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Prince Edward Island Science Curriculum

CURRICULUM

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Foreword

The pan-Canadian *Common Framework of Science Learning Outcomes K to 12*, released in October 1997, will assist in standardizing science education across the country. New provincial science curriculum is supported by the *Foundation for the Atlantic Canada Science Curriculum* (1998).

This guide is intended to provide teachers with an overview of the outcomes framework for Environmental Science 621A. It also includes some suggestions to assist teachers in designing learning experiences and assessment tasks.

Introduction

Purpose

Environmental Science 621A seeks to promote an appreciation and understanding of the environment and sustainable development. Some course content is flexible to allow teachers and students to take advantage of selecting local topics or areas of special interest. A portion of the course is dedicated to Project Based Learning (PBL) where critical thinking, problem-solving, and decision-making skills will be developed in the process of examining and analysing environmental issues. With guidance and teacher-directed models, students will learn to follow a scientific inquiry process in their own investigations of environmental issues.

Focus and Context

Environmental Science 621A will introduce students to the concepts and terminology associated with the study of environmental science. It will also cover such areas as Ecological Principles, Human Population and Carrying Capacity, Natural Resources, and Environmental Challenges and Successes. Teachers will ensure all outcomes are addressed and the PBL inquiry process is integrated with content knowledge.

Environmental Science 621A requires students to follow a PBL guided inquiry process that will result in a final product based upon an environmental issue. PBL is a model for classrooms that emphasizes long-term, interdisciplinary and student-centered activities. Learners are able to conduct in-depth investigations of real world issues and challenges. This type of learning engages students as they obtain a deeper knowledge of a subject area through research, experimentation, and the assistance of a community member.

In addition, Education for Sustainable Development (ESD) will be a foundational component of this course. The key themes of sustainable development - such as sustainable urbanization, sustainable consumption, health promotion, and environment - will be examined through a lens that highlights the profound interdependencies of ecological, societal, and economic systems.

With this in mind, it is important that teachers incorporate these key themes in their subject areas. One tool that can be used to support teachers is the searchable on-line database Resources for Rethinking, found at http://4r4.ca/en. It provides teachers with access to materials that integrate the ecological, social, and economic spheres through active, relevant, interdisciplinary learning.

Aim

The aim of science education in the Prince Edward Island is to develop scientific literacy.

Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences that provide opportunities to explore, analyse, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment.

Program Design and Components

Learning and Teaching Science

What students learn is fundamentally connected to how they learn it. The aim of scientific literacy for all has created a need for new forms of classroom organization, communication, and instructional strategies. The teacher is a facilitator of learning whose major tasks include

- creating a classroom environment to support the learning and teaching of science;
- designing effective learning experiences that help students achieve designated outcomes;
- stimulating and managing classroom discourse in support of student learning;
- learning about and then using students' motivations, interests, abilities, and learning styles to improve learning and teaching;
- assessing student learning, the scientific tasks and activities involved, and the learning environment to make ongoing instructional decisions;
- selecting teaching strategies from a wide repertoire.

Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment that reflects a constructive, active view of the learning process. Learning occurs through actively constructing one's own meaning and assimilating new information to develop a new understanding.

The development of scientific literacy in students is a function of the kinds of tasks they engage in, the discourse in which they participate, and the settings in which these activities occur. Students' disposition towards science is also shaped by these factors. Consequently, the aim of developing scientific literacy requires careful attention to all of these facets of curriculum.

Learning experiences in science education should vary and should include opportunities for group and individual work, discussion among students as well as between teacher and students, and hands-on/minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. Such investigations and the evaluation of the evidence accumulated provide opportunities for students to develop their understanding of the nature of science and the nature and status of scientific knowledge.

Communicating in Science

Learning experiences should provide opportunities for students to use writing and other forms of representation as ways to learning. Students, at all grade levels, should be encouraged to use writing to speculate, theorize, summarize, discover connections, describe processes, express understandings, raise questions, and make sense of new information by using their own language as a step to the language of science. Science logs are useful for such expressive and reflective writing. Purposeful note making is an intrinsic part of learning in science, helping students better record, organize, and understand information from a variety of sources. The process of creating webs, maps, charts, tables, graphs, drawings, and diagrams to represent data and results helps students learn, and also provides them with useful study tools.

Learning experiences in science should also provide abundant opportunities for students to communicate their findings and understandings to others, both formally and informally, using a variety of forms for a range of purposes and audiences. Such experiences should encourage students to use effective ways of recording and conveying information and ideas and to use the vocabulary of science in expressing their understandings. It is through opportunities to talk and write about the concepts they need to learn that students come to better understand both the concepts and related vocabulary.

Learners will need explicit instruction in, and demonstration of, the strategies they need to develop and apply in reading, viewing, interpreting, and using a range of science texts for various purposes. It will be equally important for students to have demonstrations of the strategies they need to develop and apply in selecting, constructing, and using various forms for communicating in science.

The Three Processes of Scientific Literacy

An individual can be considered scientifically literate when he/she is familiar with, and able to engage in, three processes: inquiry, problem solving, and decision making.

Inquiry

Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging in science. These activities provide students with opportunities to understand and practise the process of theory development in science and the nature of science.

Problem Solving

The process of problem solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

Decision Making

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are important in their own right, and they also provide a relevant context for engaging in scientific inquiry and/or problem solving.

Introduction to Project Based Learning

Project Based Learning (PBL) is a model for classrooms that emphasizes long-term, interdisciplinary and student-centered activities. Learners are able to conduct in-depth investigations of real world issues and challenges. This type of learning engages students as they obtain a deeper knowledge of a subject area through inquiry, research, experimentation, and the assistance of a community member.

PBL allows students to explore, investigate, and construct new meaning from prior knowledge and from the information that is retrieved from other sources. It is not linear in form but promotes a continual looping back and forth throughout the process as students gather and process new information, redirect their inquiries, and continue through the process. Inquiry into an environmental issue will require students to practise and refine their critical and creative thinking skills. The process of working with acquired information and reformulating it into newly constructed meaning is emphasized in this course.

In order for students of ENV621A to become fully engaged in the PBL model, they will need to draw on their prior knowledge, ask many questions, and conduct preliminary research to help them define the direction of their inquiry. Classroom discussions about specific environmental issues may help them to decide where their inquiry will take them. Local geography, initiatives, or organizations may be another avenue to create interest in particular issues. Current events portrayed in the media may also be a catalyst to student inquiry as well as several other sources. An inquiry plan will ensure that students know what is expected of them and will aid in keeping track of progress throughout the PBL model.

Habits of Mind for Inquiry

Students grow as independent inquirers and critical thinkers by developing and refining learned inquiry skills, and by practising positive dispositions that support their inquiry. Habits of mind are the attitudes or dispositions that allow a person to set aside personal bias or self-limiting beliefs that may interfere with the ability to reach newer levels of understanding.

To achieve deeper understanding in any inquiry, students need to practice being:

1) open-minded (willing to consider evidence that may oppose their own views);
2) fair-minded (willing to consider others' viewpoints);
3) independent-minded (willing to stand up for firmly held beliefs);
4) critical-thinkers (willing and able to question for clarity and validity).

Additional habits of mind that lead to a successful scientific inquiry include persistence, adaptability, and collaboration. These habits of mind enable a student to deal with common obstacles that arise during a PBL model. Persistence in researching, collecting, and analysing information, despite challenges, will ensure a broad range of information on which to base new meaning. Adaptability allows a student to deal with possible changes related to focus questions, resources, experimental conditions, or strategies. A willingness and ability to collaborate with others will enrich the inquiry process and lead to a broader and deeper understanding of new information for all involved.

Adapted from *Active Citizenship: Student Action Projects*, (2004) and *Standards for the 21st-Century Learner*, (2007), AASL

Inquiry Stages and Skills

Guided inquiry involves certain process skills (learned abilities), habits of mind (acquired attitudes), and responsibilities about interacting with new information. Independent thinkers will practise multiple strategies to maneuver through an inquiry process. A typical inquiry process may be considered to follow three stages: Beginning Inquiry, Ongoing Inquiry, and Concluding Inquiry, each stage associated with specific skills and corresponding to sequential phases within the Scientific Inquiry Model used in this document. Note that there may be some overlap of phases.

Beginning Inquiry Stage (Initiating and Planning)

- use prior and background knowledge as a base to identify a topic area for new inquiry
- develop and refine inquiry questions
- plan the inquiry (SMART goals, Gantt and PERT charts)
- find and select appropriate sources in a range of formats (e.g., textual, digital, visual, community) to pursue inquiry

Ongoing Inquiry Stage (Performing & Recording, Analysing & Interpreting)

- evaluate information for accuracy, validity, appropriateness, bias, relevance, point of view, and context
- conduct investigations into relationships among observable variables, and use tools and techniques to gather, record, and organize data
- analyse the data, accounting for sources of error, to develop and assess possible explanations for the results
- evaluate the relevance, reliability, and adequacy of data and data collection methods
- interpret patterns and trends in the data and relationships among the variables
- explain how the data support or refute the inquiry question
- review and revise the plan for inquiry

Concluding Inquiry Stage (Communication and Teamwork)

- use writing, media and visual literacy, and technology skills to create a product that expresses new understandings
- use communication skills to share new understandings of a topic in a way that others can access, view, and use
- collaborate with others to exchange new ideas and develop new understandings
- recognize and discuss the environmental, economic, and societal implications of the project and recommend new avenues of experimentation
- use information and technology ethically and responsibly by documenting sources accurately, avoiding plagiarism, and respecting the rules of intellectual property

Adapted from *Standards for the 21st-Century Learner*, (2007), AASL.

Resource-Based Learning

Effective science teaching and learning actively involves students, teachers, and teacher librarians in the effective use of a wide range of print, non-print, and human resources. Resource-based learning fosters students' development by accommodating their diverse backgrounds, learning styles, needs, and abilities.

Resource-based learning supports students as they develop information literacy: more specifically, accessing, interpreting, evaluating, organizing, selecting, producing, and communicating information in and through a variety of media, technologies, and contexts. When students engage in their own research with appropriate guidance, they are more likely to take responsibility for their learning, and to retain information.

In a resource-based learning environment, students and teachers make decisions about appropriate sources of information and tools for learning, and how to access them. A resource-based approach raises the issues of selecting and evaluating information sources. Developing the critical skills needed for these tasks is essential to science.

The range of possible resources for studying environmental issues include the following:

- print—books, magazines, newspapers, documents, and other publications;
- visuals—maps, illustrations, photographs, charts, and graphs;
- artifacts—concrete objects and primary source documents;
- individual and community—interviews, field work, community sites;
- multimedia—films, audio and video tapes, television and radio, simulations;
- information technology—computer software, databases, CD-ROMs, DVDs, GPS, live-streaming broadcasts, podcasts, and data logging technologies;
- communication technology—Internet sites, blogs, e-mail, and social media.

Resource-based learning takes place in the science classroom through a variety of means. The prescribed text book, although a principal source of information for the student, is only one of many resources available. As a tertiary resource, it contains bias of its own and must be treated accordingly. Students in an environmental science class will make use of many other sources of information, including magazines, news articles, Internet Web sites, government publications, and environmental agencies. For a fully enriched learning experience, students should be encouraged to explore and engage in as many diverse sources of information as possible.

Literacy through Science

Literacy has always been an important component of science education. In recent years, however, through the promotion of research in critical theory, the meaning of literacy has broadened to encompass all forms of communication. In today's science classrooms, learners are encouraged to examine, compose, and decode spoken, written, and visual texts to aid in their understanding of content and concepts, and to better prepare them for full and effective participation in their communities. Additionally, the goals of literacy include not only language development, but also critical engagement with text, visuals, and auditory information. These goals have implications for the role of the science teacher.

The ability to read is critical for success in school. Therefore, it is vital that science teachers develop and use strategies that specifically promote students' abilities to read, comprehend, and compose text, no matter what form that text might take. Similarly, writing as a process should be stressed as a means that allows students to communicate effectively what they have learned and to raise the questions they need to ask.

Critical literacy in science curriculum addresses several goals. Through the implementation of various strategies, teachers will facilitate development of students' awareness of stereotyping, cultural bias, author's intent, hidden agendas, silent voices, and omissions. Students are encouraged to be aware that authors construct texts with specific purposes in mind. Further, critical literacy helps students comprehend texts at a deeper level by encouraging them to view content and ideas from a variety of perspectives, and to interpret the various levels of meaning in a given text, both explicit and implicit.

In this regard, the level and focus of questioning becomes very important. The depth of a student's response will often be determined by the depth of questioning and inquiry. Teachers need to pose high-level, open-ended questions that allow students to use their prior knowledge and experiences, providing opportunity for a sustained engagement before, during, and after reading or viewing text.

Strategies that promote literacy through science include helping students comprehend the meaning of words, symbols, pictures, diagrams, and graphs in a variety of ways. It means engaging students in many learning opportunities which are designed to challenge and enhance their communication in a variety of modes, such as writing, debating, persuading, and explaining, and in a variety of media, such as the artistic and technological. In the science classroom, all literacy strands — reading, writing, speaking, listening, viewing, and representing — are significant.

In the context of environmental science, literacy also addresses the promotion of education for sustainable development (ESD). Literacy for ESD involves understanding ecological, economic, and social perspectives on environmental issues, learning how to investigate current issues, and participating creatively and critically in community problem solving and decision making.

Integration of Technology in Science

Technology, including communication and information technology (CIT), plays a major role in science learning and teaching. Computers and related technologies are valuable classroom tools for acquiring, analysing, and presenting information. These technologies provide further opportunity for communication and collaboration and allow students to become more active participants in research and learning.

CIT and related technologies (digital video and digital cameras, scanners, CD-ROMs, word-processing software, graphics software, video-editing software, data logging equipment, HTML editors, and the Internet — including the World Wide Web, databases, electronic discussions, e-mail, and audio and video conferencing) afford numerous possibilities for enhancing learning. Computers and other technologies are intended to enhance science learning. In that context, technological resources can provide a variety of opportunities.

- The Internet and DVDs give teachers and students quick and easy access to extensive and current information. Information acquisition skills are key to efficient use of these resources. Questions of validity, accuracy, bias, and interpretation must still be applied to information available on the Internet and in DVDs.

- Interactions and conversations via e-mail, video and audio conferencing, student-created Web sites, on-line discussion groups, and other social media provide connections between students and people from their communities and around the world. This exposure to first-hand information will enable students to directly employ inquiry skills.

- Students present what they have learned in a wide variety of forms (e.g., graphs, maps, text, graphic organizers, Web sites, multimedia presentations) that fit their learning styles. These presentations can be shared with others, both in their classroom and beyond.

- Students are actively involved in their learning through controlling information gathering, processing, and presentation. For example, data logging technologies and Geographic Information Systems (GIS) software enables students to collect data about a community or region, plot the data using Global Positioning Systems (GPS), and analyse and present their findings by creating maps and graphs that demonstrate their learning.

Technology can open up a means of exploring up-to-date statistics, current environmental or human issues, real-time events, and other on-line information while enabling communication with other jurisdictions in the country and around the world. Technology can also provide students with a means for communicating new learning and sharing of ideas and research with classmates and teachers through the use of various presentation tools. Diverse learning styles and abilities are found in every classroom and technology enables a myriad of approaches to the study of issues within a global context.

Science for EAL Learners

The Prince Edward Island science curriculum is committed to the principle that learners of English as an additional language (EAL) should be full participants in all aspects of science education. English deficiencies and cultural differences must not be barriers to full participation. All students should study a comprehensive science curriculum with high-quality instruction and co-ordinated assessment.

To this end:

- schools should provide EAL learners with support in their dominant language and English language while learning science;
- teachers, counsellors, and other professionals should consider the English-language proficiency level of EAL learners as well as their prior course work in science;
- the science proficiency level of EAL learners should be solely based on their prior academic record and not on other factors;
- science teaching, curriculum, and assessment strategies should be based on best practices and build on the prior knowledge and experiences of students and on their cultural heritage;
- the importance of science and the nature of the science program should be communicated with appropriate language support to both students and parents;
- to verify that barriers have been removed, educators should monitor enrolment and achievement data to determine whether EAL learners have gained access to, and are succeeding in, science courses.

Meeting the Needs of All Learners

Foundation for the Atlantic Canada Science Curriculum stresses the need to design and implement a science curriculum that provides equitable opportunities for all students according to their abilities, needs, and interests. Teachers must be aware of, and make adaptations to accommodate, the diverse range of learners in their classes. To adapt instructional strategies, assessment practices, and learning resources to the needs of all learners, teachers must create opportunities that will permit them to address their various learning styles.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching; they must also actively address cultural and gender stereotyping (e.g., about who is interested in and who can succeed in science and mathematics). Research supports the position that when science curriculum is made personally meaningful and socially and culturally relevant, it is more engaging for groups traditionally underrepresented in science, and indeed, for all students.

While this curriculum guide presents specific outcomes for each unit, it must be acknowledged that students will progress at different rates.

Teachers should provide materials and strategies that accommodate student diversity, and should validate students when they achieve the outcomes to the best of their abilities.

It is important that teachers articulate high expectations for all students and ensure that all students have equitable opportunities to experience success as they work toward achieving designated outcomes. Teachers should adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address students' needs and build on their strengths. The variety of learning experiences described in this guide provide access for a wide range of learners. Similarly, the suggestions for a variety of assessment practices provide multiple ways for learners to demonstrate their achievements.

Assessment and Evaluation

The terms **assessment** and **evaluation** are often used interchangeably, but they refer to quite different processes. Science curriculum documents provincially use these terms for the processes described below.

Assessment is the systematic process of gathering information on student learning. According to research, assessment has three interrelated purposes:

- assessment *for* learning to guide and inform instruction
- assessment *as* learning to involve students in self-assessment and setting of goals for their own learning
- assessment *of* learning to make judgments about student performance in relation to curriculum outcomes

Evaluation is the process of analysing, reflecting upon, and summarizing assessment information, and making judgments or decisions based upon the information gathered.

The assessment process provides the data, and the evaluation process brings meaning to the data. Together, these processes improve teaching and learning. If we are to encourage enjoyment in learning for students now and throughout their lives, we must develop strategies to involve students in assessment and evaluation at all levels. When students are aware of the outcomes for which they are responsible and of the criteria by which their work will be assessed and evaluated, they can make informed decisions about the most effective ways to demonstrate their learning.

Provincial science curriculum reflects the three major processes of science learning: inquiry, problem solving, and decision making. When assessing student progress, it is helpful to know some activities/skills/actions that are associated with each process of science learning. Student learning may be described in terms of ability to perform these tasks.

Assessment Techniques

Assessment techniques should match the style of learning and instruction employed. Several options are suggested in this curriculum guide from which teachers may choose, depending on the curriculum outcomes, class, and school/district policies. It is important that students know the purpose of an assessment, the method used, and the marking scheme being used. In order that assessment support learning, the results, when reported to students, should indicate the improvements expected.

Assessment Techniques *Continued...*

Observation (formal or informal)

This technique provides a way of gathering information fairly quickly while a lesson is in progress. When used formally, the student(s) would be made aware of the observation and the criteria being assessed. Informally, it could be a frequent, but brief, check on a given criterion. Observation may offer information about the student's participation level, use of a piece of equipment, or application of a given process. The results may be recorded in the form of checklists, rating scales, or brief written notes. It is important to plan in order that specific criteria are identified, suitable recording forms are ready, and all students are observed in a reasonable period of time.

Performance

This curriculum encourages learning through active participation. Many of the curriculum outcomes found in the guide promote skills and their application. There is a balance between scientific processes and content. In order that students appreciate the importance of skill development, it is important that assessment provide feedback on their various skills (e.g., how to use a piece of equipment; apply an experimental technique; interpret and follow instructions; research, organize, and present information). Assessing performance is most often achieved through observing the process.

