist teaching approach is reasonably successful at the recall level; however it is not as successful in promoting learning at higher levels of thinking.

In contrast to the behaviorist approach, information processing sees the teacher as a manager of information (Scheurman, 1998). The role of the teacher/manager is to help students become aware of their prior knowledge and to encourage students to build connections. Furthermore, the teacher is to manage the environment where student novices gain information and ask the expert (the teacher) questions about that information to help students develop their own skills and knowledge and become more expert. Although information processing allows the learning to be more independent, other constructivist approaches to teaching allows knowledge to be seen as individually constructed and objective (Scheurman, 1998). The teacher is seen as a facilitator and the learner is compared to that of a ‘naïve scientist’ who tries to make sense of the world around them through practices such as predicting, observing, describing and analyzing. The teaching activities in this view access, engage and challenge the students’ concept of reality and monitor the reflective thinking of students after discoveries (Scheurman, 1998). Students experience reality through activities that are novel and allow new schemes and operations to be developed and integrated into their knowledge. The teacher guides students to authentic resources and procedures that allow
students to construct their own understanding and to actively engage in inquiries with peers and teachers (Scheurman, 1998). Although many constructivist theories exist, two basic views of constructivism are discussed below. Cognitive constructivism assumes that “people develop universal forms or structures of knowledge that enable them to experience reality” (Scheurman, 1998, p. 8). Individuals build private understandings of reality through problem solving with others, which are shared and defended in public debate and critique. Social constructivism, on the other hand, sees knowledge as co-constructed by individuals as they interact not only with one another but with pictures, texts discourse and gestures (Scheurman, 1998). Agreement or consensus considers the validity of alternatives or identifies the most appropriate construction.

It is clear that the best student learning likely takes place in the constructivist classroom as this is where higher order thinking skills can be applied. The traditional classroom perpetuates lower order thinking. “School is seen as a place to repeat back what the teacher or textbook said and to follow the correct steps in the correct order to get the correct answer” (Paul, 1990, p.1). The constructivist classroom, on the other hand, allows for higher order thinking where critical thinking skills can be presented and practiced so students can construct and re-construct their understandings. The learner will be presented with situations where they have to determine trends and claims and decide what to do or believe based on critical analysis of evidence that the students discover. “Educators must invite students to experience the world’s richness, empower them to ask their own questions and seek their own answers and challenge them to understand the world’s complexities” (Brooks & Brooks, 1999, p. 5). Constructivism and critical thinking is as much about empowerment as it is about student
learning. Putting these theories into practice is praxis and it is praxis that can lead to not only individual empowerment but widespread social change and educational reform. The following will look at the concept of praxis and the idea that when student learning is guided by critical thinking a moral imperative comes into play where students begin to see that they can be agents of change.

**Praxis and the Science Curriculum – Putting Theory in Practice**

Praxis, put simply, is the relationship between theory and practice. Praxis produces actions which are guided by theory that shape and change the world. It is guided by a moral disposition to act truly and rightly and is concerned with continuing human well being and the good life (Smith, 1996, 2000). Curriculum guided by praxis makes an explicit commitment to emancipation and thus action is not simply informed, it is also committed. Actions and evidence can be observed and examined to determine effectiveness of praxis. Therefore, praxis can also be seen as a part of some types of action research where problem solving is also based on a reflecting process guided by the production of actions that committed and informed.

**The Concept of Praxis**

Three fundamental human interests which influence how knowledge is constructed are the technical, practical and emancipatory interests (Grundy, 1987). The technical interest is an interest in controlling and managing the environment in order for a species to survive and to get what they deem worthy from society. In this orientation towards curriculum, the teacher’s goal is to reproduce an image of a student who has already learned the desired outcome. This is done through the control of the learner and the knowledge. This relates to Tyler’s view of
curriculum as technology where there is an interest in controlling pupil learning so that at the end of teaching the students will have made and reached the products expressed in the original objectives (Grundy, 1987). In this view, the student is seen as a container to be filled (Freire, 1970). According to this view the more completely the teacher fills the receptacles, the more effective the teacher is. This also is synonymous with the behaviorist approach to teaching where the teachers’ role is to disseminate information. Both views of education, behaviorist and curriculum-as-technology, employ lower-order thinking skills that require students to do little more than memorize, repeat, recall and reproduce.

The practical interest involves understanding the environment so that one is able to interact with it and not just survive in it (Grundy, 1987). In terms of education, the teacher and students interact to make meaning of the world. There is a moral imperative associated with the practical interest because curriculum concerned with a practical interest is not only concerned with promoting knowledge but also promoting the right action. Curriculum developed in a practical interest depends on teachers’ judgment rather than teacher direction.

The emancipatory interest is concerned with empowerment and liberation of knowledge. In this interest, individuals and groups take control of their own lives in that they do more than survive in their environment and interact in their environment. Fundamental to the emancipatory interest is action based on authentic, critical insights into the social construction of human society (Grundy, 1987). Emancipation entails a reciprocal relationship between self-reflection and action. This self-reflection and action is a process which both students and teachers go through together. An emancipatory interest engages the students as active constructors of knowledge with support of the teacher. The result is the creation of a
shared responsibility to move culture and society away from the status quo. Placing a critical perspective on knowledge is fundamental to the emancipatory interest and praxis. It is through critical analysis that learners gain control of knowledge and allows students and teachers to make knowledge meaningful. Moje (2007) believes that opportunities to learn must not only provide access to mainstream knowledge and practices but also provide opportunities to question, challenge, and reconstruct knowledge. Social justice pedagogy and a curriculum informed by an emancipatory interest should offer possibilities for transformation, not only of the learner but also of the social and political contexts in which learning and other social action take place (Saunders, 2006). Freire’s (1970) work with adult literacy programmes has been informed by an emancipatory interest and has demonstrated transformative power. Students of Freire who were learning to read and write came to a new awareness of selfhood and began to look critically at the social situation in which they found themselves and were given the chance to take initiative and action to transform the society. However, this form of liberation is much more than physical, it is also liberation of intellect and liberation of self as people become more aware and more enlightened. Taking action against the oppressor is a reflection of the emancipatory interest.

The Science Curriculum and Praxis

It is important to explain how praxis relates to the science curriculum. That is, what it would look like to integrate the theory of constructivism into the science classroom. This can be done firstly, by looking at how science knowledge can be constructed and then using Freire’s cultural literacy model as a guide to putting the constructivist theory into action through the lens of praxis.
Praxis, as it relates to constructivism and the science curriculum, is how students construct scientific knowledge and the actions they take with that knowledge. When considering the science curriculum, a constructivist classroom informed by an emancipatory interest would see teachers and students constructing knowledge based on experience and observations of the natural world in a science, technology, society and environment (STSE) context. Knowledge would also be constructed through the sharing of individual students’ prior knowledge. “Whenever possible, students should be encouraged to express their ideas and try to convince each other to adopt them. Having to listen to their fellow students’ ideas, to take those ideas seriously, and to try to find ways to test those ideas with observations and experiments are necessary experiences” (Paul, 1990, p.25). The sharing and negotiation of knowledge from various groups can also help students to construct their own knowledge. For instance, First Nations’ people have their own prior knowledge explaining how many natural phenomena came to be. This is different than Western knowledge that explains similar phenomena. Based on sharing these sources, each student would construct and create their own understanding of nature and naturally occurring events. Students, like scientists, will reconstruct (change) their knowledge when they are presented with compelling experiences and forms of knowledge about a subject. Constructing knowledge is much more than students or teachers picking an idea that makes sense, that is, it is much more than an arbitrary selection. Each student must look critically at the ideas presented and experiences gained in order to construct their knowledge. A science classroom informed by an emancipatory interest where students are using critical thinking skills would allow students to construct and reconstruct science knowledge and use that knowledge to inform action in society.
Praxis shares three fundamental principles from Freire’s literacy programme in gaining an understanding of how the constructivist theory should be implemented in the science classroom. The three fundamental principles are that the learners should be active participants in the learning programme, the learning experience should be meaningful, and the learning should have a critical focus (Grundy, 1987).

1) The Learners Should be Active Participants

This means that students and teachers are given the opportunity to explore concepts in a hands-on, minds-on way. They should be testing their scientific ideas by creating and performing their own experiments. They should be given the chance to test knowledge that is relevant to them such as examining issues around farmed salmon, or looking into ideas around genetics and genetic modification. After students have constructed their knowledge about a relevant idea or issue, they should look critically at that knowledge and how it pertains to dangers of genetically altered salmon escaping into nearby ecosystems. The critical examination may reveal the ‘oppressors’ or ‘dominant groups’ and informed actions should be taken. The direction of study and the actions taken in this area would be decided by the students and teachers not handed down from a higher authority. The students and the teachers would be involved in dialogue to negotiate the direction where the knowledge is taking them. Perhaps they would be creating awareness poster to draw attention to the dangers of genetic modification. Most importantly, the students would be taking actions to face oppressors and dominant powers.
2) The Learning Experience Should be Meaningful

Meaningfulness is a matter of negotiation between students and teachers. The teacher and student together explore issues that are relevant to the students. Making learning meaningful comes from engaging students’ prior knowledge and interest. By challenging the status quo new paths for change can be developed. To be considered praxis, learning must take place in the constructed or cultural world. However, if we begin by looking at what is natural and then reflecting on the cultural implications then we may be able to make meaning and to take new action. Mentioned earlier, meaning is a social construction. As Eisner (1979, p. 65) states:

Content in the science curriculum is not exclusively to be drawn from the problems with which scientists work but from the individual and social problems for which scientific inquiry has some relevance: the causes and consequences of stress, community mental health, the implications of the right to die, eugenics, environmental pollution, the location of nuclear plants.

Exploring age and content appropriate local issues provides students with the opportunity to gain a deeper meaning and knowledge about topics that are relevant to them. The issue of farmed salmon may be particularly important to a coastal community. Everyone in the community or classroom would probably have some vested interest in this topic and therefore, it may be relevant to the entire class.

3) Learning Should Have a Critical Focus.

There is a need for students to think critically about issues that arise in the hands-on, minds-on science curriculum. The knowledge gained in the science curriculum should be used
to empower students and allow them to make or see how decisions about that knowledge affect people and society. “Critical pedagogy confronts the real problems of existence” (Grundy, 1987, p.156). It would help students question and challenge beliefs and practices that dominate (Smith, 1996, 2000). Students should be allowed, through experimentation and observation, to explore natural phenomenon. After that, they should be given the opportunity to discuss, debate and reflect about the impact of that knowledge. For the science curriculum, an interesting topic to discuss could be global warming. Compelling theories would be presented, not just one, and students would be given the opportunity to critically look at alternatives. This is a very political topic but participating in praxis is risky since there is a commitment to human well being and a search for truth. The new action that resulted from critically examining this concept would inherently lead to a better understanding of the world. People would be acting for themselves making wise, informed and committed actions.

Summary

In summary, this exploration of literature regarding critical thinking has revealed several important areas to consider when embedding critical thinking skills into science instruction and classroom practice. Firstly, it is important to analyze and acknowledge the literature from the CTC, who have laid the groundwork to embedding critical thinking skills into all areas of the curriculum. Next, it is important to look at the definitions of critical thinking. Although they are vast and varied, the one used for the purposes of this research project also must honor and value the student as an integral part of the learning process in constructing knowledge. Putting the theory of constructivism into action in the science classroom allows the teacher and
students to be co-creators of knowledge as they take action and reflect on their actions in order to work towards building a fair and just society. Putting theory into action through praxis involves students and teachers learning being informed by an emancipatory interest. Learning that is informed by the emancipatory interest honors all learners and allows students and teachers to be liberated and empowered. Finally when embedding critical thinking skills into the science curriculum it is important that learning be guided by three important principles; active, meaningful and critical learning to create thoughtful citizens for the future.
Chapter Three: Methodology

Introduction

Critical thinking skills are needed to prepare today’s students to challenge future problems and STSE issues. The goal of this action research project was to examine critical thinking skills as they relate to STSE issues in the grade five science curriculum. Embedding critical thinking into the grade five curriculum allows students not only to gain science knowledge but develop the critical thinking skills that they will need for the future.

Action Research is an instructional intervention that attempts to improve one’s teaching. It is a recursive process that does not proceed in a linear fashion. That is, action research can be seen as a ‘spiral of action’ where planning, action and evaluation of the result of the action continue in an ongoing fashion (Kemmis & McTaggert, 1988). It also involves groups of teachers collaboratively solving the problems they face on a daily basis in their own classrooms. Traditional research methods consist of researchers conducting and reporting their education inquiry to teachers practicing in the field. Researchers often hand down edicts with the expectation that teachers will be passive receivers of this information (Johnson, 2002). This process does not value the teacher’s point of view or reflect the concerns a teacher faces on a daily basis. Action research mitigates this problem by creating a two-way flow of information. It allows teachers to ask their own questions and empowers them to find and create strategies to address the needs in their classes. This effectively improves one’s practice and at the same time, improves student learning.

For this action research project, a global plan was created and then shared amongst several trusted colleagues. This allowed for collaboration and constructive feedback and to take place. The ideas shared from these colleagues were used to make changes and adjustments to
the plan. Once the plan was in place, assessment of the students’ baseline ability level was documented using a pre-test. From there, the teaching of individual lessons’ began. The teaching model used throughout the study was one which was defined by a gradual release of responsibility. That is, students were told what to do, they were shown what to do and then they were given the opportunity to practice on their own. After each lesson, reflection and analysis of student evidence took place and adjustments to teaching were made. Changes to the global plan were necessary as the teaching progressed. In several instances some lessons were revised and mini lessons were added as necessary to address detected needs or concerns.

This project used a constructivist approach, where students were invited to construct their own knowledge and opinions after gathering evidence from a wide range of sources, not just through reading but through experiences. Students were then asked to analyze that information and use it to answer a critical thinking question. Each lesson plan in a natural resources unit, was constructed using a specific framework which took students through a step-by-step process allowing them to chunk information and think deeply during each stage of the lesson. The specific critical thinking skills, or habits of mind, that were examined in this project included stating an opinion, justifying an opinion with facts, considering the alternative opinions or statements, making a sound conclusion and then reflecting on the conclusion.

**Natural Resources Critical Thinking Unit**

This project combined curriculum development along with action research to enhance grade five students’ critical thinking and the understanding of natural resources. The grade five Earth and Space Science section of the prescribed learning outcomes focuses on Renewable and
Non-renewable Resources (British Columbia Ministry of Education, 2005). The outcomes are as follows:

It is expected that students will:
- Analyze how BC’s living and non-living resources are used.
- Identify methods of extracting or harvesting and processing BC’s resources.
- Describe potential environmental impacts of using BC’s living and non-living resources.

This unit of study was chosen because of its potential for discussion of STSE issues as a context for critical thinking. The specific STSE issue chosen for discussion was fish farming. This issue involves science and technology and as well, has a strong relationship with society and the environment. This issue is also a local issue and therefore likely to be more meaningful to the students. Environmental issues are currently hot topics of conversation in our society and many of these issues present themselves in this unit of study. Children need to be invited into these discussions as they have many great opinions and ideas to contribute. Students need to discuss important and controversial issues at an early age as they will be the future leaders and decision makers. The more experience children have discussing controversial issues using critical thinking skills the more likely they will be to use these skills in the future to make well informed, respectful and responsible opinions and decisions.

Lesson Plans

Lessons for this unit were organized into two background lessons and four critical thinking lessons (Table 1). Background lessons were necessary to introduce students to
<table>
<thead>
<tr>
<th>Lesson Number</th>
<th>Activities</th>
<th>Learning Outcomes</th>
<th>Critical Thinking Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>Present Pre-test scenario question. Students respond to question. Evaluate responses using Critical Thinking Rubric.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
| **Lesson 1**  | **Science Background**  
**Classifying Renewable and non-renewable Resources**  
**Objective:** Students will classify renewable and non-renewable resources and what they can be used for (commercial or recreational purposes). Textbook (pg 161-163) Introduction to resources, living and non-living. Textbook (pg 177, 178, 205, 206, 207) Complete concept set with renewable and non-renewable resources. 4 Box Graphic Organizer to compare living vs. non-living, renewable vs. non-renewable resources.  
**Assessment:** Textbook Questions, Concept Set, 4 Box Graphic Organizer, Quick Write | **PLO** (Science 5) Analyze how BC’s living and non-living resources are used. | (Background Lesson)       |
| **Lesson 2**  | **Science Background**  
**Conserving and Protecting our Natural Resources**  
**Objective:** Students will ‘clean-up’ a simulated oil spill (textbook 164-167). Students will gain an understanding of how an ecosystem works, and how we can impact it, and ways to conserve our resources to protect ecosystems (textbook 168-171). Students will create a Public Service Announcement (PSA) convincing people to save our natural resources.  
**Assessment:** Oil spill reflection questions, Check your Understanding Questions (p.171), PSA and PSA presentation, Lesson Reflection Quick Write. | **PLO:** (Science 5) Describe potential environmental impact of using BC’s living and non-living resources.  
**PLO:** (Socials 4/5) Create a presentation on a selected topic. | (Background Lesson)       |
| **Lesson 3**  | **Extracting our Natural Resources**  
**Objectives:** Students will gain an understanding of methods used for extracting resources. Students will trace back from a tin of salmon to open water. Students do ‘Chocolate Chip Mining’ activity to gain an understanding of extracting resources and complications involved. Students read and summarize information about methods of extracting three resources; fish, trees, minerals. Students analyze the information and then decide extracting which resource has the most/least environmental impact.  
**Assessment:** Chocolate Chip Mining page, Extracting Resources Expert Pages, Summarizing Organizer, Extraction Pros and Cons Chart.  
**CT Assessment:** Critical Thinking Response Template. Partner Talk conversations. | **PLO** (Science 5): Identify methods of extracting or harvesting and processing BC’s natural resources.  
**PLO** (Science 4): Students will be able to determine how personal choices and actions have environmental consequences.  
**PLO:**(Socials 4/5): Apply critical thinking skills to a problem or an issue. | **Critical Thinking Question**  
#1) Which extraction method has the most/least impact on the environment? |
<table>
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<tr>
<th>Lesson Number</th>
<th>Activities</th>
<th>Learning Outcomes</th>
<th>Critical Thinking Question</th>
</tr>
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</table>
| Lesson 4      | **Objective**: Students will look at various sources of information about salmon farming. Students will analyze the articles to determine the article’s point of view and who is presenting it and why they would be presenting that point of view. Students will then decide which of the articles presents the most accurate view of fish farming in British Columbia.  
**Assessment**: Data chart for recording thinking and information.  
**CT Assessment**: Critical Thinking Response Template. (CT reflection rubric) | **PLO**: (Science 5) Students will be able to describe potential impacts of using BC’s living and non-living resources.  
**PLO** (Science 5): Identify Methods of extracting or harvesting and processing BC’s natural resources.  
**PLO** (Socials 4/5): Gather information from a variety of primary and secondary sources.  
**PLO** (Socials 4/5): Apply critical thinking skills to a problem or an issue. | **Critical Thinking Question**  
#2) Who is presenting the most accurate view of the salmon farming industry. |
| Lesson 5      | **Objective**: Students will analyze the information given in previous lessons and will create a list of pros and cons of both commercial net fishing and salmon fishing operations. Students will determine a level of importance/environmental impact for each of the pros and cons and then will rank them. Students will look at the list of pros and cons and will answer the critical thinking question.  
**Assessment**: Pros and Cons cue cards in ranking order.(observation)  
**CT Assessment**: Critical Thinking Reflection Question, respond using Critical Thinking Response Template (CT Reflection Rubric) | **PLO**: (Science 5) Students will be able to describe potential impacts of using BC’s living and non-living resources.  
**PLO** (Socials 4/5): Gather information from a variety of primary and secondary sources.  
**PLO** (Socials 4/5): Apply critical thinking skills to a problem or an issue. | **Critical Thinking Question**  
#3) Which is better; fish farming or commercial fishing? |
| Lesson 6      | **Objective**: Whatever position the students took in the previous lesson, students will take on the other position in order to see another point of view.  
**Assessment**: Students will create a public service announcement (PSA) for the side that they are arguing (either for a fish-farm or against one).  
**CT Assessment**: Critical Thinking Reflection Question, respond using Critical Thinking Response Template (CT Reflection Rubric) | **PLO**: (Science 5) Students’ will be able to describe potential impacts of using BC’s living and non-living resources. | **Critical Thinking Question**  
#4) What is the other perspective? |
the content of the natural resources unit, to assess prior knowledge and introduce them to some of the vocabulary. Furthermore, because many of the critical thinking lessons focused specifically on the salmon farming issue, background lessons were necessary to allow students to acquire knowledge in order to help them formulate their opinions.

The Nine-Step Smart Learning process was used as a framework for organizing each lesson (Close, 2004). The Smart Learning framework consists of nine steps that engage all learners in a safe and meaningful way. The nine-steps are broken down into before, during and after reading or information gathering (Table 2). Each step focused on one cognitive or metacognitive skill at a time allowing learning to be broken down into manageable pieces. The before learning steps include accessing prior knowledge, setting goals, predicting and asking questions. The during learning consists of chunking information into usually three manageable

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<tr>
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<th>Activities</th>
<th>Learning Outcomes</th>
<th>Critical Thinking Question</th>
</tr>
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<tbody>
<tr>
<td>Lesson 6</td>
<td></td>
<td>PLO (Socials 4): Identify alternate perspectives on a topic or an issue.</td>
<td></td>
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<tr>
<td>(continued)</td>
<td></td>
<td>PLO (Socials 5): Defend a position on a selected topic.</td>
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</tr>
<tr>
<td>Post-Test</td>
<td>Science Probe 5 Unit Test</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>(Knowledge)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Post-Test</td>
<td>Present Pre-test scenario question. Students respond to question. Evaluate question response using Critical Thinking Rubric.</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>(Critical</td>
<td></td>
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<tr>
<td>Thinking)</td>
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### Table 2: Smart Learning Framework

<table>
<thead>
<tr>
<th>Steps</th>
<th>Explanation</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Accessing Prior Knowledge</td>
<td>Connecting to the lesson, engaging the students. Accessing the students’ prior knowledge. We must draw out and work with the understandings that learners bring with them, before introducing new ideas (Donovan, Bransford &amp; Pellegrino, 1999).</td>
<td>Video clips, hands-on materials, images, A/B Partner Talk, etc.</td>
</tr>
<tr>
<td>2. Goal(s)</td>
<td>What are the goal/objectives of the lessons? What are the students learning? “I can…” format</td>
<td>A/B Partner Talk, Mining for Gold</td>
</tr>
<tr>
<td>3. Prediction</td>
<td>What can the students predict about the upcoming lesson, the concept being covered? Prediction is a critical skill and it has profound effect on the development of understanding (Marzano, Pickering &amp; Pollock, 2001).</td>
<td>A/B Partner Talk, Mining for Gold</td>
</tr>
<tr>
<td>4. Questions</td>
<td>What are the students wondering, what questions are the students having at this point in the lesson? Thinking is supported when learners are encouraged to talk about their ideas and their questions.</td>
<td>A/B Partner Talk, Mining for Gold</td>
</tr>
<tr>
<td>5.6.7. Chunk 1, 2, 3</td>
<td>Chunking up the concept and learning into manageable parts. Learners use strategies to gather and organize information, to identify what is important and make connections as they read sections or parts of text. Creating and discussing images stimulates and increased activity in the brain (Gerlic &amp; Jausovec, 1999).</td>
<td>Use of graphic organizers and text organizer. Resource: Non-fiction Reading Power.</td>
</tr>
<tr>
<td>8. Demonstration of Learning</td>
<td>Writing activities or culminating activities which demonstrate what the student has learned throughout the lesson. This requires clear understanding of criteria and expectations.</td>
<td>Quick Writes</td>
</tr>
<tr>
<td>9. Reflection</td>
<td>New ideas, connections and questions are discussed. Metacognitive processes are discussed such as what you noticed about your thinking, what changed for you during the lesson. By developing self-awareness one is effectively developing one’s intelligence (Abbott &amp; Ryan, 2001).</td>
<td>A/B Partner Talk, Table Talk, Tap-in, Personal Writes, Ticket out the Door Reflections</td>
</tr>
</tbody>
</table>
pieces and the after learning consists of demonstration what the students have learned in the lesson and then reflecting on their learning.