Journal

Although not assessed in a formal manner, journals provide an opportunity for students to express thoughts and ideas in a reflective way. By recording feelings, perceptions of success, and responses to new concepts, a student may be helped to identify his or her most effective learning style. Knowing how to learn in an effective way is powerful information. Journal entries also give indicators of developing attitudes toward science concepts, processes, and skills, and application of these in the context of society. Self-assessment, through a journal, permits a student to consider strengths and weaknesses, attitudes, interests, and new ideas. Developing patterns may help in career decisions and choices of further study.

Interview

This curriculum promotes understanding and application of scientific concepts. Interviewing a student allows the teacher to confirm that learning has taken place beyond simple factual recall. Discussion allows a student to display an ability to use information and clarify understanding. Interviews may be brief discussions between teacher and student, or they may be more extensive and include student, parent, and teacher. Such conferences allow a student to be pro-active in displaying understanding. It is helpful for students to know which criteria will be used to assess formal interviews. The assessment technique provides an opportunity for students whose verbal presentation skills are stronger than their written skills to demonstrate their learning.

Assessment Techniques *Continued...*

Paper and Pencil (assignment or test)

These techniques can be formative or summative. Several curriculum outcomes call for displaying ideas, data, conclusions, and the results of practical or literature research. These can be in written form for display or for direct teacher assessment. Whether an activity is a part of learning, or a final statement, students should know the expectations for the exercise and the rubric by which it will be assessed. Written assignments and tests can be used to assess knowledge, understanding, and application of concepts. They are less successful in assessing skills, processes, and attitudes. The purpose of the assessment should determine what form of paper and pencil exercise is used.

Presentation

The curriculum includes outcomes that require students to analyse and interpret information; to identify relationships between science, technology, society, and environment; to be able to work in teams; and to communicate information. Although the process can be time consuming, these activities are best displayed and assessed through presentations. These can be given orally, in written/pictorial form, by project summary (science fair), or by using electronic systems such as video or computer software. Whatever the level of complexity or format used, it is important to consider the curriculum outcomes as a guide to assessing the presentation. The outcomes indicate the process, concepts, and context for which and about which a presentation is made.

Portfolio

Portfolios offer another option for assessing student progress in meeting curriculum outcomes over a more extended period of time. This form of assessment allows the student to be central in the process. Decisions about the portfolio and its contents can be made by the student. What is placed in the portfolio, the criteria for selection, how the portfolio is used, how and where it is stored, and how it is evaluated are some of the questions to consider when planning to collect and display student work in this way. The portfolio should provide a long-term record of growth in learning and skills. This record of growth is important for individual reflection and self-assessment, but it is also important to share with others. For many students it is exciting to review a portfolio and see the record of development over time.

Evaluation

Evaluation is a continuous, comprehensive, and systematic process. It brings interpretation, judgments, and decisions to the data collected during the assessment phase. Questions include the following: How valid and reliable is the data gathered? What does the data suggest about student achievement of course outcomes? Does student performance confirm the success of instructional practice or indicate the need to change it? Are students ready to move on to the next phase of the course, or is there need for remediation?

Teacher-developed assessments and the evaluations based on them have a variety of uses, including the following:

- providing feedback to improve student learning;
- determining whether curriculum outcomes have been achieved;
- certifying that students have achieved certain levels of performance;
- setting goals for future student learning;
- communicating with parents about their children's learning;
- providing information to teachers on the effectiveness of their teaching, the program, and the learning environment;
- meeting goals of guidance and administrative personnel.

Evaluation is conducted within the context of the outcomes, which should be clearly understood by learners before teaching and evaluation take place. Students must understand what teachers expect of them and the basis on which they will be evaluated. The evaluation of a student's progress may be classified as pre-instructional, formative, or summative, depending on the purpose.

Pre-instructional evaluation is conducted before the introduction of unfamiliar subject matter, or when learners are experiencing difficulty. It gives an indication of *where students are* and is not a measure of what they are capable of doing. The purpose is to analyse a student's progress to date in order to determine the type and depth of instruction needed. This type of evaluation is mostly conducted informally and continuously.

Formative evaluation is conducted throughout instruction. Its primary purpose is to improve instruction and learning. It is an indication of *how things are going*. It identifies a student's strengths or weaknesses with respect to specific curriculum outcomes so necessary adaptations can be made.

Summative evaluation occurs at the end of a designated period of learning. It is used, along with data collected during the formative stage, to determine learner achievement. This evaluation is used to report the degree to which curriculum outcomes have been achieved.

Planning, Assessing, Reporting, and Weighting in ENV621A

ENV621A - Environmental Science requires thoughtful and careful planning at the outset of the course. Due to its PBL component, teachers are advised to plan carefully in advance to ensure that appropriate inquiry skills are integrated into the daily learning activities and that students are fully aware of expectations.

There is a high level of complexity within the course structure. For example, at first glance, Units 1 and 2 may appear to consist of traditional sets of "content" outcomes that can be addressed in sequence and in isolation. However, to be truly effective and meaningful, these outcomes should be approached using a variety of environmental science examples as a means to introducing and reinforcing concepts within the unit. The outcomes of the PBL unit are process-driven and will require critical up-front discussion and guidance at the beginning of the semester. Topics will fall into one of the environmental science themes within the course— ecological principles, human population and carrying capacity, natural resources, and environmental challenges and successes—and can provide daily opportunities to practise the concepts of education for sustainable development and to foster awareness of the outside world. Students' PBL projects may be based on the same environmental issue or they may differ completely. Guided instruction and modelling are critical to the inquiry process. Students will need to fully understand at the beginning of the course what will be expected of them as well as how they will be assessed throughout the duration of the course. Teachers are advised to spend some time during the first weeks of the course introducing students to the processes of planning a PBL project and other stages of the inquiry process. This "front-loading" instructional time serves two purposes: 1) it informs students of their tasks to come, and 2) it enables students to start thinking about inquiry topics that they may wish to pursue. Ideally, by giving students the necessary process tools up front, many of them will be able to self-direct their learning as the course proceeds. This will allow the teacher to act as a process facilitator for some students while freeing up time to offer more direct assistance to others.

Assessment of learning in ENV621A- Environmental Science should occur throughout the course. Assessment tools, criteria, and timelines (deadlines) should be established in advance to facilitate ongoing and informative assessment and feedback to students. Summative assessment may take place when an end-product is complete, however, teachers should consider the time and effort involved in all stages of a project to ensure that the end-product does not form the entire assessment.

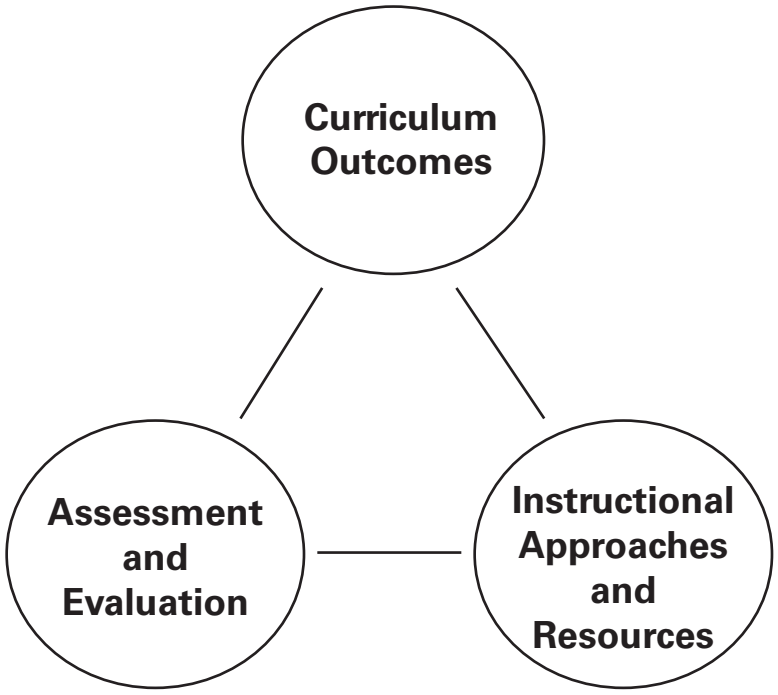
Reporting methods and weighting of assessments should be determined before the course is underway so that students are aware of expectations. Some schools may have specific policies regarding weighting of major assessment pieces. ENV621A - Environmental Science is easily adapt-

able to a variety of assessment weightings. It is important to note that this course emphasizes the inquiry process involved in PBL within an environmental science context. While specific content knowledge is important, the higher goal is in learning how information creates meaning.

Assessing and Evaluating Student Learning in the Science Classroom

There should be a congruence between what is taught, how it is taught, and what is emphasized in the evaluation process. Science educators should recognize that "...quality programming and instruction are neither content-based nor process-based, but a wise and judicious mixture of both" (Frost, 1989, 11).

The assessment of student learning must be aligned with the curriculum outcomes and the types of learning opportunities made available to students. A "backwards design" approach can help in determining the most effective way of measuring a student's level of learning. An essential question that often helps to focus on this goal is, "What evidence will I have that shows me that the student has achieved the outcome"? Once the "evidence" or criteria (assessment tool) has been established, teachers can plan effective instructional approaches and gather supporting resources that will help students to reach this goal.



(Adapted from *The Evaluation of Students in the Classroom: A Handbook and Policy Guide*, Department of Education, Government of Newfoundland and Labrador, 1990)

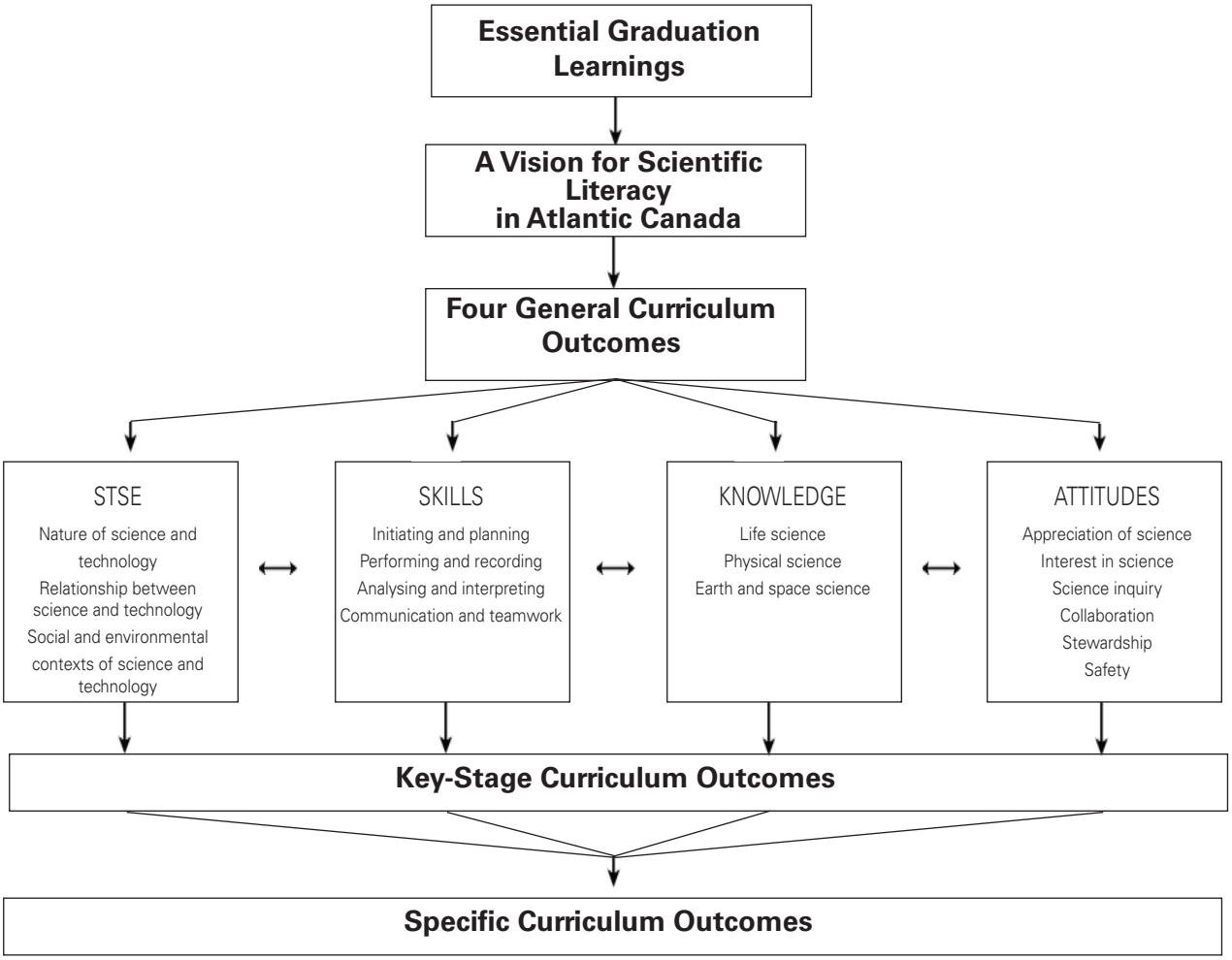
Curriculum Outcomes Framework

Overview

The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general and key-stage curriculum outcomes reflect the pan-Canadian C*ommon Framework of Science Learning Outcomes K to 12*. The specific curriculum outcomes are prescribed outcomes specially written for the Prince Edward Island environmental science curriculum. The diagram below provides the blueprint of the outcomes framework.

Outcomes Framework

FIGURE 1



Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the essential graduation learnings will prepare students to continue to learn throughout their lives. These learnings describe expectations not in terms of individual school subjects but in terms of knowledge, skills, and attitudes developed throughout the curriculum. They confirm that students need to make connections and develop abilities across subject boundaries and to be ready to meet the shifting and ongoing opportunities, responsibilities, and demands of life after graduation. The essential graduation learnings are the following:

Aesthetic Expression

Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.

Citizenship

Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.

Communication

Graduates will be able to use the listening, viewing, speaking, reading, and writing modes of language(s) as well as mathematical and scientific concepts and symbols to think, learn, and communicate effectively.

Personal Development

Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.

Problem Solving

Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, mathematical, and scientific concepts.

Technological Competence

Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.

General Curriculum Outcomes

The general curriculum outcomes form the basis of the outcomes framework. They also identify the key components of scientific literacy. Four general curriculum outcomes have been identified to delineate the four critical aspects of students' scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered interrelated and mutually supportive.

Science, Technology, Society, and the Environment

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

Skills

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Attitudes

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Key-Stage Curriculum Outcomes

Key-stage curriculum outcomes are statements that identify what students are expected to know, be able to do, and value by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in science. The key-stage curriculum outcomes are from the *Common Framework for Science Learning Outcomes K to 12*.

Specific Curriculum Outcomes

Specific curriculum outcome statements describe what students are expected to know and be able to do at each grade level. They are intended to help teachers design learning experiences and assessment tasks. Specific curriculum outcomes represent a framework for assisting students to achieve the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately, the essential graduation learnings.

Specific curriculum outcomes are organized in units for each grade level.

Attitude Outcomes

It is expected that the Atlantic Canada science program will foster certain attitudes in students throughout their school years. The STSE, skills, and knowledge outcomes contribute to the development of attitudes, and opportunities for fostering these attitudes are highlighted in the Elaborations—Strategies for Learning and Teaching sections of each unit.

Attitudes refer to generalized aspects of behaviour that teachers model for students by example and by selective approval. Attitudes are not acquired in the same way as skills and knowledge. The development of positive attitudes plays an important role in students' growth by interacting with their intellectual development and by creating a readiness for responsible application of what students learn.

Since attitudes are not acquired in the same way as skills and knowledge, outcomes statements for attitudes are written as key-stage curriculum outcomes for the end of grades 3, 6, 9, and 12. These outcome statements are meant to guide teachers in creating a learning environment that fosters positive attitudes.

The following pages present the attitude outcomes from the pan-Canadian *Common Framework of Science Learning Outcomes K to 12* for the end of grade 12.

Common Framework of Science Learning Outcomes K to 12
Attitude Outcome Statements

By the end of grade 12, it is expected that students will be encouraged to

Appreciation of Science	Interest in Science	Scientific Inquiry
436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not **437** appreciate that the applications of science and technology can raise ethical dilemmas **438** value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds *Evident when students, for example,* • consider the social and cultural contexts in which a theory developed • use a multi-perspective approach, considering scientific, technological, economic, cultural, political, and environmental factors when formulating conclusions, solving problems, or making decisions on STSE issues • recognize the usefulness of being skilled in mathematics and problem solving • recognize how scientific problem solving and the development of new technologies are related • recognize the contribution of science and technology to the progress of civilizations • carefully research and openly discuss ethical dilemmas associated with the applications of science and technology • show support for the development of information technologies and science as they relate to human needs • recognize that western approaches to science are not the only ways of viewing the universe • consider the research of both men and women	**439** show a continuing and more informed curiosity and interest in science and science-related issues **440** acquire, with interest and confidence, additional science knowledge and skills using a variety of resources and methods, including formal research **441** consider further studies and careers in science- and explore where further science- and technology-related fields *Evident when students, for example,* • conduct research to answer their own questions • recognize that part-time jobs require science- and technology-related knowledge and skills • maintain interest in or pursue further studies in science • recognize the importance of making connections between various science disciplines • explore and use a variety of methods and resources to increase their own knowledge and skills • are interested in science and technology topics not directly related to their formal studies • explore where further science- and technology-related studies can be pursued • are critical and constructive when considering new theories and techniques • use scientific vocabulary and principles in everyday discussions • readily investigate STSE issues	**442** confidently evaluate evidence and consider alternative perspectives, ideas, and explanations **443** use factual information and rational explanations when analysing and evaluating **444** value the processes for drawing conclusions *Evident when students, for example,* • insist on evidence before accepting a new idea or explanation • ask questions and conduct research to confirm and extend their understanding • criticize arguments based on the faulty, incomplete, or misleading use of numbers • recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen • expend the effort and time needed to make valid inferences • critically evaluate inferences and conclusions, cognizant of the many variables involved in experimentation • critically assess their opinion of the value of science and its applications • criticize arguments in which evidence, explanations, or positions do not reflect the diversity of perspectives that exist • insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged • seek new models, explanations, and theories when confronted with discrepant events or evidence

Common Framework of Science Learning Outcomes K to 12

Attitude Outcome Statements *(continued)*

By the end of grade 12, it is expected that students will be encouraged to

Collaboration	Stewardship	Safety in Science
445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *Evident when students, for example,* • willingly work with any classmate or group of individuals regardless of their age, gender, or physical and cultural characteristics • assume a variety of roles within a group, as required • accept responsibility for any task that helps the group complete an activity • give the same attention and energy to the group's product as they would to a personal assignment • are attentive when others speak • are capable of suspending personal views when evaluating suggestions made by a group • seek the points of view of others and consider diverse perspectives • accept constructive criticism when sharing their ideas or points of view • criticize the ideas of their peers without criticizing the persons • evaluate the ideas of others objectively • encourage the use of procedures that enable everyone, regardless of gender or cultural background, to participate in decision making • contribute to peaceful conflict resolution encourage the use of a variety of communication strategies during group work • share the responsibility for errors made or difficulties encountered by the group	**446** have a sense of personal and shared responsibility for maintaining a sustainable environment **447** project the personal, social, and environmental consequences of proposed action **448** want to take action for maintaining a sustainable environment *Evident when students, for example,* • willingly evaluate the impact of their own choices or the choices scientists make when they carry out an investigation • assume part of the collective responsibility for the impact of humans on the environment • participate in civic activities related to the preservation and judicious use of the environment and its resources • encourage their peers or members of their community to participate in a project related to sustainability • consider all perspectives when addressing issues, weighing scientific, technological, and ecological factors • participate in social and political systems that influence environmental policy in their community • examine/recognize both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans • willingly promote actions that are not injurious to the environment • make personal decisions based on a feeling of responsibility toward less privileged parts of the global community and toward future generations • are critical-minded regarding the short- and long-term consequences of sustainability	**449** show concern for safety and accept the need for rules and regulations **450** be aware of the direct and indirect consequences of their actions *Evident when students, for example,* • read the label on materials before using them, interpret the WHMIS symbols, and consult a reference document if safety symbols are not understood • criticize a procedure, a design, or materials that are not safe or that could have a negative impact on the environment • consider safety a positive limiting factor in scientific and technological endeavours • carefully manipulate materials, cognizant of the risks and potential consequences of their actions • write into a laboratory procedure safety and waste-disposal concerns • evaluate the long-term impact of safety and waste disposal on the environment and the quality of life of living organisms • use safety and waste disposal as criteria for evaluating an experiment • assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials in a safe place • seek assistance immediately for any first aid concerns like cuts, burns, or unusual reactions • keep the work station uncluttered, with only appropriate lab materials present

Curriculum Guide Organization

Specific curriculum outcomes are organized in units for each grade level. Each unit is organized by topic. Suggestions for learning, teaching, assessment, and resources are provided to support student achievement of the outcomes. Suggested times for each unit are also provided. Although Environmental Science 621A is 110 hours (~90 classes) in duration, the cumulative topic instructional time allocated is 90 hours (~74 classes). The remaining 20 hours allows for summative assessment considerations.