Each lesson therefore had the potential to span several days in order to focus on one portion or skill at a time. Throughout the lessons, students participated in structured partner-talk were all learners where actively engaged in a supportive and inclusive environment. Before the unit began, students were put into several different partnerships allowing for homogenous and heterogeneous groupings. For instance, each student had a ‘Tree’ partner who was someone with a similar academic ability. Each student also had a ‘Fish’ partner who was someone who was considered a friend and someone who was easy to talk with. ‘Rock’ partners were partnerships that were focused on different academic abilities and ‘Water’ partners were partnerships that focused on students of a different age or gender; that is, students who would not normally interact with one another in the class when given choice. These partnerships were established at the beginning of the unit to be used with ease during the teaching of the lessons. The teacher was able to call upon the partnerships to debate deep thinking questions that focused on background knowledge, making predictions, and prior knowledge. Throughout the lessons students were also given the opportunity to find a partner of their choice. The type of partnership chosen often depended on the question being asked.

Once students were in their partnerships, one of the partners was asked to respond to the question while the other partner was asked to be an active listener who asked clarifying questions. It was the role of the listening partner to report back to the class what their partner had said. Reporting back to the whole class allowed a number of new and different ideas to be shared in a safe and respectful manner. Many of the partner talk conversations and reporting
out sessions were video taped and transcribed for analysis. Not all of the conversations were videotaped due to time constraints and the lack of a research partner to video tape.

The first two lessons taught in this unit were background lessons that focused on classifying renewable and non-renewable resources and conserving and protecting natural resources (Appendix A: Lessons 1 and 2). Students were also asked to sort examples of resources as either renewable or non-renewable and then were asked to further sort examples into living and non-living resources in these lessons. The first background lesson is not a critical thinking lesson, although it did allow students to apply higher-order thinking skills according to Bloom’s Taxonomy (Bloom, 1984). The second background lesson asked students to clean-up a simulated oil spill. This lesson again allowed students to use higher-order thinking skills (some that they would be using in the critical thinking lessons) and also to gain hands-on experience and to apply that experience to answer a question. After gaining introductory knowledge of how an ecosystem worked, students were asked to create a public service announcement convincing people to conserve natural resources.

The critical thinking lessons designed for this project were focused around specific critical thinking skills (Appendix A: Lessons 3-6). Each lesson provided a question or challenge that asks the students to make a decision. Lesson three, the first critical thinking lesson, students were asked to examine consequences of extracting natural resources. They were asked to mine for chocolate chips from a chocolate chip cookie. They were then put into expert groups to gain information about a specific form of extraction and then were asked to share their findings with the whole group. Once all the information was shared, the students were asked to decide which method of extraction had the most impact on the environment. In lesson
four, students were asked to read several articles depicting differing views on the salmon farming issue. Students gathered information from each article and then were asked to decide who was presenting the most accurate view of the salmon farming industry. Lesson five asked students to determine the pros and cons of the salmon farming industry by reading several articles on both sides of the issue. Once students organized their information they were asked to respond to the question: which is better, commercial open water fishing or salmon farming? The final critical thinking lesson asked students to switch their position from the previous lesson and to argue the alternative point of view.

When students are asked to make a decision they are asked to apply knowledge that they have gained through the lesson and formulate a response that incorporates critical thinking skills. During the lessons the students were introduced to components of a complete critical thinking response including; stating an opinion, supporting an opinion with detailed facts and opinions, considering the other side of the decision, making a concluding statement and then reflection on the response (Appendix B). Students used the template as an organizer to answer each of the four critical thinking questions and thus provide a complete response that has been thought through critically. The thinking response template was introduced using a scaffolding method. That is, first the template was introduced by the teacher and a critical thinking response was created using the ‘thinking out loud’ strategy to model the process. The teacher talked through a response while writing down the various steps on a copy of the template using an overhead projector. The teacher and the students co-created a response in the next lesson. The teacher solicited information to include in the organizer meanwhile scribing students’ responses on an overhead of the template. In the next lesson, the students
and teacher co-created only two of the sections in the template leaving the remainder of the organizer for the students to complete. After these demonstration lessons were complete students were on their own to create their own responses to all sections of the template. This gradual release of responsibility allowed the students to gain an understanding of expectations and what was required of them.

**Critical Thinking Lesson Assessments**

Before beginning the teaching of the lessons an assessment rubric was created by combining several other critical thinking rubrics. The rubric was composed of what was considered necessary in a quality critical thinking response. The rubric was used to mark the critical thinking pre-test, the critical thinking responses during the instruction of the unit, and it was also used to mark the critical thinking post-test (Appendix C). During the unit, various forms of assessment were used in order to evaluate student responses including self assessment, peer assessment and teacher assessment allowing for both formative and summative assessment.

The critical thinking response rubric was used as a summative assessment tool and was used to evaluate four of the final critical thinking responses the students created. Formative assessment tools were also used throughout the lessons including descriptive feedback forms that outlined ‘What’s Working, What’s Not and What’s Next’ (Appendix D). These forms were used by students, peers and the teacher to allow the students to focus on what they had done a good job on, what needed more work and the next steps in order to improve their response. Also during the unit, the response rubric was put into kid friendly language in order to make it more user friendly for the students.
Pre-Test

A baseline of students’ critical thinking skills was established with a pre-test created using the critical thinking response template. A scenario was created that required students to respond (Appendix E). The scenario involved making a decision that would require the students to apply critical thinking skills. For instance, they would have to state their opinion in response to a scenario that involved conserving and protecting natural resources. The same scenario was used at the end of the unit for the post-test in order to compare and check for growth of critical thinking skills.

Classroom Implementation

Each lesson for this project was designed according to the Smart Learning Framework and as a result each lesson had many concepts and learning strategies to cover. Each lesson, therefore, covered a range of days. Also, because of the nature of action research design, the original unit plan outline was altered throughout the teaching process based on regular feedback with trusted professionals, in order to meet the needs of the students in the class. The implementation schedule that was followed is provided which includes the dates that the lessons were taught as well as the activities that took place (Table 3). The implementation schedule indicates which step of the Smart Learning Framework was being covered in that particular lesson. It is also important to note the effect of the particular time of the year on the implementation of the unit plan. As many educators know, the late spring is a very busy time, especially around elementary schools. Although four afternoon blocks a week were set aside for the teaching of this project those times were often interrupted or not available at all. This
<table>
<thead>
<tr>
<th>Date</th>
<th>Lesson Title</th>
<th>Activity</th>
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<tbody>
<tr>
<td>April 7&lt;sup&gt;th&lt;/sup&gt; Background</td>
<td>Lesson 1: Classifying Renewable and Non-renewable Resources</td>
<td>Sort and predict with vocabulary words from the unit. Students read textbook pages with teacher pausing to complete Listen Sketch Talk and Respond for page 160. Students complete textbooks questions for comprehension.</td>
</tr>
<tr>
<td>April 20&lt;sup&gt;th&lt;/sup&gt; Background</td>
<td>Lesson 1: Classifying Renewable and Non-renewable Resources</td>
<td>Introduce ‘Partner Talk’ groupings (Rock, Fish, Tree and Water) and glue into duo tangs. Practice finding each partner. Introduce Concept Set for renewable and non-renewable resources. Students sort examples into each category and then analyze lists. Students then sort the examples into living and non-living things and make connections between the two sorting activities.</td>
</tr>
<tr>
<td>April 21&lt;sup&gt;st&lt;/sup&gt; Background</td>
<td>Lesson 2: Conserving and Protecting our Natural Resources Accessing Prior Knowledge</td>
<td>Show a picture and talk about prior knowledge of oil spills. Students then participate in cleaning up a mock oil spill and determine the best method of removing oil is. Students complete comprehension questions in order to check for understanding.</td>
</tr>
<tr>
<td>April 23&lt;sup&gt;rd&lt;/sup&gt; Background</td>
<td>Lesson 2: Conserving and Protecting our Natural Resources</td>
<td>Students read the textbook about how to conserve our Natural Resources. While reading, students find key words and then use the key words to summarize the reading. Once done, students complete comprehension questions to check for understanding.</td>
</tr>
<tr>
<td>April 27&lt;sup&gt;th&lt;/sup&gt; Background</td>
<td>Lesson 2: Conserving and Protecting our Natural Resources Demonstration of Understanding</td>
<td>Students learn about features of a Public Service Announcement (PSA). Students then research good ways to conserve and plan and create their own PSA to present to the class.</td>
</tr>
<tr>
<td>April 30&lt;sup&gt;th&lt;/sup&gt; Background</td>
<td>Lesson 2: Conserving and Protecting our Natural Resources Demonstration of Understanding</td>
<td>Students do a Quick Write Reflection from lesson 2. Was it easy or hard to convince people to conserve resources?</td>
</tr>
<tr>
<td>May 1&lt;sup&gt;st&lt;/sup&gt; Critical Thinking</td>
<td>Lesson 3: Extracting our Natural Resources Accessing Prior, Knowledge and Chunk 1</td>
<td>Students observe a tin of salmon and trace it back to a salmon in the ocean. Students begin chocolate chip mining experiment. Groups of students are given chocolate chip cookies and equipment and try to extract as many chocolate chips as possible in order to determine if their mine is profitable. Students must reclaim the land after they are done and complete comprehension questions to check for understanding.</td>
</tr>
<tr>
<td>May 5&lt;sup&gt;th&lt;/sup&gt; Critical Thinking</td>
<td>Lesson 3: Extracting our Natural Resources Chunk 2</td>
<td>Students read information about an article on either Background Information, Method of Extraction, or Environmental Impact for fishing, mining and logging. Each group became an expert for their topic and summarized the information in their article.</td>
</tr>
<tr>
<td>Date</td>
<td>Lesson Title</td>
<td>Activity</td>
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<tr>
<td>May 7th Critical Thinking</td>
<td>Lesson 3: Extracting our Natural Resources Continue Chunk 2</td>
<td>Continue with summaries. Many students were having difficulty with the summarizing so a mini lesson on summarizing strategy was completed.</td>
</tr>
<tr>
<td>May 11th Critical Thinking</td>
<td>Lesson 3: Extracting our Natural Resources Continue Chunk 2</td>
<td>Continue with summaries.</td>
</tr>
<tr>
<td>May 12th Critical Thinking</td>
<td>Lesson 3: Extracting our Natural Resources Continue Chunk 2</td>
<td>Each group read out their three most important facts from the reading. Teacher and class did a group summary of all important ideas.</td>
</tr>
<tr>
<td>May 13th Critical Thinking</td>
<td>Extra</td>
<td>Viewed a clip of a news report about smelters in Trail, B.C. The United States is upset about runoff from the smelters reaching rivers. Students were asked if Canada should be responsible for the runoff reaching American waters.</td>
</tr>
<tr>
<td>May 19th Critical Thinking</td>
<td>Lesson 3: Extracting our Natural Resources; Demonstration of Learning</td>
<td>Students analyze the charts and the information they recorded and then answer the critical thinking question: Which method of extraction has the most environmental impact? Students used the critical thinking template to record their information. Students used the template to write out a good copy paragraph in response to the critical thinking lesson.</td>
</tr>
<tr>
<td>May 20th Critical Thinking</td>
<td>Lesson 3: Extracting our Natural Resources; Which has the Most Impact?</td>
<td>Mini lesson on adding transition words to complete a good copy response paragraph. Also, students were asked to complete the metacognition portion of the response.</td>
</tr>
<tr>
<td>May 21st Critical Thinking</td>
<td>Lesson 4: Salmon Farming; Analyzing Viewpoints Predictions and Prior Knowledge Chunk 1</td>
<td>Students analyzed pictures of fish farming and used Partner Talk to make predictions about what the articles would be about. Students read four media articles about salmon farming expressing different view points. Students’ record information about what the viewpoint is, whose viewpoint is it and why they would be expressing that viewpoint into a data chart.</td>
</tr>
<tr>
<td>May 22nd Critical Thinking</td>
<td>Lesson 4: Salmon Farming; Analyzing Viewpoints Chunk 2, Demonstration of Understanding</td>
<td>Students analyze their charts and decide who is presenting the most accurate view of the salmon farming issue. Students use the response template to answer the critical thinking question. Students put their templates into good copy paragraphs using connecting words.</td>
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Table 3: Classroom Implantation Schedule (continued)

<table>
<thead>
<tr>
<th>Date</th>
<th>Lesson Title</th>
<th>Activity</th>
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<tbody>
<tr>
<td>May 25&lt;sup&gt;th&lt;/sup&gt; Critical Thinking</td>
<td>Lesson 4: Salmon Farming; Analyzing Viewpoints Demonstration of Understanding</td>
<td>Assessing paragraphs. Students read their descriptive feedback forms and wrote good copy paragraphs as well as completed the metacognition portion.</td>
</tr>
<tr>
<td>May 26&lt;sup&gt;th&lt;/sup&gt; Critical Thinking</td>
<td>Lesson 5: Salmon Farming vs. Open Water Fishing Accessing Prior Knowledge, Chunk 1</td>
<td>Students look at forestry pictures and partner talk about pros and cons to the forestry industry. Students read four articles about the salmon farming (previous lesson) and record pros and cons. Students read four articles about commercial open water fishing and record pros and cons.</td>
</tr>
<tr>
<td>May 29th Critical Thinking</td>
<td>Lesson 5: Salmon Farming vs. Open Water Fishing Demonstration of Understanding</td>
<td>Students use the critical thinking response template to respond to the critical thinking question: ‘Which is better for the environment and for the salmon population, commercial open water fishing or salmon farming?”</td>
</tr>
<tr>
<td>June 1&lt;sup&gt;st&lt;/sup&gt; Critical Thinking</td>
<td>Lesson 5: Salmon Farming vs. Open Water Fishing; Which is Better Assessment</td>
<td>Students complete peer assessment of their critical thinking response template using Descriptive Feedback Forms.</td>
</tr>
<tr>
<td>June 1&lt;sup&gt;st&lt;/sup&gt; Critical Thinking</td>
<td>Lesson 6: Arguing the Other Side Prior Knowledge, Chunk 1, Chunk 2</td>
<td>Students participate in ‘U’ debates about various topics. The students line up in the form of a ‘U’ depending on how they feel about a topic. If they feel very strongly for the issue they line up at the top left part of the ‘U’, if they feel very strongly against the issue they line up at the top right part of the ‘U’. If they are undecided they line up at the bottom middle portion of the ‘U’. The rest of the students line up to fill in the rest of the ‘U’ depending on how they feel (slightly for, slightly against, etc.).</td>
</tr>
<tr>
<td>June 2&lt;sup&gt;nd&lt;/sup&gt; Critical Thinking</td>
<td>Lesson 6: Arguing the Other Side Demonstration of Understanding</td>
<td>Students switch their opinion from the previous critical thinking lesson. Students create a new PSA about their new opinion on which is better. Students wrote up Critical Thinking Response. Students put their response into good copy paragraphs that were assessed by the teacher.</td>
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</table>
was due to many activities going on throughout the school including track practices, track meets, special performances, field trips, assemblies, choir rehearsals and end of year performances. The implementation of the unit took longer than expected and additional classes and sessions were necessary to ensure that the concepts were covered thoroughly.

**Post-Test**

After the unit was taught it was not only necessary to test the students’ critical thinking growth but also necessary to test the knowledge of natural resources that students had gained during the unit. The knowledge post-test consisted of three end of chapter tests from the Science Probe 5 Textbook (Doyle, Bowman, & Martin, 2006), (Appendix F). The textbook had been used for various assignments and reading throughout the unit however much of the concepts covered in textbook were not covered in the unit. The end of unit chapter tests provided a good assessment of general knowledge that the students had gained throughout the unit. The tests consisted of a variety of question types including multiple choice, fill in the blanks, matching, labeling, short answer and longer response questions. The end of the chapter tests were chosen for the knowledge post-test because of the variety of types of questions that they ask the students and the assumption that the assumption that the questions were valued and reliable. To test for a gain in critical thinking skills, the same scenario that was used in the pre-test was also used in the post-test in order to test students’ critical thinking growth (Appendix E). The critical thinking response rubric was used to assess the results of this post-test.
Chapter Four: Findings

Introduction

This chapter will provide the results of the action research study conducted to investigate the success of applying critical thinking skills to the Natural Resources unit of the grade 5 science curriculum. The goal of this unit was to allow students to use and apply critical thinking skills to gain a better understanding of science content knowledge in the school curriculum but also to help empower them to become future literate citizens, who will examine meaningful STSE issues.

The literature review demonstrated that critical thinking needs to be modeled and lived continually in the classroom. This involves students observing the world around them and being a part of the hands-on experimentation process as a way of constructing knowledge about the world around them. When students are provided opportunities to create their own knowledge about what to believe and what to do it also provides them with the opportunity to compare and add it to the prior knowledge, history and beliefs of others. Critical thinking focuses on the learner constructing their own knowledge, connecting that knowledge to the learner’s life and defending what they know in a way that honours and respects all parties involved.

This unit was designed to meet these desired ends using a series of lesson plans developed using a specific framework which honored individual students’ resources, authentic assessments involving reflection used to measure growth, and STSE issues that were meaningful and relevant were presented to students. The results of this study will be presented in the form of several themes discovered on the basis of analyzing the data. They are as follows:
Influence of Differentiated Instruction on Critical Thinking and Science Knowledge

This action research project focused on testing critical thinking skills acquired throughout the unit. In order to do this, a pre-test and post-test of critical thinking was used. General knowledge gained in the unit was tested using end-of chapter tests from the Science Probe 5 Textbook (Doyle, Bowman, & Martin, 2006). The combination of these three assessments will show growth in critical thinking and will also show the level of knowledge that the students had at the end of the unit.

In both the pre-test and the post-test, the students responded to a scenario. The scenario responses were evaluated using the critical thinking rubric. The critical thinking pre-test results showed that on average students scored 10.8 out of 24 (Table 4). This corresponds to an average of 45%. The critical thinking post-test response to the scenario indicates that students scored 17 out of 24 corresponding to a percentage of 71%. On the knowledge post-test students were given three end of chapter tests. The scores from each of the three tests were combined to give one final mark and percent. The combined average score for the science knowledge test was 69.7%. These results indicate that students scored significantly (p < 0.05) better on the critical thinking post-test than the pre-test when the average gain was examined with a t-test (t = 2.18, degrees of freedom = 22). The average science knowledge performance
(69.7%) was reasonably high compared to the performance of other classes in prior years. Students gained on average important content knowledge, as indicated by the results on the science knowledge tests, and they also increased, on average, their use and application of critical thinking skills. These average performances masked some variations amongst the participating students. When looking at individual student results, some students did quite well on the knowledge post-test and not so well on the critical thinking post-test whereas others did quite well on the critical thinking post-test and not so well on the knowledge post-test (Appendix G). For instance, Student A scored 96% on the critical thinking post-test and 52% on the knowledge post-test whereas Student J scored 63% on the critical thinking post-test and 80% on the knowledge post-test. These results indicate the need for both types of assessments for this science unit and the need for several forms of assessment in general for any unit taught. Student A excelled at articulating his/her opinions and critical thinking skills and appeared to be better suited to writing a paragraph to demonstrate his/her understanding. Student J, on the other hand, proved more proficient at demonstrating his/her understanding by a more traditional test. In addition to these final assessments there are likely other students yet who would have successfully demonstrated their understanding in a more visual way, or verbal way. Having multiple forms of assessments to meet the needs of students is necessary to address the diverse learning needs of this and all other classes.

In terms of testing critical thinking skills and higher order thinking skills it is clear that assessments such as the scenario response are necessary. Knowledge can be tested through traditional paper and pencil assessments with question prompts like: list, define, tell, describe,
Table 4. Results of the Critical Thinking and Science Knowledge Tests

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<thead>
<tr>
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<th>Critical Thinking Pre-Test</th>
<th>Critical Thinking Post-Test</th>
<th>Knowledge Post-Test</th>
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</thead>
<tbody>
<tr>
<td>Score Average</td>
<td>10.8/24</td>
<td>17/24</td>
<td>69.7/100</td>
</tr>
<tr>
<td>Percent Average</td>
<td>45%</td>
<td>71%</td>
<td>69.7%</td>
</tr>
</tbody>
</table>

identify, show, label, collect, tabulate, quote, name, who, when, where, etc. However, what is most valued as shown through educational research, experience and interviews with community leaders, parents and teachers are higher-level competencies that demonstrate comprehension, application, analysis, synthesis and evaluation.

**The Action Research Process and Reflective Practice**

The process of the action research cycle (planning, action, evaluation) was fundamental to the implementation of this study. A global unit plan was completed before the teaching of the unit began but once teaching began many minor adjustments and changes to that plan were made based on informal feedback about the teaching and learning effectiveness. The keeping of a journal aided in this process as it allowed the teacher/researcher to reflect on the actions taken and to make changes as needed (Appendix H). The journal proves as a sounding board and a mode of reflection for the teacher/researcher to examine. It, like a mirror, allow the teacher/researcher to reflect on thoughts and actions to identify how best to adjust the teaching to the class and for best practices take place. Upon analyzing the notes it is evident
that many real-time adjustments to the global plan were necessary based on the ability of the students and schedule changes. The teacher cannot be a robot enacting or slave to the planned lesson, but must be a reflective professional making adjusts to the content, schedule or sequence of the learning opportunities—without learning there is no teaching. For instance the entry on May 5th is as follows:

“Summarizing the information from the article was very hard for the students. Finding the main idea for each sub-title and putting it into their own words was very hard. This was a big job for the students. After this lesson a mini lesson will be necessary to teach the strategy of summarizing.”

After this entry, the next lesson focused on the summarizing strategy allowing the students to more effectively understand the main idea of the paragraphs they were reading. This in turn helped them to better understand the content of what they were reading and to assist them in forming their opinion. Also, the entry on May 19th revealed a greater focus on important vocabulary was necessary in order to help students clearly understand the critical thinking question:

“Also, it was very important the students had a clear understanding of the vocabulary of the Critical Thinking question. For instance, students needed to have a clear understanding about what ‘impact’ ‘worst’ and ‘accurate’ meant.”

Again, this set the direction for the next lesson and for critical thinking lessons to come. These were words students have heard before but did not have fully understand. Not knowing the meaning of these words could negatively impact how they responded to the question.
Conversations with peers also proved to be an important form of reflection for the teacher/researcher. Informal conversations with the research advisor, other teachers, and teaching assistants also proved invaluable to the reflection process and in the implanting of new actions. For example, after each lesson an informal conversation took place with the teaching assistant who worked specifically with an autistic child with an intellectual disability as well as two other students with learning disabilities. These conversations revealed adaptations and modifications that could be put in place to accommodate their needs consequently allowing each of these students to participate successfully in the unit. For instance, for several students, the response template was entered into an alpha-smart key pad to allow for the response to be typed up instead of printing which, for some students is a very onerous task. Also, on some occasions, some of the students responded orally to the critical thinking questions and post-test questions.

Constructivism and Critical Thinking

Paramount to this project was the realization of the need to include critical thinking skills into the school curriculum if it is to move toward a constructivism perspective. While teaching the unit for this project it became clear that the best way to achieve this is by providing a setting modeled after the ideas of constructivism where students decided what to do and what to believe within a structured context. Students were given the opportunity to gain hands-on knowledge in each lesson of this unit and in essence construct their knowledge using critical thinking. Once students gained this knowledge they applied it and used it to form their opinions. The knowledge that they were using to form their opinions and use as a basis for
thinking critically came from experiences that they had been involved in. Subsequently, their opinions and the supporting facts that they used were much more relevant and meaningful as a result of being able to sink their hands into what they were learning about. The growth in students was evident through the pre and post-test of critical thinking. Many students in the pre-test simply provided two to three sentences in response whereas in the post-test students were able to support their opinions in greater detail.

**Authentic Assessment (Before, During and After Learning)**

Throughout the lessons student learning was assessed in an authentic way. Assessment for learning, assessment as learning and assessment of learning all took place. Assessment for learning to empower learning and inform future instruction took place in the form of regular feedback from the teacher allowing students to make adjustments to their critical thinking responses and the students’ responses allowed the teacher to confirm planned instruction or make informed adjustments to future instruction. Each individual student had differing strengths and weaknesses when responding to the critical thinking questions and it was important to highlight for them what they were doing well and what needed improvement. Simply giving them a score did not provide students enough information to make improvements to respond to the best of their ability. Students also took part in assessment as learning by self assessing and peer assessing their work allowing them to look in detail at the criteria of a critical thinking response. This allowed students to internalize the qualities of effective critical thinking and to look for specific evidence of what was being asked of them. When students are reflective of their work and the work of their peers it allows them to
become more aware of the learning goals and what is expected of them. Also, it allows students to take ownership of their learning and become more responsible for moving their thinking forward. This implied thinking about their thinking, also known as metacognition. Finally, assessment of learning took place in the form of the end of chapter tests and the post-tests. All three forms of assessment were very useful and important to this project. In fact, all three forms of assessment should be used in any unit of instruction as they all comprise quality learning.