The order in which the units of a course appear in the guide is meant to suggest a sequence. In some cases, the rationale for the recommended sequence is related to the conceptual flow across the semester. That is, one unit may introduce a concept that is then extended in a subsequent unit. Likewise, one unit may focus on a skill or context that will be built upon later in the semester. Note that the concepts in the Project Based Learning unit will surface throughout the course as teachers model concepts and facilitate students' progress through the guided inquiry process.

Some units or certain aspects of units may also be combined or integrated. This is one way of assisting students as they attempt to make connections across topics in science or between science and the real world. The intent is to provide opportunities for students to deal with science concepts and scientific issues in personally meaningful and socially, culturally, and economically relevant contexts.

Unit Organization

The PBL unit outlines the inquiry model and outcomes that students will follow during their environmental science investigation. Each subsequent unit begins with a two-page synopsis. On the first page, introductory paragraphs provide a unit overview. These are followed by a section that specifies the focus (inquiry, problem solving, and/or decision making) and possible contexts for the unit. Finally, a curriculum links paragraph specifies how this unit relates to science concepts and skills addressed in other grades so teachers will understand how the unit fits with the students' progress through the complete science program.

The second page of the two-page overview provides a table of the Prince Edward Island prescribed specific curriculum outcomes that the unit will address. The numbering system indicates the unit and the outcome number. These code numbers appear before each specific curriculum outcome (SCO). Each outcome that students are expected to complete relate directly to one or more of the four general curriculum outcome categories: Science-Technology-Society-Environment (STSE) outcomes, Skills outcomes, Knowledge outcomes, Attitude outcomes.

The Four-Column Spread

All units have a two-page layout of four columns as illustrated below. In some cases, the four-column spread continues to the next two-page layout. Outcomes are grouped by a topic indicated at the top of the left page.

Two-Page, Four-Column Spread

Page One		Page Two	
Topic Outcomes	Elaborations—Strategies for Learning and Teaching	Tasks for Instruction and/or Assessment	Resources/Notes
Students will be expected to Specific curriculum outcome based on the Prince Edward Island prescribed outcomes (outcome number) Specific curriculum outcome based on the Prince Edward Island prescribed outcomes (outcome number)	elaboration of outcome and strategies for learning and teaching elaboration of outcome and strategies for learning and teaching	*Informal/Formal Observation* *Performance* *Journal* *Interview* *Paper and Pencil* *Presentation* *Portfolio*	Useful Teacher Resources

Column One: Outcomes

The first column provides the specific curriculum outcomes. These are based on the Prince Edward Island prescribed outcomes. The statements involve the Science-Technology-Society-Environment (STSE), Skills, and Knowledge outcomes indicated by the outcome number(s) that appear(s) in parentheses after the outcome. Some STSE and skills outcomes have been written in a context that shows how these outcomes should be addressed.

Specific curriculum outcomes have been grouped by topic. Other groupings of outcomes are possible and in some cases may be necessary to take advantage of local situations (e.g., PBL outcomes). The grouping of outcomes provides a suggested teaching sequence. Teachers may prefer to plan their own teaching sequence to meet the learning needs of their students.

Column One defines what students are expected to learn, and be able to do.

Column Two: Elaborations—Strategies for Learning and Teaching

The second column may include elaborations of outcomes listed in column one, and describes learning environments and experiences that will support students' learning.

The strategies in this column are intended to provide a holistic approach to instruction. In some cases, they address a single outcome; in other cases, they address a group of outcomes.

To support teachers in assessing specific curriculum outcomes, sets of achievement indicators may be included in Column Two. Achievement indicators describe what evidence a teacher might look for to determine whether or not the student has fully met the intent of the specific curriculum outcome. Achievement indicators are not mandatory; they are suggestions only, provided to assist teachers in assessing how well their students achieve the prescribed learning outcomes.

Column Three: Tasks for Instruction and/or Assessment

The third column provides suggestions for ways that students' achievement of the outcomes could be assessed. These suggestions reflect a variety of assessment techniques and materials that include, but are not limited to, informal/formal observation, performance, journal, interview, paper and pencil, presentation, and portfolio. Some assessment tasks may be used to assess student learning in relation to a single outcome, others to assess student learning in relation to several outcomes. The assessment item identifies the outcome(s) addressed by the outcome number in brackets after the item.

Some STSE, Skills, and Knowledge outcomes that appear after the assessment item may not appear in the first column. Although these outcomes are not the key outcome(s) for this section, the assessment item provides an opportunity to address these outcomes in a different context.

Column Four: Resources/Notes

This column provides an opportunity for teachers to make note of useful resources.

Project Based Learning *(~14 Classes)*

Guided Inquiry - Project Based Learning (PBL)

This unit should be integrated within the other five units of the curriculum guide. It requires students to use a PBL model that follows a guided inquiry process that will result in a final product based on an environmental issue. While the end product is an important part of the work, the inquiry process leading up to the final product is significant due to the scope and range of skills required to complete the process. Therefore, the focus of this unit is on the process of inquiry, the synthesis of prior and background information with new information, and the sharing of the product by way of a class presentation. Assessment and evaluation are also important parts of the inquiry process and will involve student reflection on their own work as well as that of others. The "Student Guide to the Inquiry Process" (see Appendix A) and the *PBL Starter Kit* are provided to enable teachers to model each stage of inquiry and guide students in their own inquiries. The guides also provides a means of assessing process skills at various milestones during the inquiry process.

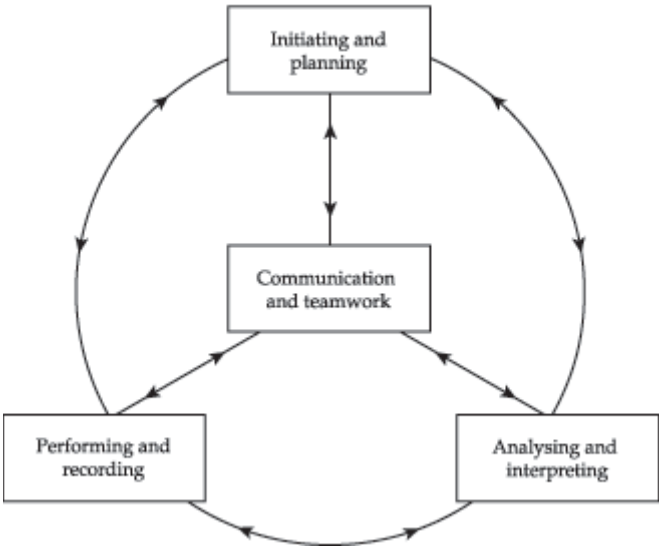
Research, experimentation, and inquiry are similar concepts but not always identical in process or results. Research and experimentation form part of a student's everyday activities from the earliest ages of learning throughout the rest of his or her life. Inquiry is the basis of the life-long learning theory. While the term "research" or "experimentation" may have a daunting air about them, inquiry may be as uncomplicated as asking a simple question or performing a simple measurement. This unit is intended to blend inquiry with research practice and experimentation.

Outcome

1.1 investigate a selected environmental science issue using a guided inquiry process
- 1.1.1 Initiating and Planning - develop a plan to investigate questions, ideas, problems, and issues
- 1.1.2 Performing and Recording - conduct investigations into relationships between and among variables, using a broad range of tools and techniques
- 1.1.3 Analysing and Interpreting - analyse data to develop and assess possible explanations
- 1.1.4 Communication and Teamwork - communicate information, ideas, and results

The Scientific Inquiry Model

Science inquiry is seeking answers to questions through research and experimentation. In PBL, students use a guided inquiry-based approach that allows the learner to engage with issues that are real and relevant in their lives. The processes and four areas of skills related to scientific inquiry are to be explicitly modeled by the teacher. Students are then to practise and apply them to their own inquiry using the PBL model.



Environmental Science 621A Themes for Inquiry

The following broad areas or themes lend themselves to guided inquiry through PBL: Ecological Principles, Human Population and Carrying Capacity, Natural Resources, and Environmental Challenges and Successes. Within each area, there are many issues from which to select for further research. Throughout the course, students will be exposed to various environmental issues within each category through whole-class discussion and inquiry. Teachers are encouraged to model various stages and aspects of the PBL method as the class proceeds through the course. Teachers may wish to make use of supplementary resources in the appendix designed specifically to support guided inquiry approaches into environmental issues.

As part of the PBL component for this course, students will be expected to conduct research and experimentation into one theme, issue, or selected area by following a guided inquiry process. The final product may be presented in a variety of formats, although the inquiry process will remain similar in all cases. Prior to assigning the PBL project, and throughout the course, teachers will need to provide guidance to students regarding inquiry and research processes, performing experiments, analysing and interpreting data, developing, presenting, and defending a position or course of action based on their findings, and other issues related to scientific research and writing. The PBL unit of this document provides teachers with broad ideas around the inquiry process as well as more detailed information within each stage of the process.

While students are conducting their own research into a selected issue, they are also asked to reflect upon and incorporate their own thinking into their work around the concepts of education for sustainable development.

Initiating and Planning

Outcomes

Students will be expected to

1.1.1 develop a plan to investigate questions, ideas, problems, and issues

Elaborations - Suggestions for Learning and Teaching

The inquiry process begins by thinking about and asking questions about broad areas of interest (e.g., water quality in the environment). However, most environmental science issues are extremely broad and will need to be narrowed down further for inquiry. At this point, some preliminary research and an opportunity to discuss with others will help students to acquire general knowledge in their field of interest. Students should be encouraged to raise and record questions as they work their way through the early stages of the inquiry. It is critical to allow enough time for this important step in the process so that students can think about and process new information, and synthesize this with their prior knowledge. Once this is complete they can begin to outline their plan for inquiry, including research methods, sampling procedures, analysis procedures, and presentation formats.

Other considerations for teachers will be the format of the end-product, allotted time in class to work on the inquiry, and sufficient time for sharing the finished products. Assessment and evaluation should be discussed with students at the beginning of the inquiry process so that students know exactly what is expected of them and when. The following is an example of the narrowing-down process to develop an inquiry question or problem statement that can be answered through student research and experimentation:

Broad Topic
Water quality in the environment

Narrowed Topics (still very broad areas)
Groundwater/drinking water quality
Water quality in the oceans
Surface water quality

Narrower Topic/Question (better but still broad)
How do rain events affect water quality?
Does cultural eutrophication affect water quality?
Does runoff from local fields affect water quality in streams?

Inquiry Question
How are turbidity and pH readings of a local stream affected by rain events?

Some achievement indicators should include:

- identify a topic area of inquiry
- develop a specific inquiry question
- outline a plan of inquiry (e.g., SMART goal, Gantt chart, PERT chart)
- identify possible information sources
- design an experiment identifying and controlling major variables and sampling procedures
- identify audience and presentation format
- establish evaluation criteria

Initiating and Planning

Suggestions for Learning and Assessment

Journal

- Reflect on what environmental science issue you think should be investigated further. Can you come up with an inquiry question that can be answered during the semester? Picture the whole process with its parts. How would you carry it out? How would you present your findings to the class? (1.1.1)

- How will you know when your inquiry question has been answered? What problems do you anticipate may occur? What contingencies have you developed? (1.1.1)

Observation

- Find other classmates who share your field of interest. Work with them to conduct some preliminary research and discuss what questions could be investigated. (1.1.1)

- In a group, brainstorm some possible presentation formats and end-products that could be used in the inquiry process. (1.1.1)

Presentation

- In small groups, present your inquiry questions to one another. Evaluate each other's inquiry questions for clarity, completeness, and detail. Some questions to ask would be: Can the question/conjectures be researched and tested? What are the predicted results? (1.1.1)

Paper and Pencil

- From a broad topic area, develop a specific driving question that could be addressed using the PBL model. (1.1.1)

- Using a SMART goal, PERT chart, Gantt chart, or other graphic organizer, manage and plan your inquiry process. Identify major milestones in your model. Do they conform with the assessment and evaluation techniques that will be used to assess your progress? (1.1.1)

- Develop a timeline for experiments and site visits. Review and revise your plan for inquiry as needed. (1.1.1)

Performance

- Design an experiment that could be used to investigate your inquiry question. What major dependent and independent variables could you measure or control? Create the sampling procedures required to carry out your plan. How could you best present your anticipated results to others? (1.1.1)

Resources and Links

Appendix A: Student Guide to the Inquiry Process

PBL Starter Kit, Buck Institute for Education

Performing and Recording

Outcomes

Students will be expected to

1.1.2 conduct investigations into relationships between and among variables, using a broad range of tools and techniques

Elaborations - Suggestions for Learning and Teaching

Selecting Information Sources

The inquiry process involves searching for reliable sources of information. This information shall guide students in their creation of an experiment or process and allow them to formulate a balanced answer to an inquiry. The World Wide Web is likely one of the first places a student will start his or her search although students should be encouraged to try out a variety of sources, including community contacts. Researching contemporary environmental science issues may require more use of the Web in order to find the most current information available. Students should be cautious in their searches and follow guidelines to ensure that the sites they access are appropriate, reliable, and worth their time searching. Some typical guiding questions may help students to make the most of their surfing time:

Sample Guiding Questions

1) What is the address or URL? Check for the domain tag -- ".edu" indicates and educational institution, ".org" indicates a non-profit or nongovernmental organization, ".gov" refers to a government site, while ".com" indicates a private corporation.

2) Who is the author? Is the source reliable or is it simply an individual's personal view? Is there any information on the author at the end of the article or in other Web sites? Generally, if the site is affiliated with a reputable organization, it is considered to be acceptable.

3) Who is the intended audience of the article? Is the site intended for educational purposes or is it a commercial site intent on selling a product?

4) Is the site current and how long has it been in existence?

5) Is there a recommended way of citing material from the site? Be sure to give full credit for the information accessed.

There are many other questions that may guide students in their inquiry. Check with other sources or the school librarian for more suggestions in navigating the World Wide Web.

Some achievement indicators should include:

- develop an information retrieval plan
- locate and collect information from a variety of sources (e.g., Internet, text formats, multimedia formats, community contacts and local experts)

Performing and Recording

Suggestions for Learning and Assessment

Journal

- Given the vast amount of information available on environmental science issues, how will you determine which information is reliable? (1.1.2)

Presentation

- In small groups, present your information retrieval plans to one another. Evaluate each other's plans for diverse sources, completeness, or misconceptions. (1.1.2)

Paper and Pencil

- Identify community partners or volunteer mentors in your inquiry area. (1.1.2)

- Create a list of research literature for your inquiry question. Include books, magazines, journals, the Internet, and community contacts. Reference each source correctly. (1.1.2)

Resources and Links

Appendix A: Student Guide to the Inquiry Process

PBL Starter Kit, Buck Institute for Education

Performing and Recording (continued...)

Outcomes

Students will be expected to

1.1.2 (continued) conduct investigations into relationships between and among variables, using a broad range of tools and techniques

Elaborations - Suggestions for Learning and Teaching

Note-taking is fundamental in any inquiry process and there may be several styles that will work. Students should practise a style that both suits them and fulfils all the needs of their research responsibilities. Teachers and teacher-librarians can help guide students in finding a format that works well. Samples may be found in various resources within the classroom or library, or on-line. Summarizing information is a skill that will serve students well into the future. It is important that students learn to cite their sources for summarized pieces to avoid plagiarism.

Students should be given the opportunity to use scientific instruments to conduct their PBL inquiries. Teachers should model the appropriate use of several instruments or probes in guided, controlled experiments (e.g., pH, conductivity, dissolved oxygen, turbidity, carbon dioxide, temperature). Teachers should also model how to compile and organize collected data in the most appropriate format for further analysis (e.g., table, diagram, graph). Students should be experienced with safe equipment use and methods of compiling and organizing data before they begin collecting data for their projects.

Some achievement indicators should include:

- select relevant information
- use instruments effectively and accurately for collecting data
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data

Performing and Recording (continued...)

Suggestions for Learning and Assessment

Journal

- Reflect on what note-taking style best works for you. (1.1.2)

Paper and Pencil

- Use a reading strategy (e.g., SQ3R, summarizing, skimming) to establish the main ideas in a piece of text. (1.1.2)

- Can your investigation be replicated exactly as described in your procedure? If not, what steps need to be corrected? (1.1.2)

Performance

- In a controlled setting, use scientific instruments and equipment to gather and record data on the variables you wish to measure in your investigation. Determine the appropriateness, limitations and sensitivity of the equipment. Review or revise your sampling procedures or inquiry plan as needed. (1.1.2)

- Accurately record and display the data collected in your investigation. Organize your data in the best format for further analysis. Carefully record all conditions and factors at the time of measurement that could lead to sources of error or affect your data. (1.1.2)

- Conduct investigations into relationships among observable variables related to your inquiry question. Record data and gather evidence by observation and/or manipulating materials and equipment. (1.1.2)

Resources and Links

Appendix A: Student Guide to the Inquiry Process

PBL Starter Kit, Buck Institute for Education

Cross-curricular Reading Tools

Analysing and Interpreting

Outcomes

Students will be expected to

1.1.3 analyse data to develop and assess possible explanations

Elaborations - Suggestions for Learning and Teaching

Evaluating Information

An inquiry search can lead to a multitude of sources which can quickly become overwhelming to a student. An important part of learning how to follow the inquiry process is to know how to evaluate sources for their usefulness and quality. Students can become more practised at this if they follow some simple guidelines such as below:

Relevance - is the material closely related to the topic, general or specific?

Reliability - who is the author or organization that is publishing or promoting the information. Follow the same guidelines here as in selecting appropriate World Wide Web sites.

Timeliness - is the information up-to-date for the topic? Does it need to be current or are there historical aspects that are useful?

Accuracy - does the information agree with commonly accepted scientific theory and evidence?

Objectivity and Bias - does the material present a balanced view or is there an obvious bias on the part of the author? Is the source promoting a particular viewpoint or product?

Quantity - is there too much or too little to be of use within the allotted time frame of the inquiry?

(Adapted from *Canadian High School Writer's Guide*)

Some achievement indicators should include:

- evaluate information for relevance, reliability, timeliness, accuracy, bias, and quantity

Analysing and Interpreting

Suggestions for Learning and Assessment

Journal

- Do you think that nationally known organizations and literature sources are more reliable than local ones? (1.1.3)

Paper and Pencil

- Should all sources of information be cited? If not, give some examples of information that do not require citation. (1.1.3)

Performance

- Perform an Internet search to find two different views on a common topic (e.g., global warming, genetically modified organisms, use of pesticides on food crops). Evaluate the information that you found in terms of appropriateness, relevance, reliability, timeliness, bias, and quantity. Which source do you think is more useful? Why? (1.1.3)

Resources and Links

Appendix A: Student Guide to the Inquiry Process

PBL Starter Kit, Buck Institute for Education

Analysing and Interpreting (continued...)

Outcomes

Students will be expected to

1.1.3 (continued) analyse data to develop and assess possible explanations

Elaborations - Suggestions for Learning and Teaching

After students have gathered and recorded information from their experiments, they will need to use tables and graphs to interpret patterns and trends in the data that will determine relationships among their variables. Analysing graphical data will help them to identify and explain sources of error and uncertainty in their measurements. Students will be required to express the results from their experiments in a form that acknowledges the degree of uncertainty. This examination of results and equipment sensitivity will allow students to evaluate the relevance, reliability, and adequacy of their data and data collection methods.

Teachers should model this process with the entire class by analysing sample data collected during a controlled experiment. Teachers may choose data sets from different groups or data sets from different lab settings to compare factors that contribute to sources of error. They may also choose to compare measurements collected with different types of equipment to model how equipment sensitivity can affect recorded results and their subsequent interpretations and conclusions.

It is important that students realize that the analysis and interpretation of the data from their experiments may lead to unexpected conclusions. In science, explaining how the data supports or refutes an inquiry question can sometimes be as important as the question itself. Reliable conclusions (whether expected or unexpected) not only help answer the inquiry question but lead to new questions or problems for further investigation. The analysis of the data may cause students to review and revise their plan for inquiry in terms of conducting further research or amending their experimental procedures and sampling methods.

Some achievement indicators should include:

- evaluate the relevance, reliability, and adequacy of data and data collection methods
- interpret patterns and trends in the data and relationships among the variables
- identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty
- explain how the data support or refute the inquiry question
- identify new questions or problems that arise from what was learned
- review and revise the plan for inquiry

Analysing and Interpreting (continued...)

Suggestions for Learning and Assessment

Journal

- What about your analysis surprised you the most? Reflect on how you may have done things differently. (1.1.3)

- How has your understanding of the topic changed/developed since the start of your inquiry? (1.1.3)

- Do you think that someone else would have interpreted your investigation data differently? Would they have drawn different results and conclusions? Explain. (1.1.3)

Paper and Pencil

- Identify all possible sources of error and uncertainty in your measurements and explain how they may affect your results. (1.1.3)

- Are the conclusions of your inquiry question drawn from comparisons, interpretations, inferences, or deductions between your research and investigation results? Explain. (1.1.3)

Observation

- In small groups, discuss with your classmates how well your investigation answered your inquiry question. What steps in the sampling procedure or data analysis could have garnered better results? (1.1.3)

Performance

- Identify patterns, concepts, meanings, or structures in your data. Does this evidence help answer your inquiry question? If so, explain how the data support or refute your inquiry question? If not, review and revise your inquiry plan as needed. (1.1.3)

Resources and Links

Appendix A: Student Guide to the Inquiry Process

PBL Starter Kit, Buck Institute for Education

Communication and Teamwork

Outcomes

Students will be expected to

1.1.4 communicate information, ideas, and results

Elaborations - Suggestions for Learning and Teaching

Creating New Knowledge

New knowledge comes from building upon prior knowledge with new information that has been uncovered during the inquiry process. Once students have researched and recorded sources of information and data, they embark upon the creation stage of the process. They must be able to analyse and interpret the information they have found and present it in a format that is coherent for others. At this stage, students will sort ideas and results, possibly using graphic organizers to aid in the process, and construct new meaning that they will transfer to a representative format. Students should be encouraged to discuss how the potential applications of their findings may have further environmental, economic, and/or social implications.

Moving from Data Collection and Analysis to End-Product

Organizing information and data can be an onerous task unless there is some sort of system for organizing or classifying data. Graphic organizers can be helpful in this task and there are a multitude of these available to suit every purpose. Following an outline created in the planning stage will also help students to organize and interpret their findings into a final product. While students will follow a similar path during the inquiry process, their end-products may differ greatly depending upon the parameters and options set by the teacher, the nature of the inquiry, time constraints, available technology, and student creativity.

Some options may include:

- formal lab report
- traditional research paper
- visual display with oral explanation
- newscast simulation
- multimedia presentation
- mini-documentary
- prototype

Some achievement indicators should include:

- select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate ideas, plans, and results
- identify multiple perspectives that influence a science-related decision or issue
- review and revise the plan for inquiry

Communication and Teamwork

Suggestions for Learning and Assessment

Paper and Pencil

- What are the environmental, economic and societal implications of your investigation? Propose solutions and recommend new avenues of experimentation based on your findings. (1.1.4)

Performance

- Determine the best way to communicate your information to an audience (e.g., digital slideshow, formal lab report, prototype, video, Web page). Use a graphic organizer to sort and organize the data from your investigation into a final product that you will present to the class. (1.1.4)

Resources and Links

Appendix A: Student Guide to the Inquiry Process

PBL Starter Kit, Buck Institute for Education

Communication and Teamwork (continued...)

Outcomes

Students will be expected to

1.1.4 (continued) communicate information, ideas, and results

Elaborations - Suggestions for Learning and Teaching

Communicating New Understandings

For many students, the "presentation" aspect of an inquiry project can be very challenging. Presenting in front of the public and one's peers requires skill and confidence which may come easily to some but not to all. It is important to create a safe, non-threatening atmosphere in the classroom for all students. Teachers may initiate some class discussion around appropriate audience behaviours or create an audience task such as peer assessment strategies to ensure a positive environment for all. Some review discussion of the language arts speaking and listening strategies may be helpful regarding effective delivery such as maintaining eye contact and stance in relation to the audience.

Time must also be built into the overall project schedule to allow for the sharing sessions. Generally, presentations do not have to be lengthy to be effective - fifteen to twenty minutes may be ample time for a student to present his or her new understandings and will keep the audience from losing focus. Incorporating just a few presentations per class into other work will also help students to stay focussed. If possible, relevant community experts and mentors should be invited to attend the presentations. The audience should interact with the students during a question-and-answer session and ask them to explain choices, describe processes, make connections and predictions, and recognize implications.

The final phase of the inquiry model should include an evaluation of the process and a student self-assessment. Learning through inquiry is not a linear process and should evoke new understandings and new questions for further inquiry. This stage is intended to have students thinking about what they have learned and, just as importantly, how they learned (metacognition). It is an opportunity for students to take pride in the work that they have accomplished and to ponder the way in which they progressed from an inquiry question or a problem statement to a polished final product and new knowledge.

Some achievement indicators should include:

- communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others
- develop, present, and defend a position or course of action, based on findings
- demonstrate appropriate audience behaviour
- evaluate the inquiry process and inquiry plan

Communication and Teamwork (continued...)

Suggestions for Learning and Assessment

Journal

- Reflect on the successes and challenges of your PBL experience and write about what you have learned. (1.1.4)

Paper and Pencil

- Use an end-of-project self assessment form to summarize what you learned about your environmental issue, conducting an experiment, following an inquiry process, presenting to an audience, and how you like to learn. (1.1.4)

Observation

- In small groups, reflect on the successes and challenges of your PBL experience and talk about what you have learned, what more you would like to learn, and how you might proceed differently next time. (1.1.4)

Presentation

- Summarize your findings and present the most important ideas or conclusions that you have discovered during your inquiry process. Organize your data into an introduction, main body, and conclusion. Clearly present your inquiry question, the plan that you followed for your investigation, and the end product that you've created. (1.1.4)

Resources and Links

Appendix A: Student Guide to the Inquiry Process

PBL Starter Kit, Buck Institute for Education

Introduction to Environmental Science *(~8 Classes)*

Introduction

The opening unit of the Environmental Science 621A course provides an introduction to the concepts and terminology associated with the study of environmental science. While students may have an awareness of some environmental issues and a keen interest in examining current world problems, it is important for them to recognize the fundamental ideas and concepts that constitute an issue at various levels. The "Introduction to Environmental Science" unit requires students to examine the economic, social, and environmental aspects of issues at a local, Canadian, or global scale, and the key role that perspective plays in analysing complex problems. Students will also practise skills that may have been introduced in earlier grade levels such as differentiating between opinion and fact, detecting bias, and validating sources of information. These are necessary skills to practise in any critical analysis of environmental issues. Students should be encouraged to start thinking about areas of interest to them that might form the basis of their PBL inquiry.

Focus and Context

This introductory unit emphasizes scientific inquiry as students will begin to ask questions about environmental science issues, sustainability, and world views. They will also begin to explore problem solving and decision making through the use of critical thinking skills and considering different perspectives.

Science Curriculum Links

The issue of sustainability builds upon information that students have studied earlier in the science curriculum. A unit on sustainability of ecosystems in Science 421A presents the Earth as a closed system, which means sustainable use of resources becomes a major concern. Previous to this, elementary students learned how humans and other living things depend on their environment.

Specific Curriculum Outcomes

2.1 demonstrate an understanding of environmental science, its history, applications, and common misconceptions 2.2 explain the environmental, social, and economic factors of sustainable development	2.3 define stewardship in relation to sustainability 2.4 demonstrate an understanding of the many different interpretations of environmental science	2.5 define the precautionary principle 2.6 demonstrate critical thinking skills through research and analysis of environmental science issues.

Environmental Science

Outcomes

Students will be expected to

2.1 demonstrate an understanding of environmental science, its history, applications, and common misconceptions

Elaborations - Suggestions for Learning and Teaching

Students should understand that this environmental science course provides a knowledge base from which to make informed decisions concerning local, regional, national and global environment issues. Teachers should ensure that students recognize that environmental science draws from a variety of areas including: science, social studies, law, math, fine arts, and health. Students also need to recognize that scientific knowledge is only one component of environmental decision-making. Government policies, societal needs, societal wants, and other factors all play a part. In this context "government" refers to the policy-making, legislation, enforcement, and decision-making that occurs at all levels of government agencies.

Students should review the history of the Western environmental movement, and the links to an increased awareness and understanding of ecology in Canada and Prince Edward Island. Students should appreciate that environmental concern and awareness is not a new cause, but that improvement in environmental quality and conservation has been slow.

Teachers may lead a general class discussion where students can talk about some misconceptions about science and specifically what science can do for us (e.g., science can solve all problems, scientific knowledge is fact, science is done for noble causes, there is one scientific method, science is not influenced by society). The teacher could list the common misconceptions on the board as they are raised. The teacher can refer back to these misconceptions later in the course as students grapple with environmental decision making.

Teachers should also ensure that students recognize the role and significance that the tools and methods of environmental science play in assessments, monitoring, decision making, and policy development. Some of these applications of environmental science include environmental impact assessments (EIA), environmental monitoring, risk assessment, decision making and policy making, and occupations. Teachers could provide students with environmental impact assessment data from previous PEI projects (available on the PEI Department of Environment, Energy and Forestry website) and have them make a decision around a particular issue and then formulate/develop policy.

Environmental Science

Tasks for Instruction and/or Assessment

Journal

- What does environmental science mean to you? (2.1)

Paper and Pencil

- What are the major phases in the history of land and wildlife conservation, and environmental protection in Canada and the United States? (2.1)

- Provide an example of a misconception for a specific environmental issue. (2.1)

- Describe environmental science and the influence that different disciplines have on it. (2.1)

Presentation

- Have students engage in a role play activity in which they are assigned various roles in which they contribute to an environmental impact assessment and as a group are required to consider all aspects of the issue. (2.1)

- Environmental Myth Busters: In a small group, research a myth to find evidence (e.g. graphics, text, videos) to disprove or prove the myth. Present your evidence either orally or as a poster collage. (2.1)

Performance

- Construct a graphic organizer showing the multi-disciplinary nature of environmental science. Include the various government departments that are involved in environmentally-related issues. (2.1)

Resources/Notes

Living in the Environment, Chapter 1
Living in the Environment, Chapter 2

Internet: EIA Samples
http://www.gov.pe.ca/photos/original/CDCoilseed.pdf

http://www.gov.pe.ca/photos/original/eef_eia_EPWF_jl.pdf

http://www.gov.pe.ca/envengfor/index.php3?number=1011005&lang=E

Sustainable Development

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
2.2 explain the environmental, social, and economic factors of sustainable development	Sustainable development has been defined as development that meets current needs without compromising the ability of future generations to meet their own needs. Students should understand that the definition of sustainable development can have very different meaning depending on the viewpoint (environmental, economic, social) that is taken. Specific ecological concepts (e.g., biotic and abiotic factors, carrying capacity, water availability) pertaining to the environmental factors of sustainable development will be discussed in further detail in later sections of the course. At this point, the teacher should identify that environmental factors are an important consideration in sustainable development, but not the only one. Teachers should guide discussions of social factors to include treatment of our culture, values, attitudes, and beliefs. Teachers should identify economic impacts of decisions related to sustainability. For example, establishing soil conservation practices may involve setting stricter guidelines for some farming practices. This would have potential economic impact on the agriculture industry and the PEI economy. Teachers could also raise the fact that political factors are involved and will effect the social and economic factors. Teachers could use an example (e.g., fishery, forestry, energy sector) to discuss and examine the three factors that influence sustainability.
2.3 define stewardship in relation to sustainability	Teachers should ensure that students recognize that stewardship is defined in terms of shared responsibility that aims to achieve sustainability. It includes activities that preserve the environment at three levels: self, local, and global. For example, recycling (self level), wetland protection and solid waste management (local level), and Kyoto accord (global level). Students could reflect on the three levels of sustainability and how they might contribute at each. They could record their thoughts in their journal and include in their portfolio. Figure 28-5 on page 655 of *Living in the Environment* outlines guidelines and strategies for achieving more sustainable development. Many of these topics will be discussed throughout the course. Students should identify how stewardship and eco-citizenship often conflicts with past/present human practices and economic realities. Students could be asked to pick the single guideline and the single strategy that they think is the most important. Their choices could act as a guide for the PBL component of the course. Students should also reflect on whether their choices change as they gain a deeper understanding of environmental science throughout the course.

Sustainable Development

Tasks for Instruction and/or Assessment

Journal

- What does sustainable development mean to you and do you consider it to be important? (2.2)

- Do you think that any of the three factors that affect sustainable development (environment, society, economy) is more important than the others? If so, which one and why? (2.2)

Paper and Pencil

- List several ecological, social, and economic factors that influence sustainability. Select one factor from each category and use a local or regional example to demonstrate an understanding of each factor. (2.2)

- Pick the single guideline and the single strategy on page 655 of *Living in the Environment* that you think are the most important for achieving more sustainable development. Explain your choices. (2.2, 2.3)

- What do you think is meant by environmental stewardship? Give an example of how you could practise environmental stewardship locally and globally. (2.3)

Performance

- Explain, on the basis of research, social and economic issues related to a particular environmental challenge (e.g., overfishing, deforestation, Canada's tar sands projects, melting of the polar ice cap) and to efforts to address it. (2.2)

- Greenhouse gas emissions from motor vehicles are a major contributor to global warming. The use of ethanol and other biofuels in motor vehicles reduces these emissions. However, diverting crops from food production can increase prices and decrease the supply of food. Compare and contrast, on the basis of research, the environmental, social, and economic factors related to this issue. (2.2)

Presentation

- Design and present a media release to encourage environmental stewardship and a sustainable lifestyle. (2.3)

Resources/Notes

Living in the Environment, Chapter 1

Worldviews

Outcomes

Students will be expected to

2.4 demonstrate an understanding of the many different interpretations of environmental science

2.5 define the precautionary principle

Elaborations - Suggestions for Learning and Teaching

Some organisms or ecosystems are valued on aesthetic or intrinsic grounds. From an ethical, spiritual, or philosophical perspective the environment can have value regardless of its potential use to humans. However, it can be very difficult to quantify an intrinsic value against the more common economic value. Not surprisingly, much of the sustainability debate centres on the problem of how to weigh conflicting values in our treatment of natural capital (Earth's resources and ecological services) and the environment. Students should have an opportunity to discuss this issue. They should also appreciate that different cultural or world views will further complicate the aesthetic or intrinsic valuation of the environment.

Teachers should ensure that students are aware that there are different belief systems and that our view is not the only, or necessarily correct, view. Teachers should also ensure that students understand that belief systems impact how people manage/interact with their environment. Students should understand that people with widely differing environmental worldviews can take the same data and arrive at quite different conclusions because they start with different assumptions, beliefs, and values.

Three broad environmental worldviews (planetary management worldview, stewardship worldview, environmental wisdom worldview) are described on pages 17, 18, and 650 of *Living in the Environment*. These world views progress from anthropocentric (human-centred) instrumental value to biocentric (life-centred) intrinsic value. Students should discuss which worldview they support and outline the strengths and weaknesses of each one. They should also acknowledge how difficult it can be to bridge the gap between believing in something and actually evoking change. The values and beliefs that are embedded in our culture often influence our worldviews and affect how we live our daily lives.

One moral and political principle that can govern environmental policies and regulations is the precautionary principle. It states that when there is evidence that a human activity can harm our health or bring about changes in environmental conditions that can affect our economies or quality of life, we should take measures to prevent harm even if some of the cause-and-effect relationships have not been fully established scientifically. Students should discuss whether or not they agree with this "better safe than sorry" approach.

Worldviews

Tasks for Instruction and/or Assessment

Journal

- What is the precautionary principle? Do you agree with this point of view? (2.5)

- Which environmental worldview do you support? What are the strengths and weaknesses of different worldviews? (2.4)

Paper and Pencil

- How can we quantify values such as aesthetic or intrinsic values, which are inherently qualitative? (2.4)

- Summarize the main beliefs of each of the three major environmental worldviews. (2.4)

- Search current articles from newspapers and magazines for environmental issues. Summarize and give your opinion of the topic. Explore the difference in the perception of the issue as seen from different perspectives. (2.4)

Presentation

- Discuss environmental aspects that have intrinsic value (e.g., nature trails, protected areas, green spaces, horticulture therapy, heritage breeds) and present them to the class. (2.4)

Performance

- Students could investigate opportunities to develop relationships with schools in other countries to share attitudes and viewpoints of environmental issues with students of different cultures. Sharing could take the form of written letters, email, discussion forums, video conferences, etc. (2.4)

Resources/Notes

Living in the Environment, pp. 167-168

Living in the Environment, pp. 17, 18, 650

Living in the Environment, Chapter 28

Critical Thinking

Outcomes

Students will be expected to

2.6 demonstrate critical thinking skills through research and analysis of environmental science issues.

Elaborations - Suggestions for Learning and Teaching

Perhaps the most valuable skill any student can gain from the study of environmental science is the ability to think purposively, analytically, and clearly about evidence. In a rapidly moving field such as environmental science, facts and explanations change constantly. Developing the ability to learn new skills, examine new facts, evaluate new theories, and formulate their own interpretations is essential for students to keep up in a changing world.

Critical thinking is thinking that moves students (1) to more meaningful learning instead of rote learning; (2) to higher levels of learning (application, analysis, synthesis, and evaluation); (3) to apply concepts and principles to real-world experiences and situations; (4) to make judgments about knowledge and values claims; and (5) to enhance problem solving skills.

This outcome will encompass the entire course so it is important that teachers model and assess students' critical thinking skills as they progress from the start to the end of the course (students have been exposed to critical thinking skills during their grades 7-9 language arts courses). These skills will be of vital importance during the PBL component of the course where students will have to evaluate prior evidence and make claims on their own evidence. Some suggestions for students to follow when evaluating evidence and claims are:

- Determine the precise question that you are trying to answer.
- Gather all the information you can.
- Be sure that you understand the key terms, concepts, procedures, and equipment.
- Question how the information (data) was obtained.
- Questions the conclusions derived from the data.
- Try to determine the beliefs, assumptions, and biases of the investigators and then question them.
- Expect and tolerate uncertainty.
- Look at the big picture (think holistically). What additional data are needed to relate the results to the whole system?
- Based on these steps, take a position by either rejecting or conditionally accepting the claims.

In addition to using the textbook's critical thinking questions at the end of each chapter, students should be presented with case studies that they can research and analyse to further develop their critical thinking skills. Examples include India, Iran, and China's national policies on population growth, the Sydney Tar Ponds, and/or global warming. More case studies and essays are available online in the student resource section of *Living in the Environment* (http://www.livingintheenvironment.nelson.com/student/essays.html).

Teachers may wish to use this opportunity to combine developing students' critical thinking skills with developing their initiating and planning skills required for the PBL inquiry process.