**Student Talk**

Throughout the teaching of this unit students were engaged in partner talk. Partner talk is an oral language tool where students are put into partners and arbitrarily it is decided that one is the speaker and one is the listener. The speaker is asked to respond to a question while the other one listens to the response. This allows students to share their thinking with a partner and also with the larger group. Partner talk ensures that each student is either sharing their ideas or listening to their partner’s ideas. This guarantees that each student is actively engaged in discussions about the topic. Sharing ideas and opinions with a partner is a safe and non-stressful way of allowing students to participate in oral language and exploratory talk where new ideas can be more fully developed. Another level of safety is involved when students are sharing with the whole group because they are not asked to share their opinions, instead they are asked to share their partner’s opinion.

Not only were students encouraged to share their opinions, they were also encouraged to become active listeners. This means, they were asked to listen to what their partner was saying and to ask clarifying questions. These questions allowed the listener to get at a deeper
understanding of what their partner was saying and to make connections to their own thinking. During partner talk there is a focus on listening, as well as thinking, because both involve being engaged in higher-order thinking skills. The speaker has to form their opinion and share it in the shape of a well composed statement and the listener has to summarize what their partner is saying, process it and put it into their own words for the class to hear.

Both the speaking and the listening components of the partner talk sessions are essential to critical thinking. Partner talk allows students to thinking deeply about their opinions as well as the opinions of others. It also allows them to hear other sides of arguments and present new and different ideas to the group. Engaging students in partner talk was important in this unit however, as explained above, partner talk involves a high level of deep thinking and can be challenging. The following examples demonstrate some of the successes and failures of a few of the partner talk sessions that students participated in during this unit.

The results of the transcriptions below show some of the higher-order thinking students’ were involved in through the sharing of their prior knowledge and summarizing of their partner’s idea.

**Student A:** Okay, [Student F] said like mining because the smelters like they’re really bad so all the pollution and they destroy habitats like when you go down into the ground you’re thinking that you will find something but you don’t always so you’re just digging a huge hole in the ground

**Student S:** She said um they capture the fish and take it to the salmon farm or whatever and they get the male and female to mate and the eggs they put in this thing this long thing (point to a pen) until the eggs crack into fry, they put them into bigger tanks until they get to the stage where they are female and male they get them to go through the process and like get them to mate and like it goes on.

In both instances the speaking partners have done a great job of sharing their opinion and then their listening partner did a great job of summarizing what they said in their own words.
The transcriptions also show some of the listening skills that the partner was involved in through the asking of probing questions and extensions of their partner’s thinking.

**Student A:** My second opinion would probably be the um B.C. farming fishing people  
**Student M:** Why  
**Student A:** Because they actually know what’s going on with the fish farming because they actually work there  
**Student M:** They will have enough sense to know to not say anything bad  
**Student B:** (Can’t hear) Fish farms won’t lie?  
**Student M:** Why do you think that?  
**Student A:** Yeah, why do you think that?

In this example, this group of three does an excellent job of asking for more information from their partners and asking questions that allow them to gather more information from their partner.

Finally, the transcriptions also show some of the challenges and frustrations that students faced during the partner talk sessions.

**Teacher:** good, okay, Jocelyn what did your partner say?  
**Student L:** (whispering) I’m not quite sure

Some of the students found it hard to listen and summarize what their partner was saying. For Student L, who is learning disabled, this was very challenging and often needed help from the teacher, assistant or from another student in order to be fully engaged in partner talk. However, as mentioned above, partner talk can be beneficial to all students, including those with difficulties, in fact it can allow them better access to learning. Even though partner talk is challenging, especially for those students with specific learning challenges, it is important to student success and should be tried and persevered through because of its many benefits.

Oral language is an important component to learning and instruction in the classroom. The Ministry of Education has also become aware of this by including oral language as a large
component of the Language Arts learning outcomes (British Columbia Ministry of Education, 2005). Although, oral language outcomes are found in the language arts component of the learning outcomes, oral language can be infused in any aspect of the curriculum, especially science and more importantly critical thinking. By sharing opinions orally, students gain the opportunity to further construct their own knowledge and make connections to new knowledge.

Summary

In conclusion, five important themes have emerged for the analysis of this study of critical thinking skills in the science classroom. All of the themes are related to aspects of critical thinking requiring higher-order thinking skills; differentiated instruction revealed that critical thinking skills were necessary to tap into the higher-order thinking skills of all students and it also showed that students learn in many different ways. The action research process served as a reflective tool to allow fine tuning and adjustments to be made when teaching complex strategies such as critical thinking skills, the theory of constructivism served as the avenue for critical thinking to take place, authentic assessments allowed students to become responsible for their own learning through metacognition and finally student talk allowed students to think deeply about their own thinking and that of their peers. After looking at the results of this study, it is clear that all five trends were effective in the learning involved in the study of Natural Resources for grade five students. Furthermore, it is also clear that the five themes found can be applied to any unit of study for any age student where students are actively negotiating what to believe and what to do. Constructivist approaches must build engaging
experiences that access, engage and challenge prior knowledge, allow students to explore and experience the focus ideas, and to consolidate these ideas and integrate them with prior knowledge using critical thinking and active negotiations. In the last chapter of this project a conclusion of this study will be presented as well as considerations and future recommendations.
Chapter Five: Reflection, Evaluation and Future Considerations

Introduction

Inviting students to engage in critical thinking skills is not an easy task, especially when the students are young and have a limited background in critical thinking. It can be even more difficult when students are also being asked to learn about science simultaneously. However, in reality, these may be the perfect conditions to engage students in authentic/meaningful critical thinking. Engaging young students who have limited critical thinking experience in science-based critical challenges presents a unique opportunity for learning for both students and the teacher/researcher. Young students are eager learners and keen to participate, especially when their teachers are enthusiastic about the subject matter. Often, young children participate in critical thinking in informal ways. Students engage in debate, inquiry, questioning and opinion forming on a daily basis in a variety of subjects. However, these informal experiences do not necessarily encourage students and teachers to unpack the critical thinking and related learning. Frequently the problem needs to be broken down into a set of simple issues after students have had preliminary discussions. This project involved formalizing these skills into critical thinking about an important STSE issue. Critical thinking about STSE issues is fundamental in allowing students to construct rational understandings based on theories and evidence. Ideally, critical thinking should be embedded in all content areas that involve STSE issues so students can make sense of these issues and ultimately become problem solvers of the future and becoming more fully engaged in the public debate about such issues resulting in informed decisions and sustainable actions.
Certain obstacles and challenges are involved when applying critical thinking skills to STSE issues. These obstacles, when viewed through the lens of a reflective practitioner, can be transformed into valuable learning experiences. The theme of reflection, through action research for the teacher/researcher and formative assessment for the students, has been extremely valuable to the success of this project. Although important themes have emerged from this project there are also important cautions and considerations that emerge when engaging students in critical thinking in the constructivist classroom. The reflection and evaluation of this project revealed future considerations.

**Project Evaluation**

The results of this project demonstrated that students scored significantly better on the critical thinking post-test than the pre-test. This indicates that there was a gain in the use and application of critical thinking skills after the teaching of the critical challenges in science unit. The success that the students had with critical thinking skills can be attributed to several factors.

Firstly, teaching in the constructivist classroom allows and encourages students to construct are their own knowledge and be in control of their learning. This is in contrast to the behaviorist classroom where the teacher is the dispenser of knowledge. For the most part constructivism was the driving theory behind the unit allowing students to look at issues from different angles and perspectives however, finding a balance between constructivism and behaviorism seemed to produce the best results for the students. It was up to the teacher/researcher to strike a balance between tight (behaviorist) and loose (constructivist)
control of the class. Direct instruction and mini-lessons were necessary to ensure that concepts were being learned and requisite skills and knowledge were available when needed. Direct instruction on how to respond to a critical thinking question using the response template was necessary to ensure students grasped the importance of each step and responded to each step completely. The direct instruction on how to use the response template followed a gradual release of responsibility where the teacher told the students how to respond, then showed them, then responses were done together and finally the students responded on their own. This gradual release of responsibility ensured students were successful and that the task of responding to a critical thinking question was not impossible. Finally, the instruction around the rubric was also considered ‘tight’ and ‘direct’ to ensure students were well aware of the criteria that was being asked of them. All other component of the lessons fell under the category of constructivism. Students participated in many exploratory lessons where they were designing experiments, gathering data and formulating opinions. They were also involved in open-ended questioning from both the teacher/researcher and their peers. It was this balance between tight and loose control that led to the success of the students. The real challenge as the teacher/researcher was knowing when direct instruction is necessary or when open-ended exploration is necessary.

Although this project produced successful results and achieved its underlying goals, there were several factors which were barriers to success. These barriers were involved timing and teams. In terms of timing, this project took place during the last term of the school year. Typically, this is a very busy time of the year. There were frequent interruptions to learning and many scheduled and unscheduled events that caused the lessons to be put on hold.
Furthermore, the teacher/researcher was only in the classroom for a limited time, four afternoons each week. This made it difficult to catch-up on missed lessons especially when each of the afternoons was devoted to the teaching of the unit. Catch up blocks had to be found in other ways such as pushing back the teaching of lessons and by negotiation with the morning teacher to teach some lessons in the morning. On the other hand, this time of year presented some benefits as well. Students had been in the class long enough for routines to be established, as well as a report with the teacher and other students. The students were also slightly more advanced in terms of having previous science units taught to them. They could draw on that knowledge and apply it to the responses they made.

More time for the unit would have been more beneficial. ‘If I just had more time’ is a common complaint heard from most teachers and certainly is the case for this project. More time would allow the teacher and the students to go deeper and further into the topic. More time would also allow the students to expand on the knowledge that they gained and apply it to other areas. Specifically, it would have been interesting if students could have applied their critical thinking knowledge to an area of their choosing. This would allow for a further development of the relationship between critical thinking skills and constructivism.

The ‘team’ approach was also missing component to this project. Although the teacher/researcher had many people to bounce ideas off and to provide a sounding board to for reflection, ideally, having someone else teaching the same unit at the same time would have been beneficial. This would have enriched the action research component of this project. Having the ability to plan a lesson with someone would allow two minds to think about the same topic, debate the value and effectiveness in real-time, and possibly come up with new
and better ideas, but it would also allow sharing in frustrations and roadblocks. Teaching the same lesson and then coming together at the end of the day to reflect would have been ideal since reflection with a trusted and informed other is essential to action research. This, no doubt, would have led to deeper discussion about direction. Conversations such as ‘try this, scrap that, persevere through this, have you tried it this way, don’t worry so much’ would no doubt have led to better instructional practice and adjustments that could be implemented more quickly and strategically. Again, having some external practitioners to reflect in this way was beneficial, but someone who was engaged in the same events and issues would have been more valuable.

**Reflections**

Reflection before, during and after the teaching of this project has been an invaluable. The completion of this project presents an especially important opportunity for reflection. Although the main goal of this project was to measure and improve students’ critical thinking ability, several other benefits have emerged. What has become very clear is the importance of action research as a form of professional learning or professional development. This study has demonstrated that there is a need for critical thinking skills in schools but there is also a need for action research. Based on the results of this project, perhaps a combination of the two is useful. In the case of this project, the action research process has been a platform for embedding critical thinking by creating an atmosphere of inquiry, problem solving and searching for solutions. Daily reflection of classroom activities, responses and student work has allowed for changes to be made in order to meet the individual and whole group needs of the
students. The action research process has been especially significant in meeting the specific learning needs of students with special learning needs. Special education students come to the classroom with Individual Education Plans (IEPs) outlining strengths, weaknesses, learning adaptations and modifications. Often these adaptations and modifications allow students to be successful in covering grade level curriculum. However, when learning about complex issues using higher-order thinking skills often these adaptations fall short of assisting the students.

Action research enhances the diagnosis of learning problems and allows solutions to be put in place. These solutions can be monitored closely allowing adjustments and changes to be made on a daily basis. This task is more easily done with the help of a teaching assistant who can put these changes in place and monitor them closely. Having a chance for collaboration between the teacher/researcher and the teaching assistant at the end of each lesson ensures that important issues (successes and failures) are identified and addressed and that adjustments are made to the planned lessons to address these insights.