Critical Thinking

Tasks for Instruction and/or Assessment

Journal

- Can you come up with an example in which critical thinking has helped you make a major change in one or more of your beliefs or helped you make an important personal decision? Can you reflect on a decision you have made that might have had a better outcome had you used critical thinking? (2.6)

Paper and Pencil

- A law of environmental science might be that for any expert there is always an equal and opposite expert. How can you decide what is true and meaningful amidst all this contradictory information? (2.6)

- What is critical thinking? Why is it important in environmental science? (2.6)

- Suppose you see a claim in a book, on television, or the Internet. How would you evaluate its reliability? (2.6)

Resources/Notes

Living in the Environment, pp. 3-4

Internet: *Living in the Environment,* Student Resources
http://www.livingintheenvironment.nelson.com/student/essays.html

Ecological Principles *(~12 Classes)*

Introduction

A study of environmental science issues should only begin once students have a firm understanding of the biotic and abiotic factors that can affect local and global ecosystems. Students should also appreciate how the biodiversity of an ecosystem is directly linked to its sustainability. Students must also begin to understand the role that humans play in ecosystems and the impact that they can have on living and nonliving things. This unit should allow students to explore activities that organizations can take to preserve and restore ecosystems and biodiversity. They should also discuss the social, economic, and ecological ramifications to any decisions that impact the environment.

Focus and Context

Activities in this unit provide an opportunity to focus on observation/inquiry. Students should be given the opportunity to examine and discuss real-world situations in which human activity has affected ecosystems or biodiversity, in order to make informed decisions on various courses of action. The context of the unit should depend on current local or regional issues involving impacts to living and nonliving things.

Science Curriculum Links

This unit, "Ecological Principles," connects with other clusters in the science curriculum primarily at the elementary and intermediate levels, and in Science 421A. The major focus in elementary grades is on habitat and community, including the identification of regional and local habitats and examination of how the removal of plant or animal populations would affect the remainder of the community. The life science portion of the curriculum in the intermediate grades concentrates on interactions within ecosystems; an introduction to biotic and abiotic factors; the flow of energy within an ecosystem through producers, consumers, and decomposers; and ecological succession. Science 421A builds on this background with its more in-depth look at the sustainability of ecosystems; a discussion of characteristics and responses of ecosystems; the cycling of matter through biotic and abiotic components; and an introduction to ways in which natural populations are kept in equilibrium in relation to the availability of resources. Students who elect to take Biology 521A will have also studied human ecology in a unit on interactions among living things. By the time students arrive in Environmental Science 621A, they have a broad background with which to pursue their study of ecological principles.

Specific Curriculum Outcomes

3.1 demonstrate an understanding of the concept, characteristics, and scale of systems

3.2 explain the relationship between abiotic factors and biotic factors of an ecosystem

3.3 define the components of the Earth's life support system:
- atmosphere
- hydrosphere
- lithosphere
- biosphere

3.4 explain how balance is maintained in ecosystems

3.5 illustrate the cycling of matter through biotic and abiotic components of an ecosystem

3.6 conduct an experiment to measure abiotic factors of an ecosystem

3.7 demonstrate an understanding that humans can have a great impact on systems of living and nonliving things

3.8 define the different types of biodiversity: genetic diversity, species diversity, ecological diversity, functional diversity, and structural diversity

3.9 explain how factors that lead to loss of diversity affect the sustainability of an ecosystem

3.10 analyse the role and activities of intergovernmental and non-governmental organizations in preserving and restoring ecosystems and biodiversity

Ecosystem Components

Outcomes

Students will be expected to

3.1 demonstrate an understanding of the concept, characteristics, and scale of systems

3.2 explain the relationship between abiotic factors and biotic factors of an ecosystem

3.3 define the components of the Earth's life support system:
- atmosphere
- hydrosphere
- lithosphere
- biosphere

3.4 explain how balance is maintained in ecosystems

Elaborations - Suggestions for Learning and Teaching

Teachers could begin this topic by having students brainstorm the concept and characteristics of a system. The emphasis should be on ecosystems but some mention should be made of economic, social and value systems. Students should investigate small-scale local ecosystems and large global ecosystems to identify and understand the levels of organization and the interaction among living and non-living things at these levels. Students should understand that all of the Earth's ecosystems together make up the biosphere, but that the biosphere is only one of several interconnected layers of the Earth.

The major biological components of ecosystems (producers and consumers) and the factors that determine where an organism can live, and how quickly their populations can grow should be reviewed at this time. Students should identify and explain trophic levels in food chains and food webs. Food chains and food webs help us understand how eaters, the eaten, and the decomposed are interconnected in an ecosystem. Again, the focus should begin at the local level and then expand to different environments. Examples of freshwater, marine, and terrestrial ecosystems should be provided.

Energy flow in a food web or food chain decreases for each succeeding organism in a web or chain. Pyramids of numbers and pyramids of energy should be used to visualize the loss of usable energy through a food chain or food web. Students should discuss how the pyramid structure affects the functioning of an ecosystem

Teachers could clarify the nature of equilibria in that ecosystems naturally establish a balance (one example would be carrying capacity). When humans interact with the ecosystem (e.g., build towns, cut down trees, etc.) they usually shift the natural balance. Sustainable practices are human attempts to minimize their impacts and to help ensure the ecosystem will continue to exist and thus continue to provide the things humans want.

Note: Students should recognize the concepts listed above as they have been covered in part in grade 7 science and in SCI421A. Teachers should assess students' understanding of these topics and, if necessary, provide a brief review.

Ecosystem Components

Tasks for Instruction and/or Assessment

Paper and Pencil

- Explain how changes to abiotic factors of an ecosystem can affect the biotic factors of an ecosystem. (3.2)

- Explain how interactions between living and nonliving things in a small ecosystem can affect ecosystems at a much larger scale. (3.1, 3.2, 3.3, 3.4)

- Define the components of the Earth's life support system. (3.3)

Presentation

- Collect graphics that describe the components of the Earth's life support system. Present your findings in a visual collage, poster, or multimedia presentation. (3.1, 3.3)

Performance

- Locate a graphic of an ecosystem and describe the five most important biotic and abiotic factors. Provide a reason to support each choice. (3.2, 3.4)

Resources/Notes

Living in the Environment, Chapter 4

Ecosystem Components (continued...)

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
3.5 illustrate the cycling of matter through biotic and abiotic components of an ecosystem	Nutrient cycles (biogeochemical cycles) are global recycling systems that interconnect all organisms. Processes involving the transfer and transformation of water, carbon, nitrogen, phosphorus, and sulfur as they cycle within an ecosystem should be described. Students should construct and describe flow diagrams of these cycles.
3.6 conduct an experiment to measure abiotic factors of an ecosystem	Students should know methods for measuring significant abiotic factors (e.g., salinity, pH, temperature, dissolved oxygen, turbidity, light intensity, wind speed, weather, drainage) and how these may vary in a given ecosystem over time. Students should conduct an experiment that measures one or more of these abiotic factors. They may choose to measure an abiotic factor that will be a variable in the PBL component of the course or teachers may select a common experiment that the whole class will conduct.
3.7 demonstrate an understanding that humans can have a great impact on systems of living and nonliving things	As an example, teachers may use this opportunity to discuss the effects of eutrophication on water systems and nitrates in groundwater. The increase of nitrates and phosphates can lead to rapid growth of algae, increased turbidity, death of aerobic organisms, accumulation of dead organic matter, and unhealthy drinking water. Cultural eutrophication is the topic of the sample inquiry question used in the Student Guide to the Inquiry Process. Teachers should use this opportunity to begin to model the four stages of inquiry that students will be using in their PBL process. Teachers should ensure that students realize that human impact does not always mean negative impact. Some human impacts have positive effects on ecosystems. However, teachers should briefly discuss the fact that even though humans are only one part of the system of living things, they often have the greatest impact on other living things.

Ecosystem Components (continued...)

Tasks for Instruction and/or Assessment

Journal

- Reflect on some of the impacts that your activities have on the environment on a day-to-day basis. Which ones are positive and which ones are negative to living and nonliving things? (3.7)

- What are your thoughts on this quote by Lawrence Slobodkin "No part of the world is what it was before there were humans." (3.7)

Presentation

- Working in groups, construct and describe a diagram that illustrates the cycling of one nutrient (water, carbon, nitrogen, phosphorus, or sulphur) through biotic and abiotic components of an ecosystem. Present your matter cycle to the rest of the class. Interpret and respond to the matter cycles presented by other groups. Use their presentations, and your own, to construct flow diagrams of each nutrient cycle. (3.5)

Performance

- Conduct an experiment to measure abiotic factors on an ecosystem. Ensure that you follow the four stages of inquiry (initiating and planning, performing and recording, analysing and interpreting, and communication and teamwork) while conducting your experiment. (3.6)

- Conduct a class debate on the topic "Human impact on the environment does not always mean negative impact". (3.7)

Resources/Notes

Living in the Environment, Chapter 4

Biodiversity

Outcomes

Students will be expected to

3.8 define the different types of biodiversity: genetic diversity, species diversity, ecological diversity, functional diversity, and structural diversity

3.9 explain how factors that lead to loss of diversity affect the sustainability of an ecosystem

3.10 analyse the role and activities of intergovernmental and non-governmental organizations in preserving and restoring ecosystems and biodiversity

Elaborations - Suggestions for Learning and Teaching

Biodiversity is the variation of life forms within a given ecosystem, biome, or for the entire Earth. Biodiversity provides the spectrum of organisms needed to keep us alive and support our economies. Students should understand the relationship between ecosystems and biodiversity. Habitats that are very diverse and complex lead to more stable environments with greater species and genetic diversity.

Students should describe and explain how environmental factors, isolation, succession, and natural selection can affect biodiversity. Students should also examine human activities that modify or simplify ecosystems. Examples may include logging, farming, grazing, unregulated hunting, pollution, urbanization, or introduction of non-native species.

Students should consider the United Nations Environment Programme (UNEP) and the Convention on Biological Diversity (CBD) as intergovernmental organizations and the World Wildlife Fund (WWF) and Greenpeace as non-governmental organizations. Analyse these organizations' use of the media, political influence, ability to promote action, and diplomatic constraints. Teachers should emphasize that Canada is an active member of both the CBD and UNEP.

Biodiversity

Tasks for Instruction and/or Assessment

Journal

- Do you think that Canada's involvement in intergovernmental organizations should hold our nation to a higher environmental standard? (3.10)

Paper and Pencil

- Define the different types of biodiversity. (3.8)

- (a) How would you set up a self-sustaining aquarium for tropical fish? (b) Suppose you have a balanced aquarium sealed with a glass top. Can life continue in the aquarium indefinitely as long as the sun shines regularly on it? (c) A friend cleans out your aquarium and removes all the soil and plants, leaving only the fish and water. What will happen? Explain. (3.9)

- Explain how farming practices on Prince Edward Island have affected the stability and diversity of local ecosystems. (3.9)

- From a biodiversity point of view, state the arguments for preserving species and habitats. (3.8, 3.9)

- Explain some of the risks and benefits of human intervention (e.g., tree plantations, monoculture of livestock or agricultural crops, overharvesting of wild plants for medicinal purposes, using pesticides to control pests, suppression of wild fires) to the biodiversity of aquatic or terrestrial ecosystems. (3.7, 3.8, 3.9)

- Analyse how intergovernmental and non-governmental organizations (e.g., UNEP, CBD, WWF, Greenpeace) use the media and political influence to promote action in preserving and restoring ecosystems and biodiversity. (3.10)

Presentation

- Present the case history of a local natural area whose biodiversity has been threatened by natural factors or human activities. (3.9)

Resources/Notes

Living in the Environment, Chapter 4

Internet: United Nations Environment Programme
http://www.unep.org/

Internet: Convention on Biological Diversity
http://www.cbd.int/

Internet: World Wildlife Fund
http://wwf.ca/

Internet: Greenpeace
http://www.greenpeace.org/canada/en/

Human Population and Carrying Capacity *(~10 Classes)*

Introduction

During a discussion of resource limits of an ecosystem, students will build on their knowledge of population growth and equilibrium. It is important that they understand that many issues affect global population growth and that these factors impact the Earth's carrying capacity. Students will examine how land use patterns on Prince Edward Island have changed and the causes for these changes. Finally, they will examine how human population growth, lifestyle, and land use may be causing a degradation of the Earth's natural capital.

Focus and Context

The focus of this unit is on inquiry and decision making. Students will discuss the STSE issues that have affected, and will continue to affect, population dynamics, land use, and human population demands on natural capital.

Science Curriculum Links

This unit connects with other clusters in the science curriculum primarily at the elementary and intermediate levels, and in Science 421A. Students began to understand the conditions essential to growth and reproduction in grade 7. The relationship between resource limits and natural population equilibrium was introduced in grade 10. Biology 521A has similar curriculum outcomes to this unit pertaining to carrying capacity, population growth and the factors that affect population dynamics.

Specific Curriculum Outcomes

4.1 evaluate how the resource limits of an ecosystem affect its natural population

4.2 identify the relationship between human population growth, demand for resources, and increased consumerism

4.3 identify individual impacts on the environment using the concept of ecological footprint

4.4 analyse resource and land use on Prince Edward Island over time

4.5 identify local land owners' responsibilities and rights regarding land use

4.6 explain how the term natural resources has evolved into the term natural capital

4.7 demonstrate an understanding of Earth's carrying capacity, considering human population growth and its demands on natural capital

Population Growth

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
4.1 evaluate how the resource limits of an ecosystem affect its natural population	Teachers should use the terms birth rate, death rate, immigration and emigration to derive the equation for population size. Specific local and global examples or case studies of exponential population growth could be used to describe and explain S and J population curves, biotic potential and environmental resistance. Students should be able to discuss the factors that affect the carrying capacity of a specific species or a large ecosystem. Examples specific to Prince Edward Island (e.g., coyotes, beaver, skunk, periwinkles) should be used. The factors that affect population growth in other species should now be transferred to human populations. Historical population trends in Prince Edward Island, Canada, and the United States should be examined to identify and discuss the large discrepancy between population growth on Prince Edward Island and the rest of North America. Population trends between urban and rural settings should also be discussed.
4.2 identify the relationship between human population growth, demand for resources, and increased consumerism	Teachers should point out that the resource demands of developed countries go well beyond our life-sustaining need for food, water, and space. Students should be encouraged to produce their own list of resource and energy demands on Earth. This will allow students to understand that our resource demands are driven at an individual and global level in order to meet our population growth and consumerism. Lifestyle trends in Asia (the most populated areas of the world) are shifting toward a more western lifestyle. With such a large population, this shift will have an enormous impact on the demand for resources and energy. A theme that should be continued throughout this course is for students to consider ways in which humans could reduce the impacts of their resource demands and consumption of energy.
4.3 identify individual impacts on the environment using the concept of ecological footprint	Students should understand that the area of land and water ecosystems required to produce resources that the population consumes, and to assimilate the wastes that the population produces is called the ecological foot print. As a model, it is able to provide a quantitative estimate of human carrying capacity. Students should be able to calculate their individual ecological footprint using the suggested web site. Using the results, students are able to predict their individual impact on the environment. This activity should be followed with students submitting a realistic plan to reduce their own foot print, which can be included in their portfolio.

Population Growth

Tasks for Instruction and/or Assessment

Journal

- Do you believe that people should be able to have as many children as they want? (4.1)

Paper and Pencil

- Define and briefly explain birthrate, death rate, immigration, emigration, biotic potential, environmental resistance, and carrying capacity. (4.1)

- What are some of the characteristics of growing developed countries that may have contributed to many of today's environmental problems and issues (e.g., selfishness, greediness, profit oriented)? (4.1, 4.2)

- What kinds of changes do you think industrialized and developing countries might make to improve the quality of life? (4.2)

- What is meant by the term ecological footprint? Predict what you think are your individual impacts on the environment. (4.3)

Performance

- Determine, using computer simulations, the characteristics of population growth of two different populations (e.g., the different population cycles of a predator and its prey; the population cycle of two populations that compete for food; the human population cycles of a developed nation and a developing nation). (4.1, 4.2)

Observation

- Calculate your ecological footprint using one of the tools available on the Internet. Print the results and discuss in small groups what steps can you take to lower your personal impact on the Earth? At the end of this course, measure your ecological footprint again. (4.3)

Resources/Notes

Living in the Environment, Chapter 9 - Population Ecology

Living in the Environment, Chapter 10 - Applying Population Ecology: The Human Population

Internet: Ecological Footprint
http://www.myfootprint.org/

Prince Edward Island Land Use

Outcomes

Students will be expected to

4.4 analyse resource and land use on Prince Edward Island over time

4.5 identify local land owners responsibilities and rights regarding land use

Elaborations - Suggestions for Learning and Teaching

Teachers should ask students to compare and contrast the different attitudes and actions between Aboriginals and European settlers with regards to carrying capacity and land use. This could be accomplished through an examination of natural ecosystems as compared to farmed lands. The Sieur de la Roque 1752 census and Samuel Holland 1765 survey map are useful documents to illustrate the population transition from Aboriginals to European settlers.

Students should investigate aerial photos of local areas and known landmarks from the 1900s to today. Exploring historic aerial photos can tell us about our environment and ourselves. Students should understand what roles economic and cultural factors have in Prince Edward Island land use. They should compare how these factors affected past decision making and what roles they may have in the future. Specific land use issues (e.g., land clearances, land abandonment, rural exodus, increased urbanization, land ownership laws) could be discussed at this time. Also, students should investigate how land use can lead to loss of species and introduction of new species in local ecosystems.

Teachers should ensure that students recognise that a paradigm shift has occurred from a view of limitless resources to a view of humans practising more responsible resource utilization.

Prince Edward Island land owners do not have unlimited rights to use their land in any way they see fit. Regulations and policies exist that limit the environmental, economic, and cultural development of land on Prince Edward Island. Although it is not the intent for students to memorize all regulations pertaining to land use, they should be able to identify some pertinent policies that relate to land owners rights and responsibilities. These may include zoning issues, issues pertaining to water and soil quality, pesticide use, managing landscape and biodiversity, and commercial development. The 1997 report *Round Table on Resource Land Use and Stewardship* identifies many of these issues and how they relate to Prince Edward Island lands. Students could also investigate any local bylaws of their municipality that restrict or protect land owners and land use.

Prince Edward Island Land Use

Tasks for Instruction and/or Assessment

Journal

- Have you noticed any land use changes in your community in your lifetime? If so, how did it make you feel? (4.4)

- Do you feel that land owners should be able to do whatever they want with the land they own? (4.5)

Paper and Pencil

- How did aboriginal peoples attitudes and actions regarding land use differ from European settlers? How did these changes affect land use on Prince Edward Island? (4.4)

- Use historic aerial photos to track land use changes of a local area. What prompted these changes to occur? Were they due to social, economic, or environmental influences? How might these three influences affect future land use in this area, or to a greater extent, on Prince Edward Island? Is it possible to balance the social, economic, and environmental influences on land use? If so, develop a plan for the sustainable use of a piece of land. (4.4)

- Identify some of the responsibilities and rights that land owners have with respect to land use on Prince Edward Island (4.5)

Presentation

- Create a poster or electronic presentation of the historical time line and change of land use of a specific area. (4.4)

Performance

- Research aboriginal and European settler environmental attitudes with regards to land use. Take a position and debate with other students. (4.4)

Resources/Notes

Living in the Environment, pp. 591-596

Internet: Sieur de la Roque 1752 Census
http://www.islandregister.com/1752.html

Internet: Samuel Holland 1765 Survey Map
http://www.islandregister.com/holland/hollandmap.html

Internet: Report of the Round Table on Resource Land Use and Stewardship
http://www.gov.pe.ca/agriculture/

Prince Edward Island historic aerial photographs

Natural Capital

Outcomes

Students will be expected to

4.6 explain how the term natural resources has evolved into the term natural capital

4.7 demonstrate an understanding of Earth's carrying capacity, considering human population growth and its demands on natural capital

Elaborations - Suggestions for Learning and Teaching

All life depend on energy from the Sun (solar capital) and the Earth's resources and ecological services (natural capital) to survive. The term "capital" implies that if properly managed, renewable and replenishable resources are forms of wealth that can produce "natural income" indefinitely in the form of valuable goods and services. This income may consist of marketable commodities such as timber and potatoes (goods) or may be in the form of ecological services such as the flood and erosion protection provided by forests (services). Students must understand that natural capital is renewable but natural resources may not be.

Solar capital creates renewable energy such as solar power, wind power, hydropower, and biomass (e.g., wood, crops). Natural capital includes natural resources such as air, water, soil, wildlife, energy resources, etc., and ecological services (e.g., nutrient recycling, climate control, population control, biodiversity).

Natural capital refers to all aspects of our environment used to provide manufactured goods, to secure our quality of life, and to support a range of economic activities such as agriculture, forestry, tourism, and recreation. Natural capital has a broader meaning than natural resources in that its emphasis is on ecosystems and their services.

Students should understand that an environmentally sustainable society meets the basic resource needs of its people indefinitely without degrading or depleting the natural capacity that supplies these resources. Any society that degrades or depletes its natural capital is unsustainable. Humans must protect our natural capital and live off the income that it provides. Many people believe that human population growth and lifestyle are causing an accelerated depletion and degradation of the Earth's natural capital. Some people disagree on the seriousness of population, resource, and environmental problems. Students should investigate different views of this problem and form their own conclusions regarding our species' impact on natural capital.

It is important for students to appreciate that it is difficult to apply the concept of carrying capacity to human populations. The range of resources used by humans is usually much greater than for any other species. Furthermore, when one aspect of natural capital becomes limiting, humans show great ingenuity in substituting one resource for another or importing resources from outside their immediate environment. Natural capital requirements vary according to lifestyles, which differ from time to time and from population to population. Students must also consider that technological developments give rise to continual changes in the resources required and available for consumption.

Natural Capital

Tasks for Instruction and/or Assessment

Journal

- Do you think that humans can overcome natural capital problems through ingenuity and technological advances? If so, which ones and how? (4-6)

Paper and Pencil

- As a class exercise, compile a list of resources that are considered important today but were not recognized as resources 100 years ago (e.g., uranium, due to the development of nuclear technology). What are some things that have ceased to be significant resources during the last 50 years? What resources of the present will probably be of little value 50 years from now? (4-6)

- What is the difference between natural resources and natural capital? (4-6)

- Estimate the size of the human population in relationship to the Earth's carrying capacity. Is the world overpopulated? Is Prince Edward Island overpopulated? What do you feel are the costs and benefits of the population size of your community? (4-7)

Resources/Notes

Living in the Environment, pp. 6-8

Living in the Environment, Chapter 9 - Population Ecology

Living in the Environment, Chapter 10 - Applying Population Ecology: The Human Population

Natural Resources *(~20 Classes)*

Introduction

The purpose of this unit is to provide students with an overview of natural resource management as it applies to food resources, soil resources, water resources, ocean resources, forest resources, and energy resources. Due to the large breadth of this topic, the focus has been primarily kept at a local level, with factors and issues that are specific to Prince Edward Island. The intent is that once students have a better appreciation of the issues at a local level, they will be able to transfer their knowledge to the broader national and global levels. Some course content is flexible to allow teachers and students to take advantage of selecting local topics or areas of special interest or concern that relate to their geographic area, school, or community. These areas of special interest may generate topic ideas for students' PBL inquiry process. **Teachers are required to deliver the specific curriculum outcomes in the Energy Resources section and then complete three of the five remaining sections in the Natural Resources unit.**

Focus and Context

By considering questions that you and your students generate pertaining to natural resource management, various learning and assessment activities will meet specific curriculum outcomes. All three areas of scientific literacy: inquiry, problem solving, and decision making will be explored as students ask questions about natural resource use, investigate possible solutions, and then propose strategies to responsibly manage these resources.

Science Curriculum Links

The issue of natural resource management builds upon information that students have studied earlier in the science curriculum. A unit on sustainability of ecosystems in Science 421A presents the Earth as a closed system, which means sustainable use of natural resources becomes a major concern. A discussion of ways in which natural populations are kept in equilibrium in relation to the availability of natural resources occurs in Biology 521A. Students conduct research projects on alternative energy and fuels in Applied Science 701A and Chemistry 621A. Issues pertaining to natural resource management also arise in Oceanography 621A and Agriscience 801A.

Specific Curriculum Outcomes

Teachers are required to deliver the specific curriculum outcomes in the Energy Resources section and then complete three of the five remaining sections in the Natural Resources unit.

Food Resources

5.1 identify factors involved in responsibly developing Earth's resources

5.2 describe the processes used for the four major types of agriculture

5.3 demonstrate an understanding of strategies that affect the state of global food production

5.4 describe the present level of agriculture in Prince Edward Island
- levels of employment
- impact on the economy
- number of active farms
- primary products

5.5 distinguish between organic and traditional farming practices

Soil Resources

5.6 demonstrate an understanding of soil conservation, erosion, and degradation

5.7 describe the environmental impacts from agriculture
- water contamination
- pesticide and herbicide use
- erosion
- diversity loss

Water Resources

5.8 demonstrate an understanding of sustainable water use at local, national, and global levels

5.9 evaluate the significance of water resources for international relations

Ocean Resources

5.10 evaluate global fishery management from a sustainability viewpoint

5.11 describe the environmental impacts of various fishing techniques
- mobile bottom fishing gear
- bycatch
- ghost fishing

5.12 identify the importance of ocean resources to Prince Edward Island over time

Forest Resources

5.13 identify the major forest regions of Canada

5.14 identify the role forests have as natural capital, as well as their economic, ecological, and social value
- biodiversity
- animal habitat
- water cycle
- domestic and commercial harvesting
- employment
- recreation
- soil stabilizers
- reducing air pollution

5.15 examine the history of old growth forests, second-growth forests, and tree farms on Prince Edward Island

5.16 explain how to manage forests more sustainably
- role of forest certification
- harvesting
- deforestation
- natural capital degradation
- national parks and reserves

Energy Resources (Compulsory)

5.17 evaluate renewable and nonrenewable energy sources from a variety of perspectives

5.18 describe factors that might affect future energy use on Prince Edward Island

5.19 create a plan to improve energy efficiency in the home

Food Resources

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	Students should consider how cultural, economic, technological, and other factors influence the status of a resource over time.
5.1 identify factors involved in responsibly developing Earth's resources	Teachers could begin this topic by explaining that the practice of agriculture from the human perspective is a relatively new practice having arisen only about 10,000 years ago (as compared to the approximately 200,000 years that Homo sapiens have been on the Earth). Students should compare the energy sources, environmental impacts, yields, and sustainability of traditional and industrial agriculture. Students should also evaluate the successes and failures associated with the green revolution.
5.2 describe the processes used for the four major types of agriculture	
5.3 demonstrate an understanding of strategies that affect the state of global food production	Students should be familiarized with the terms malnutrition, undernutrition, and overnutrition. Teachers should indicate how many people on Earth suffer from these problems, where these problems are most likely to occur, and what strategies can affect food production. Students should be aware of global organizations' (e.g., UNICEF) efforts in dealing with malnutrition and undernutrition. Although these conditions are not as prevalent on Prince Edward Island, students should still be made aware of their effects at a local level (demands on Prince Edward Island food banks, etc.). Another suggested class activity would be for students to prepare a strategy to reduce overnutrition in Prince Edward Island school-aged children.
5.4 describe the present level of agriculture in Prince Edward Island - levels of employment - impact on the economy - number of active farms - primary products	Teachers are recommended to download information from the Prince Edward Island Department of Agriculture or the Prince Edward Island Agriculture Sector Council which maintain current data on the level of agriculture on Prince Edward Island. Students should discuss the impact of the agriculture industry on Prince Edward Island from economic, social, and environmental perspectives. They should also be aware of the challenges and successes that Prince Edward Island farmers have had regarding finding new markets and growing new crops to help meet the world's food needs.
5.5 distinguish between organic and traditional farming practices	Organic farming is a growing trend on Prince Edward Island and elsewhere in the world. Students should examine how the quality of food, quantity of food, and general farming practices are similar or different between organic farming and traditional farming. Teachers should discuss the term "certified organic" and what processes farmers must follow to gain this certification.

Food Resources

Tasks for Instruction and/or Assessment

Journal

- What do you think is the best way to manage food distribution for foreign aid? (5.3)

Pencil Paper

- What do we mean by green revolutions? What problems have accompanied the benefits of the green revolution? (5.2, 5.3)

- What are the three most important actions that you would take to reduce hunger (a) on Prince Edward Island and (b) in the world? (5.1, 5.3, 5.4)

- What are genetically modified foods and how might they help or hurt agriculture and the environment? (5.3)

- In what ways can consuming locally grown foods help the local economy, society, and the environment? (5.1, 5.4)

- What are the similarities and differences between organic and traditional farming practices? (5.5)

Performance

- Research the process that farmers must follow to create a Prince Edward Island Enhanced Environmental Farm Plan in order to evaluate the environmental risks and strengths of their operations. (5.1)

Interview

- Interview or invite a local farmer to your class to discuss local agricultural problems and opportunities. What major changes in agricultural practices are likely to occur in the coming decades? With what consequences? What types of farming activities are carried on in your locale? What is the balance between large and small farms? What are the major products? How much of the produce is used in local areas? How much is shipped out and where does it go? (5.4, 5.5)

Resources/Notes

Living in the Environment, pp. 284-290

Living in the Environment, pp. 297-315

Internet: Prince Edward Island Department of Agriculture
http://www.gov.pe.ca/agriculture/

Internet: Prince Edward Island Agriculture Sector Council
http://www.peiagsc.ca/

Internet: Prince Edward Island Enhanced Environmental Farm Plan
http://www.peiefp.ca/

Soil Resources

Outcomes

Students will be expected to

5.6 demonstrate an understanding of soil conservation, erosion, and degradation

5.7 describe the environmental impacts from agriculture
- water contamination
- pesticide and herbicide use
- erosion
- diversity loss

Elaborations - Suggestions for Learning and Teaching

Teachers could begin by asking students how soil can be managed. Students may not recognize that soil resources need to be managed just as forestry, fishery, and other resources require management. It is important that students recognize that although soil is a renewable resource, mismanagement or changes in the climate can greatly affect its use. Students should be able to explain different ecologically sound practices for improving and maintaining soil structure and fertility. Examples of practices for improving soil structure and fertility include: crop rotation, fallowing, adding compost or manure, terracing, contour planting, strip cropping, windbreaks, buffer zones, riparian zones. Students should identify and describe local examples of soil management practices.

The causes of soil erosion and soil degradation (e.g., road construction, poor forestry practices, urban development) and their connection with desertification should be investigated at a local and global level.

Teachers should use this opportunity to conduct a laboratory experiment to measure the effects of agriculture practices on soil and water quality (note: a water quality analysis will be a compulsory outcome in Unit 6 - Environmental Challenges and Successes). An analysis of soil or water samples from a local farm could be compared to samples from a non-cultivated area to highlight different concentrations or characteristics (e.g., nitrates, pH, salinity). **Please note that all experiments should be conducted in accordance to the precautions outlined in the *Science Safety Resource Manual* to protect students from bacteria or fungi that may be present in soil or water samples.**

The recycling of animal waste as fertilizer is economical and is generally considered an environmentally sustainable practice. However, care must be taken that the manure does not run off into water sources, as it can contaminate them with *E. coli* and other bacteria. Teachers could have students investigate the tragedy at Walkerton, Ontario or other case studies of potential environmental impacts from agriculture. This topic may also be the basis for an inquiry question for one or more students in their PBL activity.

Soil Resources

Tasks for Instruction and/or Assessment

Journal

- How do you think monoculture farming practices (e.g., planting only potatoes) affects soil quality and biodiversity of local ecosystems? (5.7)

Pencil Paper

- What steps can be taken to prevent agriculture practices from having a negative impact on the environment? (5.7)

- What causes erosion? Why is it a problem? (5.6)

- What are the most common soil problems in your area? (5.6, 5.7)

- Using aerial photographs, identify areas that demonstrate soil management practices, or identify an area at risk and develop your own soil management plan. (5.6)

Presentation

- Conduct research on the various ways that Prince Edward Island farmers have tried to by-pass the limitations of our soil and climate by attempting to grow crops that are not normally grown here. Share your results with the class. (5.6)

- Research and present environmentally sustainable methods of managing and maintaining healthy and productive agriculture zones. (5.6)

- As a class exercise, discuss the economic, political, social, and environmental consequences that might ensue if the fertile soils of Prince Edward Island were ruined by human-accelerated soil erosion. (5.6, 5.7)

Performance

- Use an inquiry process to design and conduct a landscaping project for your local area (e.g., a rooftop garden, a plot in a community garden, a riparian restoration), taking into account local conditions (e.g., soil composition, amount of sunlight and rainfall), and propose a course of action to ensure sustainability of the project and its healthy interaction with the surrounding environment (e.g., the use of compost to fertilize the soil, the use of native plants, the inclusion of plants that attract birds or butterflies). (5.6)

- Perform a soil analysis of a sample obtained from a certified organic farm and of a sample obtained from a farm that may use fertilizers, pesticides, fungicides, and/or herbicides. Share your results with the class. (5.5, 5.7)
- Conduct an experiment to test for nitrates in groundwater. (5.7)

- Have a class discussion contrasting excellent soil management practices with poor ones. (5.6)

Resources/Notes

Living in the Environment, pp. 291-297

Science Safety Resource Manual

Water Resources

Outcomes

Students will be expected to

5.8 demonstrate an understanding of sustainable water use at local, national, and global levels

5.9 evaluate the significance of water resources for international relations

Elaborations - Suggestions for Learning and Teaching

Students have already been exposed to the water cycle in grade 8 science and Science 421A. Teachers could use a graphic to quickly review the water cycle. It is important for students to realize that water is a finite resource and recognize that all the water that currently exists on Earth is all the water that has ever been here. Although our planet is covered by approximately 70% water, less than 1% is readily accessible fresh water. Teachers could use the water cycle again to demonstrate how fresh water moves, where it is accessible for human use, and define watersheds and groundwater. Teachers could use topographical maps of the local area to show the watershed for their community. They could also contact their local watershed group for additional information about their community.

Although it will be obvious to students that there is a difference between accessing surface water and ground water, they may be surprised to discover which is the largest source of fresh water. Teachers could use a sponge analogy to describe the ground's ability to hold much more water than what lies on the surface.

Students should be made aware of primary uses of water around the world (mainly agriculture and energy) and the primary uses in Canadian households (mainly flushing toilets and taking showers). Canada has an abundance of water resources but our per capita consumption is very high. Also, students should be aware that humans are withdrawing water from underground aquifers and degrading it with wastes at a greater rate than it can be replenished. This is of significant importance on Prince Edward Island as all of our drinking water comes from groundwater resources. The issue of nitrates in Prince Edward Island groundwater could be examined as a class laboratory activity or as a student inquiry (PBL).

Students should create a plan for more sustainable water use. The plan should consist of a water budget for domestic water use and a plan for more global/holistic strategies for improved water sustainability.

Students should evaluate the significance of water resources for international relations. The case study on page 317 of the text could lead to student assessment on how water scarcity can lead to conflicts between nations. Students should be challenged to discuss how the natural capital that exists in Canada's water resources will be affected as the world's demand for fresh water continues to increase.

Teachers should note that many other topics relating to water resources (e.g., methods to increase water supply, irrigation techniques, flooding issues) could be investigated by students as part of their PBL inquiry.

Water Resources

Tasks for Instruction and/or Assessment

Journal

- Which in your opinion, will be a more valuable resource in Canada in the year 2100, oil or fresh water? Explain. (5.9)

Pencil Paper

- Identify areas of your daily consumption in which you are wasting water and suggest ways to conserve water. (5.8)

- Congratulations! You are in charge of managing the world's water resources. What are the three most important things that you would do? (5.8, 5.9)

- What are some of the social and economic challenges associated with cleaning up and conserving fresh water supplies? (5.1, 5.9)

- What are some strategies that the world could follow to use water more sustainably? What are the advantages and disadvantages associated with these strategies? (5.8)

- Is it better to drink bottled water instead or tap water? What regulations are there that monitor what goes into bottled water? (5.8)

Presentation

- Conduct a class debate on the topic "Should Canada sell water to the United States?" Use the information in the Spotlight on page 331 of your text as a starting point for your arguments. (5.9)

Portfolio

- Collect and display local articles relating to development or farming activities and how they impact watershed areas or groundwater. (5.8)

Interview

- Interview a representative from a local environmental or watershed group to discuss how various activities and developments can affect the local watershed. (5.8)

Resources/Notes

Living in the Environment, Chapter 15 - Water Resources

Project WET: A Drop in the Bucket

Ocean Resources

Outcomes

Students will be expected to

5.10 evaluate global fishery management from a sustainability viewpoint

5.11 describe the environmental impacts of various fishing techniques
- mobile bottom fishing gear
- bycatch
- ghost fishing

5.12 identify the importance of ocean resources to Prince Edward Island over time

Elaborations - Suggestions for Learning and Teaching

There are many pressures facing the global fishery. Like most resources, it is due to demand from rising global population. This is followed by pressures due to climate change, pollution, and habitat loss. Teachers could begin this topic by providing students with an overview of the present status of the global fishery. Teachers could have students consult the United Nations Food and Agriculture Organization (FAO) for the most recent data on the global fishery. This data will provide many useful graphs that communicate the levels of exploitation and dependence.

Overfishing is a serious threat to biodiversity in coastal waters and to some marine species in open ocean waters. Studies indicate that about three quarters of the world's 200 commercially valuable marine fish species are either overfished or fished near their sustainable limits. Students could research the lessons to be learned from the decline of a specific fish resource due to overharvesting (e.g., the whaling industry, the collapse of the Atlantic cod, New Zealand's orange roughy). Students should also be exposed to Prince Edward Island's aquaculture industry and the advantages and disadvantages of this type of food production.

Teachers could ask students what they see as the main elements of responsible recreational fishing. Students should come up with ideas on following catch limits, taking care of the environment, and proper fishing techniques. From here teachers could take the discussion to the commercial fishery with focus on fishing gear, fishing practices, and training.

Students should discuss and describe environmental impacts of various fishing techniques. Teachers can access videos of bottom trawling through the internet from such sources as www.youtube.com and use this as a starting point to explore the topic. Students should discuss the effects of bycatch (unwanted marine creatures that are caught in the nets while fishing for another species) on local populations. When addressing the topics of ghost fishing (fishing nets that have been left or lost in the ocean and continue to kill fish), teachers could address how biodegradeable nets can reduce the impact. Many excellent video clips relating to ghost nets are available on the web through such sources as www.youtube.com.

Students could consider the importance that available ocean food resources played on Prince Edward Island settlement by Mi'kmaq and European settlers. Today, the ocean is still a very important contributor to the economy of our province. Since much of our history of settlement has been directed by proximity to ocean resources, our social and cultural identity is strongly linked to it as well.

Sustainable management strategies for Prince Edward Island's fishery resources may be a topic of interest for students' PBL inquiry.