Another important reflection that came out of this project was the importance of formative assessment. Assessment practices that foster individual student growth were used during the instruction phase such as descriptive feedback, performance rubrics, using kid friendly rubrics, and self and peer assessments. These assessment for learning practices allow students to be in the driver seat of their learning and to take ownership of their education. Furthermore, these assessment practices help to inform the teacher/researcher about the learning activities. Black and William (1998) believe formative assessment has taken place when the feedback from learning activities is actually used to adapt the teaching to meet the learner’s needs and to empower future learners. Looking at the results of formative
assessments on an individual and whole group level allows the adjustments to instruction to be made to reach the overall learning goals of the unit. It is quality formative assessments’ that allows the ‘actions’ of action research to take place.

**Considerations and Cautions**

Engaging students in critical thinking can be risky for the classroom teacher. Critical thinking often involves looking at controversial issues and then having students form an opinion about it. Allowing controversial issues into the classroom can cause emotions to rise especially when students are deeply invested in the subject matter. Although many controversial issues effect us on one level or another, some issues are more upsetting to some individuals given their past history, race, or gender. As a classroom teacher it would be important that you have created an environment of respect when engaging in controversial issues. Setting this tone at the beginning of the school year is fundamental in allowing students to feel comfortable and confident is sharing their opinions with the class in a safe and respectful way.

Students learning in the constructivist classroom were involved in exploring, problem solving, forming opinions and discovering knowledge to uncover how it is created and has been influenced by people and cultures. There is also an important caution when students are allowed to take full ownership of their learning. This may sounds like a loss of control of the learning environment for some teachers. The role of the teacher in the constructivist classroom however, is that of a facilitator within a safe and respectful learning environment. The teacher is still very necessary component to learning and more so in the constructivist classroom. It is now up to the classroom teacher to guide students in the right direction, to point students to a
variety of sources of information and to ask questions that allow students to look deeper into the issues they are working on and the classroom teacher. However, there still may be times when it is necessary to provide direct instruction to whole groups, small groups or individuals as the needs arise (just-in-delivery).

**Future Recommendations**

Based on the results of this study, it is clear that there is a need for critical thinking skills in the classroom. It is also clear that action research is a platform for successful professional learning and instructional intervention. Action research is a unique form of research in that it takes places in the researcher’s classroom with the researcher reflecting on their own practice. Traditional forms of research are defined by researchers doing research on other people and are often less likely to get transformed into real change. Action research, on the other hand can result in immediate change. As a school leader, it would be important to tap into the benefits of action research to ensure immediate success and overall school improvement. Action research, in a professional group learning context, could take place both formally and informally. It could also take place with teams or individuals. Either way, action research always begins with the question of how to improve one’s practice: a question central to professional practice. Implementing an action research program as a form of professional development would likely lead to whole school improvement. This could begin by asking each teacher, or group of teachers to define a question that would lead to improved student learning as a basis for self-directed professional learning. From there, it would be important to support the teachers as they work toward meeting those goals or redefine the central focus as the cycle
process advances. That support could be in the form of release time to meet with colleagues to plan, dialogue, team-teach or assess. It could also be in the form of resources to meet the learning goals. It would be important to set specific time frames to check progress on goals and to allow for valuable reflection. This model could be used in almost all school settings from elementary, middle to high school, and from rural school to inner city school. This form of professional development is likely to see immediate positive change in student success as opposed to traditional forms of professional development that are defined by an acknowledged experts offering advice that rarely makes it into the classroom and results in change.

**Conclusion/Final Thoughts**

In conclusion, this project has been successful in that students gained valuable experience using and applying critical thinking skills to an important STSE issue, despite the barriers of time and lack of team dialoging. One of the most important reflections that has come out of this project is the value in the action research process. It has lead to the success of embedding critical thinking skills into the researcher/teacher’s classroom and led to many important changes in procedure and instruction during the implementation of the lessons. As a school leader it would be very important to tap into the value of action research in order to achieve student success.
References


Appendix A:
Lesson Plans 1-6
# Lesson Plan One: Classifying Resources

<table>
<thead>
<tr>
<th>Steps</th>
<th>Tasks</th>
<th>Materials/Strategy</th>
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</thead>
<tbody>
<tr>
<td><strong>Learning Outcome</strong></td>
<td>Analyze how BC's living and non-living resources are used (1). <em>Classifying Renewable and Non-renewable Resources</em></td>
<td></td>
</tr>
<tr>
<td><strong>Accessing Prior Knowledge</strong></td>
<td>Unit opener: students do a 'Sort and Predict' with a list of vocabulary words from the unit. Students sort the words into two categories: words they know and words they don't know.</td>
<td>List of vocabulary words, sort and predict, unit title page</td>
</tr>
<tr>
<td><strong>Goals</strong></td>
<td>I can become familiar with vocabulary from the unit. I can sort resources into living and non-living things I can sort natural resources into categories of renewable and non-renewable.</td>
<td>Posted on Chart Paper</td>
</tr>
<tr>
<td><strong>Predictions</strong></td>
<td>Students predict what the unit will be about based on the categories they created and the words in the categories.</td>
<td>A/B Partner Talk. Student partner talk charts.</td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td>What are students wondering about the words? About the unit they will be studying?</td>
<td>A/B Partner Talk. Student partner talk charts.</td>
</tr>
<tr>
<td><strong>Chunk 1</strong></td>
<td>Read pages 160-163. While reading paragraph on page 162 students complete 'Listen Sketch Talk Respond' (LSTR) in order to connect to the reading. After reading students complete chart where they organize resources into living and non-living resources.</td>
<td>Text book pages (160-163), 'LSTR' page, textbook questions</td>
</tr>
<tr>
<td><strong>Chunk 2</strong></td>
<td>Concept Set: Renewable vs. non-renewable. Read page 177, 178, 205, 206, 207. Model renewable resources (pass around bucket of water, everyone takes a cupful until it runs out, then refill bucket), create definitions for 'renewable'. Model non-renewable resources (everyone takes a handful of a 'mineral' until it runs out, then it's not replaced create a definition for 'non-renewable'. Students then sort resource examples into these categories based on the definitions created. Once sorted, students discuss recreational and commercial purposes of each resource.</td>
<td>Textbook pages, Renewable vs. non-renewable resources concept set organizer.</td>
</tr>
<tr>
<td><strong>Demonstration of Learning</strong></td>
<td>Living and non-living resources connection to renewable and non-renewable resources sorting using a four box graphic organizer. Students sort resource examples into categories of living, non-living and renewable and non-renewable. Students then analyze the graph and look for trends or generalizations. Students summarize their learning in a quick write response.</td>
<td>Four Box Organizer Quick Write</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td>What did you add to your brain after this lesson?</td>
<td>A/B Partner Talk</td>
</tr>
</tbody>
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# Lesson Plan Two: Conserving and Protecting our Natural Resources

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<thead>
<tr>
<th>Steps</th>
<th>Tasks</th>
<th>Materials/Strategies</th>
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</thead>
<tbody>
<tr>
<td>Learning Outcome</td>
<td>Describe potential environmental impact of using BC’s living and non-living resources (4).</td>
<td></td>
</tr>
<tr>
<td>Accessing Prior Knowledge</td>
<td>Show picture of an oil spill. Students use partner talk to talk about the environmental impacts of oil spills. Students talk about what they already know about oil spills and their impact.</td>
<td>Picture of an oil spill, Student partner talk charts.</td>
</tr>
<tr>
<td>Predictions</td>
<td>What do you think is the best way to clean-up an oil spill? If you were given a mini-spill to clean up, what would you use to clean it up with?</td>
<td>A/B Partner Talk, partner talk charts</td>
</tr>
<tr>
<td>Questions</td>
<td>What are you wondering about oil spills? What are you wondering about impacting ecosystem?</td>
<td>A/B Partner Talk, partner talk charts</td>
</tr>
<tr>
<td>Goals</td>
<td>I can understand how an ecosystem works</td>
<td>Chart Paper</td>
</tr>
<tr>
<td></td>
<td>I can understand how we can impact an ecosystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I can understand how we can conserve our natural resources to protect them</td>
<td></td>
</tr>
<tr>
<td>Chunk 1</td>
<td>&quot;environmental impact&quot; Clean-up an oil spill. Put 15 ml of oil into 250 ml of water and mix. Use what you think will work best to remove the oil. Record observations. Students reflect on how they were able to remove oil. What worked, what didn’t. Read pages 164-167. Check your understanding questions page 167.</td>
<td>Oil spill experiment page, olive oil, water, container, materials to remove oil (paper towel, sponge, spoon), Text pg 164-171</td>
</tr>
<tr>
<td>Chunk 2</td>
<td>&quot;Conserving our Resources&quot; Read pages 168-171. Students complete 'Key words organizer' by finding key words from each section of text and then summarizing the section. Students then complete Check Your Understanding Page 171.</td>
<td>Pages 168-171 Key Words Organizer Check Understanding Questions.</td>
</tr>
<tr>
<td>Demonstration of Learning</td>
<td>Students create a Public Service Announcement designed to give information on best ways to conserve. Students research effective ways to conserve, they research effective public service announcement strategies and create their own to present to the class. -Read Pg. 53-57 Talk about Public Service Announcements. -Present Public Service Announcement (PSA)Task Page/Rubric</td>
<td>-Text (Nelson) 53-75 -Energy Survey/Feature of a PSA Organizer -PSA Task Page -PSA Criteria</td>
</tr>
<tr>
<td>Reflection</td>
<td>Quick Write: Why is it important to conserve our Natural Resources? Is it easy or hard to convince people to conserve? What strategies can you use to convince people to conserve our Natural Resources?</td>
<td>Quick Write</td>
</tr>
</tbody>
</table>
**Lesson Plan Three: Extracting our Natural Resources**

<table>
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<tr>
<th>Steps</th>
<th>Tasks</th>
<th>Materials/Strategies</th>
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</thead>
<tbody>
<tr>
<td><strong>Learning Outcome</strong></td>
<td>Students will be able to identify methods of extracting or harvesting and processing BC’s natural resources</td>
<td></td>
</tr>
<tr>
<td><strong>Accessing Prior Knowledge</strong></td>
<td>Show tin of salmon. Ask students: ‘How did a salmon swimming in the ocean get to be in this can?’ What were some of the steps? What impact does that have on the environment?</td>
<td>Tin of Salmon A/B Partner Talk</td>
</tr>
<tr>
<td><strong>Predictions</strong></td>
<td>What are some of the environmental impacts of extracting our other Natural Resources?</td>
<td>A/B Partner Talk</td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td>What questions do you have about extracting our Natural Resources? What are you wondering?</td>
<td>Teacher Question</td>
</tr>
<tr>
<td><strong>Goals</strong></td>
<td>I can identify methods of extracting/harvesting our Natural Resources. I can identify the environmental impact of extracting our natural resources. I can think critically about which method has the most impact on the environment.</td>
<td>Post on black board</td>
</tr>
<tr>
<td><strong>Chunk 1</strong></td>
<td>Chocolate Chip Mining (see textbook page 219-221). Students choose one of three cookies and a type of tool. They mine out the chocolate chips in order to determine if their mine is profitable. They must reclaim the land after they are done. Students answer reflection questions when they are done.</td>
<td>Textbook Pages and Questions (Science Probe), 3 boxes of cookies, toothpicks, paper clips, graph paper</td>
</tr>
<tr>
<td><strong>Chunk 2</strong></td>
<td>A group of three students reads an article on either ‘Background Information’, ‘Methods of Extraction’ and ‘Environmental Impact’ for each of the three natural resources; fishing, mining and logging. This group of three students becomes an ‘Expert Group’ in one area and summarizes the information in the article and then presents it to the rest of the class. Class summarizes information they hear into a chart. Students analyze charts in order to decide, in their opinion, which method has the most/least impact on the environment.</td>
<td>Reading selections on forestry, fishing and mining extraction methods and impacts, Summarization Organizer, 3 Main Points, Organizer to summarize presentations</td>
</tr>
<tr>
<td><strong>Demonstration of Learning</strong></td>
<td>Students will answer the critical thinking question; extracting which resource has the most/least environmental impact. Students will use ‘Making A Decision Critical Thinking Response Page’. Scaffold: teacher will model how to use response template.</td>
<td>Critical thinking response template, Critical Thinking response rubric</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td>Metacognition of Critical Thinking Response Thinking about your thinking and Taking action based on your thinking</td>
<td></td>
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## Lesson Plan Four: Sources of Information