Ocean Resources

Tasks for Instruction and/or Assessment

Journal

- Do you feel that the economic importance of Prince Edward Island's fisheries should outweigh the ecological impacts that it may be having on ocean resources? Explain. (5.10, 5.12)

Pencil Paper

- What are some of the major issues facing the world's ocean resources? (5.10)

- Study the proposed solutions to managing fisheries on page 276 of your textbook. Explain how some of these solutions could be applied to a specific Prince Edward Island fishery (e.g., lobster, herring, mussels, bluefin tuna). (5.10)

- How are managing ocean resources important to Prince Edward Island's environment, economy, and society? (5.10, 5.12)

- What are some of the main environmental impacts of commercial fishing techniques? Suggest some strategies to minimize these effects. (5.11)

- Do the advantages of aquaculture outweigh its disadvantages? Explain your answer. (5.10)

Presentation

- Research a fish population that has been threatened by overharvesting (e.g., Atlantic cod, orange roughy, bluefin tuna, red snapper). Present to the class the conditions that led to its threatened state and what actions were taken to protect its remaining population. (5.10)

Interview

- Interview a local fisher and discuss how fishing practices have changed throughout his or her career. Do they feel that current practices are sustainable? If not, what needs to change? (5.12)

Resources/Notes

Living in the Environment, Chapter 13 - Sustaining Aquatic Biodiversity

Living in the Environment, Section 14-8

Internet: CBC One Ocean
http://oneocean.cbc.ca/

Internet: United Nations Food and Agriculture Organization
http://www.fao.org/

Internet: Prince Edward Island Department of Fishery and Aquaculture
http://www.gov.pe.ca/fa/

Forest Resources

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	Teachers could use a map of Canada or a projected image to visually represent the location of the major forest regions of Canada. Students should note that Prince Edward Island is primarily Acadian forest. However, forests are evolving ecosystems that change naturally over time. The forest that we see today on Prince Edward Island is very different than the forest that began after the ice age. Teachers should emphasise that physical and geographical features determine the characteristics of an ecosystem (i.e. latitude, temperature, rainfall, etc.). It is important to remember that the Acadian forest ecosystem has many plants and animals with specific adaptations to these characteristics. Teachers could point out that the plants and animals adapted to living in the Acadian forest would not necessarily be able to survive in a different forest area (and vice versa). Students should understand how human activities and global changes (e.g. increased temperature, non-native insects) could threaten the existence of the Acadian forest.
5.13 identify the major forest regions of Canada	
5.14 identify the role forests have as natural capital, as well as their economic, ecological, and social value - biodiversity - animal habitat - water cycle - domestic and commercial harvesting - employment - recreation - soil stabilizers - reducing air pollution	Teachers could have students brainstorm the various roles that forest ecosystems play in the support of life on earth and the value of the Acadian forest on Prince Edward Island. The teacher could write each of the student's suggestions on the board in random order. Teachers could also highlight the varying uses of the forests in our province. Students could then be asked to take the list the class has generated and to classify them under one of the three headings (economic, ecological, and social).
5.15 examine the history of old growth forests, second-growth forests, and tree farms on Prince Edward Island	Using a current map of Prince Edward Island, students could be asked to identify areas which they feel might be classified as "old growth forest" - forest that has not been disturbed by natural disasters or human activities. They will quickly realize that there is little, if any, true old growth forest left on Prince Edward Island. Current maps could then be compared to historic maps or aerial photographs to identify the changes in Prince Edward Island's old growth forests, second growth forests, and tree farms. Students should discuss causes for these changes and their effects on ecosystem biodiversity. They should recognize that a paradigm shift has occurred in forest management from exploitation to sustainable development.
5.16 explain how to manage forests more sustainably - role of forest certification - harvesting - deforestation - natural capital degradation - national parks and reserves	Proper forest management must consider supporting multiple forest usage, maintaining biological diversity, long-term production of timber, and appropriate cutting. Students should understand how different harvesting methods and the harmful effects of deforestation can affect the forest ecosystem. As is often the case, the economic value of ecological services is seldom included in the decision making process concerning the world's forests. Students should investigate forest management examples outside of Canada (e.g. tropical deforestation, Kenya's Green Belt Movement, Costa Rica's forest protection) to better understand global forest sustainability issues. A class activity, or student PBL activity, could be to create a sustainable forest management plan for a local woodlot.

Forest Resources

Tasks for Instruction and/or Assessment

Pencil Paper

- Identify on a map of Canada the major forest regions. (5.13)

- What factors have caused a reduction of old growth forests and an increase in second growth forests and tree farms on Prince Edward Island? (5.15)

- 88% of Prince Edward Island forests are privately owned and only 12% are publicly owned. How do you think this might affect forest management practices on Prince Edward Island? (5.14, 5.16)

- How could we restore characteristics of old growth forests on Prince Edward Island? Focus on public land, private land, or both. Who should pay for this restoration? (5.15)

- Identify some possible solutions for sustainable forestry. How might these solutions change at provincial, national, and global levels? (5.16)

Presentation

- Conduct a role play activity to represent a situation in which members of a community are at odds over how a public forest resource may or may not be utilized. Students could be divided into groups to represent the various ecological/social/economic interests (e.g. logger, conservationist, hiker, hunter, etc.). Each group develops a plan or proposal that will be presented to their town council. One member in the group will present the plan. The students who do not present will represent the Council and will identify the strengths and weaknesses in each proposal. At the end, your class will vote on which of the proposals (or modified proposals) should be awarded the use of the forest resource. (5.14)

Interview

- Interview a member of the Prince Edward Island Model Forest Network Partnership to see how forest use has changed over the years and what factors affect its use and sustainability. (5.15, 5.16)

Portfolio

- Create a visual product (e.g. collage, poster, multimedia presentation) or a written product (e.g. an article for a newsletter, poem, song, short story) that describes how we use forests in Prince Edward Island. (5.14)

- Create a visual product (e.g. informational brochure, collage, poster, multimedia presentation) that outlines the main characteristics of the Acadian Forest. Indicate how these characteristics create an ecosystem that could be easily threatened by human activities. (5.13, 5.16)

Resources/Notes

Living in the Environment, Chapter 11 - Sustaining Terrestrial Biodiversity

Internet: Prince Edward Island Department of Environment, Energy and Forestry
http://www.gov.pe.ca/eef/

Internet: Landuse photographs and maps
http://www.gov.pe.ca/gis

Internet: Prince Edward Island Model Forest Network Partnership
http://www.novaforestalliance.com/default_pei.asp

Internet: MacPhail Woods Ecological Forestry Project
http://www.macphailwoods.org/

Energy Resources

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
5.17 evaluate the advantages and disadvantages of renewable and nonrenewable energy sources from a variety of perspectives	Students should be able to define renewable and nonrenewable energy resources. In the case of nonrewable energy resources, they should be able to briefly describe how they were formed (e.g., coal, oil, natural gas). Listing the advantages and disadvantages of renewable and nonrenewable energy resources should prompt student discussion on their use. Teachers should make students aware of other factors (e.g., availability, economic, cultural, environmental, technological, security) that may affect the choice of energy sources adopted by different societies. Students should be aware that Canada has made major investments (e.g., Hibernia, tar sands projects) in meeting the world's increasing demand for oil. A discussion or debate on the trade-offs of using conventional oil may be valuable to students. Renewable energy resources (e.g., geothermal, solar, wind, hydro, biomass) could be researched by students and presented to the class as a small project or as a larger PBL activity.
5.18 describe factors that might affect future energy use on Prince Edward Island	Teachers should highlight that most of the energy resources used on Prince Edward Island are imported from off-Island. Wind power is becoming more widely used on Prince Edward Island and some municipalities (e.g., Summerside) have invested in this technology to supplement their energy demands. Students should discuss if the advantages of investing in this type of renewable energy resource outweigh the disadvantages of the increased costs to taxpayers and limitations of this energy system.
5.19 create a plan to improve energy efficiency in the home	Students should study the energy use in their homes and use the findings to develop an energy efficiency improvement plan. They should calculate, if possible, the cost savings that their plan will create. Students should also reflect on what changes to their lifestyles will be needed to enforce their energy efficiency plan. Finally, students should think about what would be needed to expand their plan from a local one to a more national or global plan. They should discuss how a broader plan requires political, cultural, and economic considerations that do not necessarily occur at a local or home level.

Energy Resources

Tasks for Instruction and/or Assessment

Journal

- What kind of energy resource do you think Canada should be investing in further developing? (5.17)

- Do you feel that Prince Edward Island should be producing its own electrical power? (5.17, 5.18)

Pencil Paper

- Will oil shortages act to encourage the development of new technologies or merely increase the potential for political tension, war, and terrorism in the world? Explain. (5.17)

- What role will economics and politics play in our energy future (e.g., selling oil, natural gas, or wind power to the United States)? (5.17)

- Given the potential benefits and drawbacks of wind power, should Prince Edward Island greatly increase its dependence on this renewable type of energy? (5.17, 5.18)

- How do political, cultural, and economic factors influence energy policy at a national or global level? (5.17)

- What are some alternative energy sources? What social and economic challenges are associated with their development? (5.1, 5.17)

Presentation / Performance

- Calculate the amount of energy that is used by several major appliances in your home. How much do these appliances cost to operate every month? Identify the major areas where energy can be conserved and develop an energy efficiency plan that you can use in your own home. Present your findings to the class. (5.18, 5.19)

Resources/Notes

Living in the Environment, Chapter 17 - Nonrenewable Energy Resources

Living in the Environment, Chapter 18 - Energy Efficiency and Renewable Energy

Internet: Prince Edward Island Department of Environment, Energy and Forestry
http://www.gov.pe.ca/eef/

Internet: Maritime Electric
http://www.maritimeelectric.com/

Environmental Challenges and Successes *(~10 Classes)*

Introduction

All around us evidence is accumulating that humans are modifying our climate on both a local and global scale. The exact causes of climate change are complex but most scientists agree that recent changes have had noticeable impacts on environmental systems. Students must appreciate the impacts of climate change and global warming on the Earth and specific examples on Prince Edward Island.

This unit also describes the main sources and types of air and water pollution and solid domestic waste. Students will discuss prevention strategies and management strategies for dealing with pollution and municipal waste. They will consider questions such as "What decisions and courses of action do we face because of climate change and pollution?" and "What courses of action must we take to mitigate, adapt, and prevent future climate change?" All proposed courses of action will take into account social, economic, and environmental factors.

Focus and Context

The unit on environmental challenges and successes emphasizes scientific inquiry and problem solving on the causes, consequences, and preventative measures related to climate change and pollution. Students will have opportunities to conduct investigations and experiments on the variables that cause these phenomena. Many outcomes can be accomplished by using a decision making focus, thereby moving students to think globally at a more sophisticated level.

Science Curriculum Links

Seasonal changes, air and water in the environment, and weather are all discussed in the elementary grades. The major concepts associated with atmospheric conditions that produce weather, and how weather affects society is investigated in Science 421A. This unit deepens the understanding and consequences of climate change that began in earlier years.

Specific Curriculum Outcomes

6.1 describe the characteristics of the troposphere and stratosphere layers of the atmosphere

6.2 demonstrate an understanding of how Earth's climate has changed over time

6.3 demonstrate an understanding of the greenhouse gases found in the troposphere and stratosphere
- natural sources of greenhouse gases
- anthropogenic sources of greenhouse gases

6.4 distinguish between the greenhouse effect and global warming

6.5 identify that climate change can have a catastrophic effect on Earth.

6.6 identify the effects that climate change can have on Prince Edward Island
- sea level rise
- increased erosion
- economic effects
- social effects
- species movement/loss

6.7 compare different schools of thought about global warming and its future projections

6.8 demonstrate an understanding of challenges and successes made to address climate change
- individual
- industries
- provincial governments
- federal governments
- international agreements

6.9 summarize the main types, sources, and effects of air pollution

6.10 summarize the main types, sources, and effects of water pollution

6.11 explain strategies that reduce air and water pollution
- improved energy efficiency
- cleanup of groundwater
- cultural eutrophication prevention

6.12 conduct an experiment to determine water pollutants
- presence
- concentration

6.13 identify the types of solid domestic waste

6.14 evaluate pollution management strategies for solid domestic (municipal) waste on Prince Edward Island

6.15 propose a course of action on a social issue related to waste management, taking into account human, economic, and environmental needs

Climate Change

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
6.1 describe the characteristics of the troposphere and stratosphere layers of the atmosphere	Students should understand that the air we breath (made up mostly of nitrogen and oxygen) is found in the troposphere layer of the atmosphere. This thin layer of the atmosphere is also responsible for our short-term weather and long-term climate. The second layer of the atmosphere, the stratosphere, contains ozone that filters out most of the sun's harmful UV radiation.
6.2 demonstrate an understanding of how Earth's climate has changed over time	Scientific records of the troposphere's average temperature has shown that in the past the Earth has undergone long periods of global warming and global cooling. Teachers should ensure that students know that there may be a natural cyclic event on Earth causing global warming. Some sources include volcanic activity, ocean currents, solar variability, Earth's orbit and tilt, and plate tectonics. Students should describe scientific evidence that it is very likely that the troposphere is getting warmer (e.g., increases in surface temperature, melting glaciers and sea ice, sea level rise). The case study on page 475 of *Living in the Environment* may prompt a discussion on more recent local warming and its potential effects.
6.3 demonstrate an understanding of the greenhouse gases found in the troposphere and stratosphere - natural sources of greenhouse gases - anthropogenic sources of greenhouse gases 6.4 distinguish between the greenhouse effect and global warming	Students should be familiar with the term "greenhouse effect" from prior coursework. However, teachers may wish to review a visual of the greenhouse effect and identify the relative warming impacts that different greenhouse gasses have. It is important that students realize that the greenhouse effect is a normal and necessary condition for life on Earth. However, human activities are increasing the amount of greenhouse gases that would normally exist in the atmosphere. It is predicted that this increase in greenhouse gases may be leading to global warming.
6.5 identify that climate change can have a catastrophic effect on Earth.	Burning fossil fuels, deforestation, and increases in number of livestock are among the top three anthropogenic sources that emit large amounts of greenhouse gases into the troposphere at a faster rate than natural processes can remove them. Students should briefly investigate the impacts that global warming can have on biodiversity, forests, agriculture, water resources, weather extremes, and human health.

Climate Change

Tasks for Instruction and/or Assessment

Journal

- Do you believe that human activities significantly impact global warming? (6.3, 6.4)

- Which personal lifestyle changes are you willing to make to reduce greenhouse gas emissions? Explain. (6.3)

Pencil Paper

- What is the difference between the greenhouse effect and global warming? (6.4)

- Describe the characteristics of the troposphere and stratosphere layers of the atmosphere. (6.1)

- Try to develop projections of what would happen to local flora and fauna if the temperature of the Earth dropped 10°C, 5°C, or was raised by the same amounts. (6.5)

- Research an area that climate change has had, or is forecast to have, a catastrophic effect (e.g., Tuvalu, Greenland). (6.5)

Presentation

- Not all scientists agree on the science surrounding climate change. Some scientists are skeptical and believe that climate change is a natural, cyclic process. Research to find opposing arguments to climate change. Take one side of the issue and debate it with another student with an opposing viewpoint. (6.2, 6.3, 6.4)

- Critique some myths and misconceptions related to climate change and present your findings to the class. (6.2, 6.3, 6.4, 6.5)

Performance

- Conduct an experiment that models the warming effect of greenhouse gases. (6.3)

Resources/Notes

Living in the Environment, Chapter 21 - Climate Change

Climate Change (continued...)

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
6.6 identify the effects that climate change can have on Prince Edward Island - sea level rise - increased erosion - economic effects - social effects - species movement/loss	Global warming could have catastrophic effects on Prince Edward Island shorelines. Increasing sea levels, and accompanying storm surges, will lead to flooding and accelerated coastal erosion. Teachers should present students with maps of projected sea level increases and photographs of past storm events. Students could identify areas that are most susceptible to coastal inundation and discuss the environmental, economic, and social effects that may occur if sea level continues to rise. Global warming may also have some positive effects on Prince Edward Island. Increased temperature may allow for new crops to be planted or growing seasons to be increased. The tourism industry may benefit from more visitors if temperatures increase. Energy use required for heating homes may also decrease as a result of global warming (but energy use for cooling may increase). Again, students should discuss the trade-offs of global warming on Prince Edward Island. The diagram on page 490 of *Living in the Environment* could be used as a guide for this discussion.
6.7 compare different schools of thought about global warming and its future projections	Students should appreciate the variety of conflicting arguments and viewpoints surrounding the issue of climate change. They should note the complexity of the problem and the uncertainty of projected global climate models. However, most climate scientists agree that human activities have influenced recent temperature increases and will lead to further significant temperature increases during this century. Teachers should discuss the three main schools of thought about global warming and ask students which one they favor. Students could then describe local, provincial, national, and global efforts to address climate change and how different schools of thought lead to different efforts.
6.8 demonstrate an understanding of challenges and successes made to address climate change - individual - industries - provincial governments - federal governments - international agreements	Students should investigate the challenges and successes that have been prompted by international agreements on new environmental climate change policy (e.g., the Rio Declaration on Environment and Development, the Kyoto Protocol, the Copenhagen Summit, carbon tax and carbon trading). The topic of climate change and global warming may be of great interest to many environmental students. Students may wish to propose plans to mitigate and adapt to these global warming changes as their PBL component of the course. Teachers should encourage students to pursue this topic but ensure that project ideas are realistic given class resource and time constraints.

Climate Change (continued...)

Tasks for Instruction and/or Assessment

Journal

- Do you think that economic costs should be considered in responding to the threat of climate change? (6.6)

Pencil Paper

- What are some individual actions that you could take to lower your impact on climate change? What are some actions your school could take? Your municipality? (6.8)

- What are the three schools of thought concerning what we should do about projected global warming? Which do you favour? Why? (6.7)

- What are the main challenges that nations face in coming to an agreement on international policies for climate change? (6.8)

- Assuming that global warming will continue, research the potential to introduce replacement species to Prince Edward Island that are acclimatized to warmer environments. (6.6)

- Identify the impact that climate change might have on the diversity of living things (e.g., rising temperature can result in habitat loss or expansion; changing rainfall levels can cause drought or flooding of habitats). (6.5, 6.6)

- How have industries and government adapted to the challenges of climate change? What are some successful changes/innovations that they have made? (6.8)

Presentation

- Conduct a class debate on the topic "Benefits and Consequences of Global Warming to Prince Edward Island". Use the information on page 490 of your text as a starting point for your arguments. (6.6)

- Identify one area on a Prince Edward Island map that is susceptible to coastal inundation. Present to the class the environmental, economic, and social effects that may occur in this area if sea levels continues to rise. (6.6)

Performance

- Create a model of a device that could protect homeowners on coastal shores from the threats of rising sea levels. (6.6, 6.8)

- Briefly outline the assumptions and limitations of a computer model that projects global climate change. (6.7)

Resources/Notes

Living in the Environment, Chapter 21 - Climate Change

Air and Water Pollution

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
6.9 summarize the main types, sources, and effects of air pollution	This section briefly summarizes the types and sources of air and water pollution. Teachers may wish to focus more attention on water pollution than air pollution as contamination of groundwater is a major concern on Prince Edward Island. Students may wish to explore a deeper aspect of air pollution (indoor or outdoor) as the basis of an inquiry question in the PBL component of this course. Students should understand that most outdoor air pollutants come from natural sources although they rarely reach harmful levels. Human activities that burn fossil fuels can often cause harmful levels of air pollution in the troposphere, especially in urban areas. Although this is not typically a concern for Prince Edward Island residents, students should investigate examples of the effects of smog on large cities. Students should distinguish between primary and secondary air pollutants. They should briefly describe the serious negative effects that air pollution can have on our environment. Each year air pollution prematurely kills about 3 million people, depletes soil nutrients, kills fish, and damages property and infrastructure. Students should discuss possible solutions for reducing air pollution.
6.10 summarize the main types, sources, and effects of water pollution	As with air pollution, water pollution kills millions of people worldwide every year. Students should understand how these pollutants enter water resources and distinguish between point sources and nonpoint sources. Strategies to prevent, clean, and monitor pollutants from point sources are easier than those from nonpoint sources. Municipal runoff and agricultural runoff are two such nonpoint sources that lead to cultural eutrophication. Students should discuss or present strategies to mitigate or prevent these water pollution sources.
6.11 explain strategies that reduce air and water pollution - improved energy efficiency - cleanup of groundwater - cultural eutrophication prevention	Elevated nitrate levels in Prince Edward Island groundwater is a common concern as this is our only source of drinking water. Pollutants that enter groundwater are often unseen and take a very long time to decompose. This makes removal of the contaminate difficult and costly. Students should propose strategies to protect groundwater from pollutants.
6.12 conduct an experiment to determine water pollutants - presence - concentration	Teachers should explain how coliform bacteria counts, dissolved oxygen levels, turbidity and colorimetry can be used to detect water pollutants. Students should conduct an experiment to test the water quality of various samples from local sources (e.g., ocean, stream, well, municipal water) and present their results. Note: experiments must be conducted in accordance to the *Science Safety Resource Manual*.