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<tr>
<th>Steps</th>
<th>Tasks</th>
<th>Materials/Strategies</th>
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</thead>
<tbody>
<tr>
<td><strong>Learning Outcome</strong></td>
<td>Identify Methods of extracting or harvesting and processing BC’s natural resources. Gather information from a variety of primary and secondary sources.</td>
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</tr>
<tr>
<td><strong>Predictions</strong></td>
<td>Students will look at the pictures that go with the articles on fish farming. Based on the pictures alone students will make a prediction about what the articles will be about.</td>
<td>Pictures from each article. A/B Partner Talk</td>
</tr>
<tr>
<td><strong>Accessing Prior Knowledge</strong></td>
<td>What do you already know about salmon fish farming? What are some viewpoints about fish farming?</td>
<td>A/B Partner Talk</td>
</tr>
<tr>
<td><strong>Goals</strong></td>
<td>I can learn about different viewpoints on an issue. I can analyze information and make an informed decision.</td>
<td></td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td>What are you wondering about fish farming? About the different view points?</td>
<td></td>
</tr>
<tr>
<td><strong>Chunk 1</strong></td>
<td>Students read each article and decide what is the viewpoint, who is presenting the view point and why they would be presenting that information through the media.</td>
<td>Viewpoint organizer Salmon Farming Articles (p 109-111)</td>
</tr>
<tr>
<td><strong>Chunk 2</strong></td>
<td>Students analyze the information in their charts and determine, in their view, who is presenting the most accurate view of the salmon farming industry?</td>
<td></td>
</tr>
<tr>
<td><strong>Demonstration of Learning</strong></td>
<td>Students use the Critical Thinking Reflection Template to answer: Who is presenting the most accurate view of the salmon farming industry? Students will put the template into a complete paragraph using connecting words.</td>
<td>-Critical Thinking Reflection Template -Critical Thinking Reflection Rubric</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td>Metacognition; analyzing the decision.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Thinking about your thinking. Was your decision, fair, biased? (What was influencing your bias)</td>
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<tr>
<td></td>
<td>2) Taking action based on your decision.</td>
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# Lesson Plan Five: Pros and Cons of the Salmon Industry

<table>
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<tr>
<th>Steps</th>
<th>Tasks</th>
<th>Materials/Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Outcome</td>
<td>Students will be able to describe potential impacts of using BC's living and non-living resources</td>
<td></td>
</tr>
<tr>
<td>Predictions</td>
<td>What is the biggest pro to forestry and the biggest con to forestry?</td>
<td>A/B Partner Talk</td>
</tr>
<tr>
<td>Accessing Prior Knowledge</td>
<td>Pros and cons sorting activity. Show pictures of a clear cut and of worker building a log home. Students determine the pros and cons of forestry. Students try to decide what the biggest/most important pro and con is.</td>
<td>A/B Partner Talk</td>
</tr>
<tr>
<td>Goals</td>
<td>I can determine pros and cons of salmon farming and commercial salmon fishing. I can make an informed decision.</td>
<td>Post on chart paper</td>
</tr>
<tr>
<td>Questions</td>
<td>What are you wondering about? Will there be more than one biggest pro or con? Will this decision be easy or hard?</td>
<td></td>
</tr>
<tr>
<td>Chunk 1</td>
<td>Students will analyze the four articles they read in the previous lesson on the salmon farming industry and will determine pro's and cons of salmon farming. Students record each pro and each con on a cue card. Teacher will model for first article, students will complete for other articles.</td>
<td>Yellow/Blue Cue cards</td>
</tr>
<tr>
<td>Chunk 2</td>
<td>Students will read several articles on commercial open water net fishing and will determine pros and cons of commercial open water salmon fishing. Students record each pro and each con on a cue card.</td>
<td>Green/Pink Cue cards</td>
</tr>
<tr>
<td>Chunk 3</td>
<td>Students rank the pro and con cue cards by putting them in order.</td>
<td>A/B Partner Talk</td>
</tr>
<tr>
<td>Demonstration of Learning</td>
<td>Students use Critical Thinking Reflection Template to answer; After looking at the pros and cons of commercial fishing and salmon farming, decide which is better; commercial fishing or salmon farming.</td>
<td>A/B Partner Talk, Critical Thinking Reflection Template (peer assessed), Critical Thinking Reflection Rubric</td>
</tr>
</tbody>
</table>
| Reflection                 | 1) Thinking about your thinking  
2) Where will decision lead you? |                                    |
## Lesson Plan Six: What is the Other Point of View?

<table>
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<tr>
<th><strong>Steps</strong></th>
<th><strong>Tasks</strong></th>
<th><strong>Materials/Strategies</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Learning Outcome</strong></td>
<td>Students will be able to describe potential impacts of using BC’s living and non-living resources. Apply critical thinking skills to a problem or an issue.</td>
<td></td>
</tr>
<tr>
<td><strong>Predictions</strong></td>
<td>Will it be easy or hard to take on a different point of view?</td>
<td>A/B partner talk</td>
</tr>
<tr>
<td><strong>Goals</strong></td>
<td>I can consider another point of view. I can look in depth at an issue.</td>
<td>Posted on chart paper</td>
</tr>
<tr>
<td><strong>Accessing Prior Knowledge</strong></td>
<td>Students will debate an argument in a ‘U’ shaped debate (eg, which is better uniforms or no school uniforms). Then students will be assigned one side of the debate and then asked to switch sides.</td>
<td>‘U’ shaped debate A/B partner talk</td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td>What are you wondering? Do you have any questions about the salmon farming/commercial fishing debate?</td>
<td>A/B partner talk</td>
</tr>
<tr>
<td><strong>Chunk 1</strong></td>
<td>Students will share their opinions on the previous critical thinking question. They will partner up with someone from the other side and both will switch opinions and then debate the issue with their new stance.</td>
<td>A/B Partner talk</td>
</tr>
<tr>
<td><strong>Chunk 2</strong></td>
<td>Students will create a PSA (public service announcement for their new position.</td>
<td>Students create PSAs. PSA rubric.</td>
</tr>
</tbody>
</table>
| **Demonstration of Learning** | Students use the Critical Thinking Reflection Template to answer what is the other side of the salmon farming/commercial fishing debate?                                                                | -Critical Thinking Reflection Template (self assessed)  
-Critical Thinking Paragraph (Teacher assessed using Critical Thinking Reflection Rubric) |
| **Reflection**     | Metacognition  
1) How could you make your thinking/reasoning stronger  
2) Thinking about your thinking  
3) Where will decision lead you?                                                                                              |                                              |
**Appendix B: Critical Thinking Response Template**

| Here’s What | I think______________________________
<table>
<thead>
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<tbody>
<tr>
<td>(Opinion Statement)</td>
<td>_____________________________________</td>
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<td>_____________________________________</td>
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| 2)___________________________________
| | _____________________________________|
| | _____________________________________|
| 3)___________________________________
| | _____________________________________|
| | _____________________________________|

| Although... | 1)___________________________________
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<tr>
<td>(Counter arguments and rebuttals, the other side)</td>
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</tbody>
</table>
| 2)___________________________________
| | _____________________________________|
| | _____________________________________|

| Finally | Finally, I think______________________
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<td>(Conclusion)</td>
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| Extension: | _____________________________________
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<tbody>
<tr>
<td>Metacognition</td>
<td>_____________________________________</td>
</tr>
<tr>
<td>(Reflecting on the conclusion, implications)</td>
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<td>_____________________________________</td>
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</tbody>
</table>
### Appendix C: Critical Thinking Reflection Rubric

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Not Yet Meeting Expectations</th>
<th>Approaching Expectations</th>
<th>Fully Meeting Expectations</th>
<th>Exceeding Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Opinion</strong></td>
<td>Does not state their opinion.</td>
<td>Gives an opinion but it is not reasonable or plausible.</td>
<td>Gives a reasonable and plausible opinion.</td>
<td>Gives a reasonable, plausible and insightful opinion.</td>
</tr>
<tr>
<td><strong>Support</strong></td>
<td>Does not give any reasons to support their opinion and/or the reasons given don’t make sense.</td>
<td>Gives 1-2 reasons that make sense to support their opinion.</td>
<td>Gives 2-3 reasons that make sense (logical) to support their opinion. Reasons may be based on prior knowledge.</td>
<td>Gives 3 or more reasons that are insightful and logical to support their opinion. Reasons may consider prior knowledge.</td>
</tr>
<tr>
<td><strong>Evidence</strong></td>
<td>None of the reasons given refer to specific evidence and/or factual information. Does not give details or examples.</td>
<td>Some of the reasons refer to specific evidence and/or factual information. Gives few details or examples.</td>
<td>Reasons often refer to specific evidence and/or factual information. Gives details and examples.</td>
<td>Reasons refer to specific evidence. Evidence and factual information are used in a creative and insightful way to present reasons. Details and examples are original.</td>
</tr>
<tr>
<td><strong>Counter Claims</strong></td>
<td>Does not consider or ignores obvious alternate points of view.</td>
<td>Identifies one aspect of another point of view.</td>
<td>Identifies and analyses obvious alternative points of view.</td>
<td>Identifies and thoughtfully analyzes all major alternative points of view.</td>
</tr>
<tr>
<td><strong>Conclusion</strong></td>
<td>Makes no conclusion or conclusion is irrelevant and/or unwarranted.</td>
<td>Draws unwarranted or untrue (fallacious) conclusions.</td>
<td>Draws warranted and accurate (non-fallacious) conclusions. Conclusion has an impact on the reader.</td>
<td>Draws warranted judicious, non fallacious conclusions. Conclusion leaves a strong impact on the reader.</td>
</tr>
<tr>
<td><strong>Reflecting on Reasoning</strong></td>
<td>Provides no reflection and does not follow where evidence leads.</td>
<td>Reflection is on thinking is limited. Follows where evidence leads in a limited way.</td>
<td>Reflection on thinking is logical. Follows where evidence and reasons lead.</td>
<td>Reflection on thinking is insightful. Fair-mindedly follows where the evidence or reasons lead.</td>
</tr>
</tbody>
</table>
Appendix D: Descriptive Feedback Form

Descriptive Feedback Form

To: _____________

What’s working: __________________________
_____________________________________
_____________________________________
_____________________________________
_____________________________________

What’s not: _____________________________
_____________________________________
_____________________________________
_____________________________________
_____________________________________

What’s next: _____________________________
_____________________________________
_____________________________________
_____________________________________
_____________________________________

From: _____________________
Appendix E: Critical Thinking Pre-Test and Post-Test

1) Scenario: You are the mayor of a small town on the West Coast of British Columbia. A forestry company wants to open a new mill in your town. This will mean a lot of jobs and more money for the economy of your town. It will also mean the cutting down of trees in the forests near-by and will also mean polluted water from the mill will be put into the ocean, harming the local salmon population.

Do you allow the mill to be set-up or tell the owner of the company to set-up in another town?
Appendix F: Chapter Tests

Name: ___________________________ Date: _____________________

Chapter 8 Quiz

Part A: True or False
Circle True if the sentence is true. Circle False if the sentence is not true.

1. Earth is a large ecosystem. True False
2. Natural resources are only non-living things. True False
3. All resource use harms the environment. True False
4. Recycling is one way to conserve Earth's resources. True False

Part B: Complete the Sentences
Use the following words to complete the sentences.
recycling environmental impact natural resources biodegradable

5. Everything we need to survive is provided by Earth's

6. A(n) __________________________ product is made from resources that were once living.

7. Things that change an environment are said to have a(n) __________________________

8. The process of __________________________ is to take an old product and turn it into a new product.

Part C: Multiple Choice
Circle the letter of the correct answer.

9. Which product is biodegradable?
(a) Styrofoam
(b) potato chip
(c) most plastic bags

10. Aboriginal peoples use the circle to represent
(a) harmony and connections in nature
(b) the Sun
(c) ecosystems
Chapter 8 Quiz (continued)

11. Which is not a petroleum product?
   (a) plastic
   (b) gasoline
   (c) paper

Part D: Complete the Diagram
Use the following words to complete the diagram. Label everything you can find in the picture that is an example of reducing, reusing, or recycling.

reuse recycle reduce

Part E: Answer the Question
Use sentences to answer the question.

13. Why should everyone learn the different methods of conservation?
Chapter 9 Quiz

Part A: True or False
Circle True if the sentence is true. Circle False if the sentence is not true.

1. Leaching can cause soil pollution. True  False
2. Some types of energy are renewable. True  False
3. Resources usually have one use. True  False
4. Logging doesn’t have an impact on streams and rivers. True  False

Part B: Complete the Sentences
Use the following words to complete the sentences.

harvesting renewable raw materials water pollution

5. Plants and animals are ________________________________ resources.
6. ________________________________ are harvested and processed into products we use.
7. When harmful substances or organisms that can make plants and animals sick enter streams, lakes, and oceans, then there is ________________________________
8. ________________________________ forests have an impact on the animals and plants in the ecosystem.

Part C: Multiple Choice
Circle the letter of the correct answer.

9. Which is not a forestry product?
   (a) paper
   (b) lumber
   (c) clothing

10. Logging all the trees in an area is called
    (a) clear-cutting
    (b) selective logging
    (c) natural logging
Chapter 9 Quiz (continued)

Part D: Complete the Diagram
Use the following words to complete the diagram.

- groundwater
- evaporation
- surface runoff
- Watershed
- condensation
- precipitation
- Water Cycle

Part E: Answer the Question
Use sentences to answer the question.

12. Describe three ways traditional Aboriginal cultures conserved the salmon resource.
Chapter 10 Quiz

Part A: True or False
Circle True if the sentence is true. Circle False if the sentence is not true.

1. Reclamation means owning a mine. True False
2. Fossil fuels means fossils are used for energy. True False
3. The decision to open a mine is made by one person. True False
4. Extracting ore has an impact on the environment. True False

Part B: Complete the Sentences
Use the following words to complete the sentences.

air pollution non-renewable extracted air shed

5. Minerals and fossil fuels are non-renewable from the surface of Earth.

6. The air above an ecosystem is called the _______________.

7. Digging, removing, and crushing waste rock can cause _______________ when dust and debris are released into the air.

8. Resources that cannot replace themselves are called _______________.

Part C: Multiple Choice
Circle the letter of the correct answer.

9. Reclamation is the process of
(a) opening a mine  (b) closing a mine  (c) returning mines to usable land

10. What is the first step in processing copper?
(a) Copper ore is put into a flotation tank  (b) copper ore is crushed  (c) pure copper is burned off
### Chapter 10 Quiz (continued)

#### Part D: Complete the Diagram

Sketch the two types of mines. In each, show the location of the ore deposit. Include these labels:

<table>
<thead>
<tr>
<th>ore deposit</th>
<th>main shaft</th>
<th>tunnel</th>
<th>air shed</th>
<th>air pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>An Open-Pit Mine</td>
<td>An Underground Mine</td>
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</table>

#### Part E: Answer the Question

Use sentences to answer the question.

12. Describe two reasons humans must find other materials to replace fossil fuels.
**Appendix G: Individual Student Results**

<table>
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<tr>
<th>Student ID Letter</th>
<th>Pre-Test Score</th>
<th>Pre-Test %</th>
<th>Post-Test Score</th>
<th>Post-Test %</th>
<th>Knowledge Test %</th>
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## Appendix H: Research Notes

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<tr>
<th>Date</th>
<th>Research Notes</th>
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<tbody>
<tr>
<td><strong>April 7</strong></td>
<td>Standard opening lesson. Students are familiar with Sort and Predict and Listen Sketch Talk and Respond activities. Students have some background knowledge about some words and none about others. For instance, many did not know what leaching was but were able to make good predictions. Many came up with similar groupings in their Sort and Predict. Comprehension questions varied in responses. In general, simple responses need more detail and explanation.</td>
</tr>
<tr>
<td><strong>April 20</strong></td>
<td>Spent time organizing for Partner Talk groups and practicing partner talk. We worked on building criteria for effective partner talk. Set-up various groupings for Partner Talk (friend, homogenous pair, opposite sex pair and four/five pairing) Begin concept set for renewable and non renewable resources. Students sorted words into categories of renewable and non renewable. This helped to solidify student understanding of the concept. Students then sorted words into four categories (renewable, non-renewable, living and non living). They discovered that there are no living non renewable resources. Everything that is living can be renewed. Students completed a quick write to demonstrate their learning. Many students grasped this concept easily with the visual of the concept set.</td>
</tr>
<tr>
<td><strong>April 21</strong></td>
<td>Students simulated an oil spill and how to effectively clean it up. Oil spill reflections demonstrated that students thought that a giant sponge would be efficient in cleaning up an oil spill but they needed to consider how much ocean and sea life but might harmed in the clean-up process. If they were sucking up large volumes of water.</td>
</tr>
<tr>
<td><strong>April 23</strong></td>
<td>For the textbook questions many were unable to find specific information from the textbook. Many need to add more detail and explanation to responses. This was a basic, low level activity.</td>
</tr>
<tr>
<td><strong>April 27</strong></td>
<td>Students created PSA’s about how to conserve our natural resources and then presented them to the class. Students are excited about the project and got into being creative and finding facts on the computer. Continued to work on this project on April 28th as well. Presentations were generally weak. Lots of twos. Students did not do a lot of prep. There was also a lack of enthusiasm for the presentations. Need more practice. The criteria was there.</td>
</tr>
<tr>
<td><strong>April 30</strong></td>
<td>Quick writes were fairly well done. Many students referenced important things to include in a PSA such as accurate facts, pictures, making it appealing to look at as well as incentives. Range of responses. This lesson was used as an opportunity for students to begin to see how important to not just state their opinion but to support it as well.</td>
</tr>
<tr>
<td><strong>May 1</strong></td>
<td>Lots of good discussion. Students seem to enjoy working with their various partners. Tracing the tin of salmon back to salmon in the wild brought u discussion of waste of salmon. What happens to unused parts of the salmon? Student discussion also centered on processing and transporting of salmon. That is, using trucks to deliver. Many unexpected ideas came up. Chocolate Chip mining, students very enthused about this. Many used different strategies to go about mining. Many connections made to the real world. Realization that you don’t always know if a mine is going to be worth while or not. Many good sound decisions were made by the students.</td>
</tr>
<tr>
<td><strong>May 5</strong></td>
<td>Summarizing the information from the article was very hard for the students. Finding the main idea for each sub title and putting it into their own words was very hard. This was a big job for the students. After this lesson a mini lesson will be necessary to teach the strategy of summarizing.</td>
</tr>
<tr>
<td><strong>May 7</strong></td>
<td>Introduced the strategy of someone reading two or three sentences and then the other group members putting those sentences into one sentence of their own words seemed to help. Some groups were better able to</td>
</tr>
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</table>
complete this task than others. Some began find three main ideas from all of their summarized ideas.

**May 11th**

Students continued to find main idea of each section using the new strategy. When done, students found the three most important ideas from their summarized ideas.

**May 12th**

Teacher summarized all points on an organizer (overhead) and students recorded onto their own charts. Once students had three main points for all of the reading selections (Background, Methods of Extraction, and Environmental Impact for Forestry, Fishing and Mining) they analyzed them to find which method has the most impact.

**May 13th**

Video clip generated great discussion about who should be responsible and how impacts from one smelter having far reaching consequences.

**May 19th**

In order to respond, we went through the Making a Decision Response Template (includes all elements of a complete critical thinking response). Teacher completed and students recorded (Scaffolding). We did one together (for mining) and then students completed response on their own. Template is good for recording and organizing information but it doesn’t make for a complete response. From the template students will need to create a paragraph using the template. The template lacks transition words to make the paragraph smooth. Began videotaping students doing ‘Partner Talk’ to generate ideas or their responses. Hard to get all group sat once. Have to randomly video tape groups one at a time.

Marking responses using rubric. Marked based on everything except metacognition. Students did not record their thoughts. We did this piece orally therefore the mark for this response was out of 20 instead of 24. Responses often lacked detail and explanation. This will be one of the primary focuses for future responses.

Also, it was very important the students had a clear understanding of the vocabulary of the Critical Thinking question. For instance, student needed to have a clear understanding about what ‘impact’ ‘worst’ and ‘accurate’ meant.

**May 20th**

Completed a lesson on adding different types of transition words.

Went over metacognition portion of lesson. Two components to metacognition. Was their thinking fair and why? Looking for responses like ‘it was fair because I looked at all of the information’ and ‘I didn’t let my bias influence me’. Also, now that they have made a decision how will that effect their future actions. Now that they have made this decision what will they do. Looking for responses like ‘reduce the amount of paper I use’ or ‘write a letter to a government official’.

**May 21st**

Video taped partner talk. Predictions and prior knowledge indicated that they already know some information about fish farming. Background and prior knowledge that they have often comes into play when making their responses. Also students are able to successfully use the background information and prior knowledge of other students to formulate their critical thinking responses.

Students use a graphic organizer to summarize the viewpoint and why they were expressing that viewpoint. This was tricky for the students to determine ‘why’ they would be expressing that viewpoint. This required a lot of inference making. This was a difficult task for students.

**May 22nd**

Partner Talk before responding again allowed students to gain an understanding of other points of view and to share important information that they had gathered as well as share their background and prior knowledge with the rest of the class so that everyone could build from it. Answers to this response varied widely. What was most important was that no matter who students picked they were able to support their opinions. (Some with more details and explanation than others) and they were also able to determine why another point of view was accurate but not as accurate as the one that they chose. Again for this response the vocabulary in the question became very important. For this question words like ‘accurate’ were very important to understand.

Began to notice how important it is to allow the students to engage in activities that let them add to their knowledge base. Activities that focus on higher order thinking skills such as analyzing, ranking, sorting and justifying. This may make a difference in the post test when they simply respond to a question cold without having participated in any previous activity. However, that would mirror real-life more accurately.
<table>
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<tr>
<th>Date</th>
<th>Description</th>
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<tbody>
<tr>
<td>May 25th</td>
<td>In order to assess using a variety of strategies I marked the templates with the Descriptive feedback rubric (What’s Working, What’s Not and What’s Next). Students used the feedback to write their good copy of their paragraphs. In most cases, what was missing were details and description and examples in order to make their opinions stronger, as well as adding the transition words in order to make their paragraphs flow smoothly.</td>
</tr>
<tr>
<td>May 26th</td>
<td>Articles for salmon farming came from a textbook (Nelson Literacy) and displayed a range of media (newspaper articles, radio caller, pamphlet, etc). There was no set of four articles about commercial fishing so that had to found and created in order to suit the ranges of reading abilities in the class. The related articles were based on articles from the internet and other sources but had to be changed in order to accommodate the class. Students recorded pros and cons on cue card with the intent of ranking the pros and cons. This began difficult from an organizational standpoint and some children lost card and pros for one were also cons for the other side. Original critical thinking question was: What is the ‘biggest pro’ and the ‘biggest con’ for salmon farming and what is the ‘biggest pro’ and ‘biggest con’ to commercial open water fishing. This task was way too involved and involved a high level of thinking skills. This was above the level of many students. In the end, students analyzed the pros and cons for both sides and then made a decision in order to answer the critical thinking question: ‘Which is better for the environment and for the salmon population, commercial open water fishing or salmon farming?’</td>
</tr>
<tr>
<td>May 29th</td>
<td>Students respond using the template. For assessment, teacher and students together transferred the rubric into kid friendly language.</td>
</tr>
<tr>
<td>June 1st</td>
<td>Students use descriptive feedback forms to assess their partner’s templates. Many generic comments and ones that the teachers has previously used. Students use the kid friendly rubric to help to complete the descriptive feedback form. Students then used their partners’ comments to complete their good copy paragraphs. Teacher assessed paragraphs using teacher rubric. Overall, paragraphs are showing a better understanding of supporting opinions with details and examples. Students are writing more in order to make it their points of view more substantial.</td>
</tr>
<tr>
<td>June 1st</td>
<td>Using Partner Talk students talk about how hard/easy it is to switch their opinions. Range of responses for this question. Some though it was easy, others thought it was difficult. Some students became more entrenched in their answers than others. Students were asked to switch their opinion from the previous lesson. A good critical thinker would be able to find arguments for both sides and also learn more about their side by arguing the opposite. In order to take on the other side of the argument students were asked to create a public service announcement for their side of the argument.</td>
</tr>
<tr>
<td>June 2nd</td>
<td>For assessments students did a self evaluation using Descriptive Feedback forms. We used peer assessment to mark the good copy paragraph using the kid friendly rubric. Teacher marked the paragraphs using the teacher rubric.</td>
</tr>
</tbody>
</table>