Air and Water Pollution

Tasks for Instruction and/or Assessment

Journal

- Have you ever breathed highly polluted air? How did it feel? (6.9)

- Do you think that clean drinking water should be a human right? If so, what responsibilities do developed countries have to make this happen? (6.10, 6.11)

Pencil Paper

- How can your personal actions influence the air or water quality in your local area? (6.9, 6.10)

- List several ways to prevent pollutants from entering groundwater resources. (6.11)

- Describe some of the effects of air pollution on our environment. (6.9)

- Why is groundwater so hard to clean once polluted? (6.11)

- Explain some of the main culprits of cultural eutrophication on Prince Edward Island. Why are they so hard to detect or prevent? (6.10, 6.11)

Performance / Presentation

- Conduct an experiment to determine the presence and concentration of water pollutants. As a class, present the water quality test results from different water sources. Are there any geographic areas, or water sources, that had higher readings than others? If so, what could be the cause of these elevated readings? (6.10, 6.12)

- Explain, on the basis of research, the effectiveness of government initiatives or regulations, and the actions of individuals, intended to improve air and water quality, and propose a personal action plan to support these efforts. (6.11)

Resources/Notes

Living in the Environment, Chapter 20 - Air Pollution

Living in the Environment, Chapter 22 - Water Pollution

Science Safety Resource Manual

Waste Management

Outcomes	Elaborations - Suggestions for Learning and Teaching
Students will be expected to	
6.13 identify the types of solid domestic waste	Teachers could begin this section by stating the percentage of the world's solid wastes that is produced by the affluent style of Canadians and Americans in comparison with the rest of the world. Students should consider their own and their community's generation of waste. Consider the different types of material, for example, paper, glass, metal, plastics, organic waste, packaging, as well as their total volume.
6.14 evaluate pollution management strategies for solid domestic (municipal) waste on Prince Edward Island	In the early 1990s, there were very few waste diversion efforts in place on Prince Edward Island. Most people just put their garbage at the curb and forgot about it. In 1999 the Island Waste Management Corporation (IWMC) was created to administer and provide solid waste management services throughout Prince Edward Island. The Prince Edward Island program, Waste Watch, is a mandatory program where residents, visitors and businesses must separate the solid waste they produce at the source, into the following three categories: recyclable material, compost, and waste. The residents of Prince Edward Island have proven that the goal to reduce waste going to landfills by 50% by the year 2000, which was set by the federal government, can be achieved as we were the first province in Canada to surpass this feat by diverting as high as 65% from landfill.
6.15 propose a course of action on a social issue related to waste management, taking into account human, economic, and environmental needs	Students should consider recycling (closed loop and downcycling), incineration, composting, and landfill management strategies for solid waste. The Prince Edward Island Energy Systems Waste Plant (incinerator) has been in operation since 1983 in Charlottetown. This plant incinerates solid waste to produce hot water used to heat local governmental and institutional buildings. Students should discuss the advantages and disadvantages of the solid waste management strategies used locally and provincially. They should then create and present their own solid waste management plan at a household or school level. Students should think about what would be needed to expand their plan to the local, provincial, or national level. This activity could be completed individually, in teams, or as a topic for the PBL component of the course. If possible, teachers could arrange for a class visit to a waste management facility (IWMC), Prince Edward Island Energy System Waste Plant, or municipal waste facility.

Waste Management

Tasks for Instruction and/or Assessment

Journal

- How closely do you follow the rules for the Waste Watch program? Are there any areas where you could improve? (6.14, 6.15)

- Have you visited a landfill? How did you feel during your visit? (6.14)

Pencil Paper

- What are the different forms of solid domestic waste? (6.13)

- Do the advantages of recycling materials such as paper, plastics, and metals outweigh the disadvantages? (6.14)

- What is the waste management strategy for your school? Is it followed by students and staff? If not, what steps can you take to improve its efficiency or effectiveness? (6.14, 6.15)

- Do the advantages of incinerating solid waste as an energy source outweigh the disadvantages? (6.14)

- Should disposable goods and built-in obsolescence be discouraged by legislation and economic means (such as taxes)? (6.15)

Performance / Presentation

- Conduct a field trip to a local waste management facility. Present to the class a summary of its operation and areas for improvement. (6.14)

- Maintain a record of solid wastes discarded by your family in the course of one week. What percentage of this material could be affected by the 5 R's (refuse, reuse, reduce, recycle, rethink)? (6.13, 6.14)

- Create a solid waste management plan at either a household or school level. Present your plan to the class and respond to the ideas of others. (6.13, 6.15)

Resources/Notes

Internet: Island Waste Management Corporation
http://www.iwmc.pe.ca/

Living in the Environment, Chapter 24 - Solid and Hazardous Waste

Appendix A

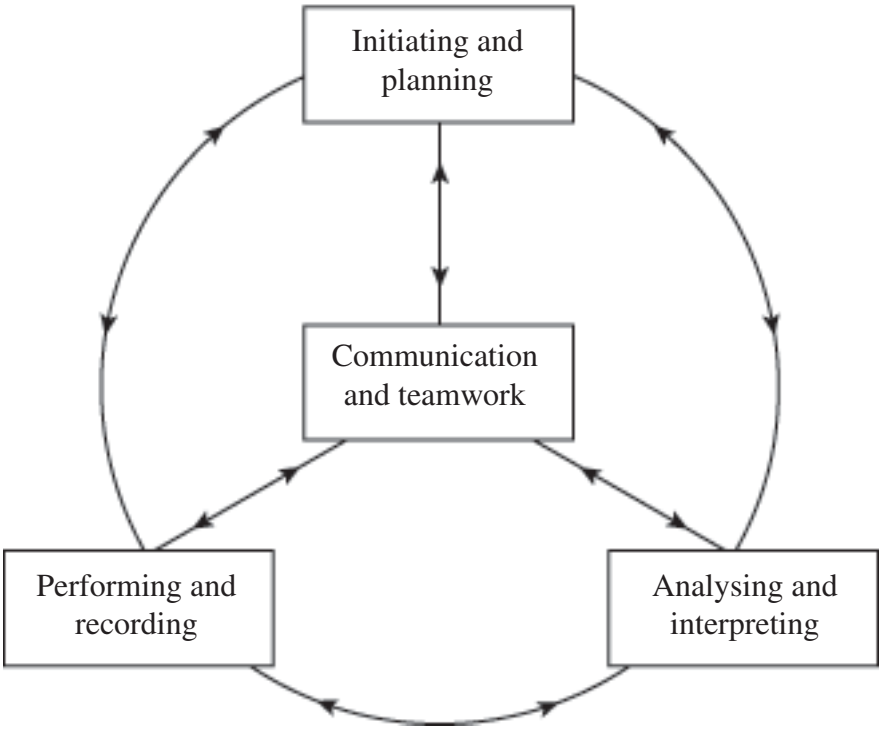
Student Guide to the Inquiry Process

STUDENT GUIDE
to the
INQUIRY PROCESS

INCLUDES

Guided Practice
Project Planning
Work Report Template

Inquiry Model



PROJECT GROUP CONTRACT	
Project	
Members of Group:	

Complete this contract, providing as much detail as possible. Consider the terms of your contract carefully, ensuring that each member of your group agrees before signing the document. Clearly describing, and understanding, what everyone is required to do will be important when misunderstandings occur during the activity—and they **will** occur! Establish the details right from the start. Each person in the team is expected to contribute to the best of his or her ability. How you decide who will do what is up to you and is to be recorded on this contract.

Remember, you will assess how well each member of your team lives up to this contract, and your team will assess you as well, so it is important to divide the work equally as much as possible.

Our Agreement

- We all promise to listen to each other's ideas with respect.
- We all promise to do our assigned work to the best of our ability.
- We all promise to turn in our work on or before due dates.
- We all promise to ask for help if we need it.
- We all promise to share responsibility for our success and for our mistakes.
- We all promise to turn in work that is our own.

If someone in our group breaks one or more of our rules, the group has the right to call a meeting and ask the person to follow the rules.

Date:_____

Group member signatures:

_____ _____

_____ _____

Work Agreements

To be completed for **each member** of the team. (Use back of sheet, if necessary)

1. _____ agrees to be responsible for: (List of tasks)
   (Print name here)

   _____ (Sign here)

2. _____ agrees to be responsible for: (List of tasks)
   (Print name here)

   _____ (Sign here)

3. _____ agrees to be responsible for: (List of tasks)
   (Print name here)

   _____ (Sign here)

4. _____ agrees to be responsible for: (List of tasks)
   (Print name here)

   _____ (Sign here)

PROJECT MANAGEMENT LOG: **GROUP TASKS**	
Project Name:	
Members of Group:	

Task	Who Is Responsible	Due Date	Status	Done

PROJECT WORK REPORT: **GROUP**			
Project Name:			
Members of Group:		**Date:**	
For the Time Period:	Day(s): _____ Week: _____		

During this time period we had the following goals for project work:	1	
	2	
	3	
	4	
	5	
During this time period we accomplished …	1	
	2	
	3	
	4	
	5	
Our next steps are…	1	
	2	
	3	
	4	
	5	
Our most important concerns, problems or questions are…	1	
	2	
	3	
	4	
	5	

PROJECT WORK REPORT: **INDIVIDUAL**			
Project Name:			
Student Name:		**Date:**	
For the Time Period:	Day(s): _____ Week: _____		

During this time period I had the following goals for project work:	1	
	2	
	3	
	4	
	5	
During this time period I accomplished …	1	
	2	
	3	
	4	
	5	
My next steps are…	1	
	2	
	3	
	4	
	5	
My most important concerns, problems or questions are…	1	
	2	
	3	
	4	
	5	

Selecting a Topic for Inquiry

Guided Practice Sheet

Outcome 6.1.1

How do you select a topic and plan your inquiry?

Brainstorm ideas and ask questions that interest you. For example, if you want to know more about "water quality", then you need to generate a number of questions that are of interest to you. This will help you narrow the focus to something that can be researched, an experiment that can be performed, or a problem that can be solved. As you conduct your preliminary search for sources, your inquiry question may change or be refined many times.

TIPS: Web Searches

Google is a search engine, not a Web site or source that can be cited in your research. It is a good starting place to get ideas but do not rely exclusively on this for your research. **Wikipedia** may be tempting to use for research, but is not totally reliable as a source, and should be viewed as a starting point where you can find ideas for additional sources at the end of each article.

Planning and Practice:

Enter "water quality" into an on-line search engine. Note how many possible links there are for this topic – hence, the need to narrow your topic!

Broad Topic:	Water quality
Narrowed Topic:	Water quality of a local stream
Narrower Topic / Question:	Eutrophication. Does runoff from local fields affect water quality in streams?
Possible Inquiry Questions:	How are turbidity and pH readings of a local stream affected by rain events?
Possible Information Sources:	List potential Web sites, encyclopedia, journal, and community sources that can provide reliable information. Use a variety of formats.
Audience:	Class/teacher/community/other
Format of Presentation:	Digital presentation, mini-documentary, photo-essay, research paper, oral presentation, talk show simulation
Evaluation Criteria:	Teacher and/or student-generated criteria to evaluate product AND process (includes "learning to learn skills")

Project Planner for Inquiry

Initiating and Planning

Outcome 6.1.1

What is your broad area of inquiry?

Narrow your focus...

Try out some inquiry questions...

How will you collect reliable data?

Who will be the audience and what format will your presentation take?

How will you be evaluated on this inquiry project?

What is your plan and schedule to accomplish this? Create SMART goals, a Gantt chart, and/or a PERT chart. Include checkpoints.

Project Planner for Inquiry

Creating SMART Goals

Outcome 6.1.1

SMART Goals:

Students and teachers are to create SMART goals to guide the initiating and planning phase.

E.g., By the end of first semester I will determine how rain events affect the turbidity and pH levels of a section of the Dunk river.

Specific

- What inquiry question will you answer?
- Why did you decide to engage in this process?

Measurable

- What will be measured?
- How will you know you're on track?
- How will you know when the goal is met?

Attainable

- Is the goal challenging but still achievable?
- What actions are required to achieve the goal?

Realistic

- Why do you want to achieve this goal?
- Is the goal realistic with the resources at hand?
- Are you willing to commit to the goal?

Timely

- Can you reach the goal in the time allowed?

Project Planner for Inquiry

Using Gantt Charts

Outcome 6.1.1

GANTT Charts

In 1917 Henry L. Gantt, an American engineer and social scientist, developed a production control tool that subsequently has been named the Gantt chart. Gantt charts are useful tools for planning and scheduling projects.

Gantt charts allow project managers to:

1. Assess how long a project should take
2. Lay out the order in which tasks need to be carried out
3. Help manage the dependencies between tasks
4. Determine the resources needed
5. Helps monitor progress

The Gantt chart provides a graphical illustration of a schedule that helps to plan, coordinate, and track specific tasks in a project. Gantt charts may be simple versions created on graph paper or more complex using project management applications such as Microsoft Project or Excel.

	Time			
Tasks	Week 1	Week 2	Week 3	Week 4
Task 1				
Task 2				
Task 3				
Task 4				

A Gantt chart is constructed with a horizontal axis representing the total time span of the project, broken down into increments (for example, days, weeks, or months) and a vertical axis representing the tasks that make up the project (for example, if the project is outfitting your computer with new software, the major tasks involved might be: conduct research, choose software, install software).

	Time			
	Morning	Lunch	Afternoon	Evening
Computer 1				
Computer 2				
Computer 3				
Computer 4				
Legend				
In Use				
Idle				
Maintenance				

Gantt charts are also used by supervisors and team leaders to schedule and track the use of resources. This data can help the project manager determine schedule the optimal use of a technology.

Project Planner for Inquiry

Using PERT Charts

Outcome 6.1.1

PERT Charts

A PERT chart is a project management tool used to schedule, organize, and coordinate tasks within a project. PERT stands for Program Evaluation Review Technique, it was developed by the U.S. Navy in the 1950s to manage the Polaris submarine program.

Some project managers prefer a PERT chart because of its ability to represent events and milestones of a project in a graphical method. The PERT chart shows which parts of the project need to be completed in a sequential method and which parts can be worked on simultaneously. The PERT chart is often preferred over the Gantt chart because it is able to clearly illustrate task dependencies. Frequently, project managers use both techniques.

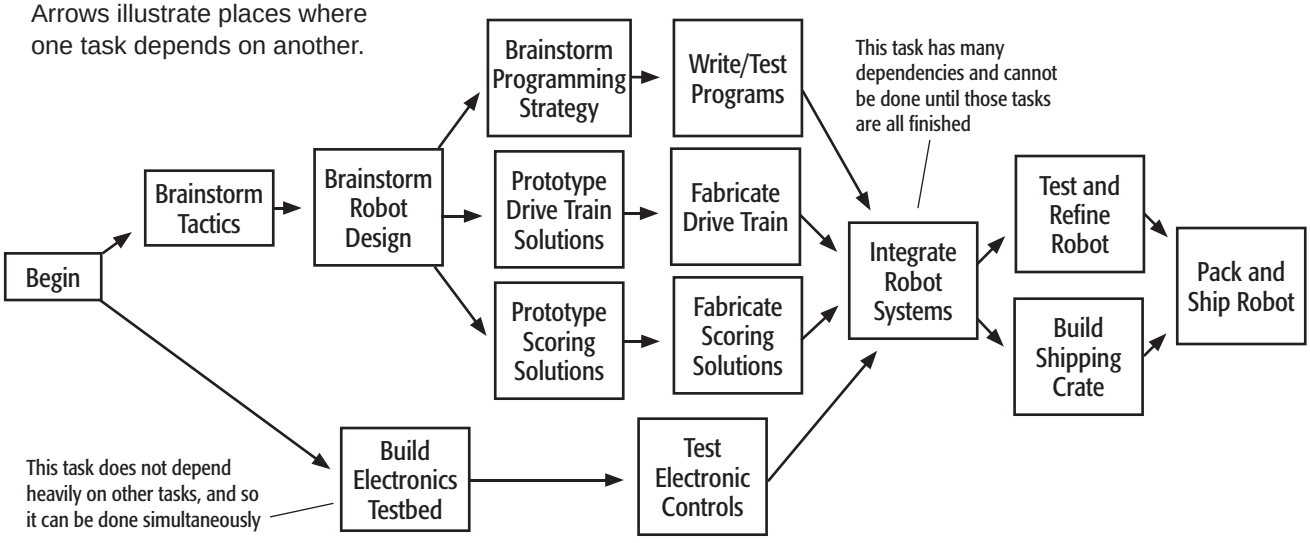
Development of a PERT chart

The first thing that the team must do is divide their overall project into small tasks. Each small task should be assigned a leader. Then the team must sequence the order of completion. Some tasks of the problem may be completed independent of others. These tasks can be worked on simultaneously. Some tasks may need to be completed before others can start. These things must be worked on sequentially. The team will look at the tasks and try to set deadlines based on prior experience. They should break tasks into the smallest parts possible to accurately calculate time.

1. Discuss the overall problem
2. Break the problem into small tasks
3. Sequence the order of completion of tasks
4. Schedule the tasks
5. Assign responsibility for tasks to teams and individuals
6. Meet regularly to check progress of overall project
7. Help each other complete tasks in a timely manner

Sample PERT Chart

Arrows illustrate places where one task depends on another.



Retrieving Information

Guided Practice Sheet

Outcome 6.1.2

How do you go about retrieving information for your inquiry?

Searching for information can be a daunting job for even the most experienced of researchers. Stay organized and keep a record of your searches. You will likely need to find these sites again. Start by planning out your search. You might assume that the World Wide Web is the best place to begin but there are lots of other options to be explored. On-line searches can be time-consuming and frustrating. Try out encyclopedias, texts, videos, periodicals, and databases such as EBSCO right within reach at school, home, or your local library. There are often community sources as well such as government records or materials produced by community organizations. Don't forget to ask a librarian!

TIPS: Primary and Secondary Sources

Primary sources are first-hand materials such as a novel written by an author, letter, diary entry, scientific journal, autobiography, speech, personal interview, first-hand accounts of events, experimental procedure, photograph, or other original work. Secondary sources include all second-hand accounts of primary sources or materials that have been interpreted by others: movie and book reviews, textbooks, translations, encyclopedia articles, scientific reviews (written by someone who was not present at the time of the event), or recreated artifacts. Sometimes it is difficult to tell if a source is primary or secondary (and may in fact be a bit of both). In the case of Web searches, articles on a specific topic with a stated author are generally primary sources, but would be considered secondary if the article is an interpretation of previously published work.

Planning and Practice:

1. Make a checklist of all the possibilities where you might find information.
2. Keep detailed records of the sources you find that you intend to use. If a source is not a good match, discard the record to avoid confusion.
3. Look closely at the URL addresses of any Web sites that you may use – URLs hold clues to reliable sites or ones that may be biased. Enter "water quality" into a search engine such as GOOGLE and note the domain tag on the URLs (this is the 3-letter clue to the origin). For example, "edu" refers to an educational organization/ institution; "org" refers to a (usually) non-profit or governmental organization; "gov" refers to governmental; and "com" means the site is commercial.
4. Scroll through the first 20-30 hits for "water quality" and see how many fit the four categories above: edu _____; gov _____; org _____ ; com _____

Project Planner for Inquiry

Retrieving Information from the Web

Outcome 6.1.2

URL Note the domain tag and the country of origin: ca- Canada; uk - United Kingdom; us - United States; au - Australia, etc.	**Author** Is this an expert author or simply someone's personal view? Is there any information on the author at the end of the article or in other web sites?	**Audience** Who is the intended audience of the article? Is it for educational purposes or intended to sell a product or a point of view?	**Current** Is the site current or dated? When was it last updated or how long has it existed?	**Citation** Is there a recommended way of citing material from the site?
Source #1				
Source #2				
Source #3				
Source #4				
Source #5				

Evaluating Sources

Guided Practice Sheet

Outcome 6.1.3

How do you know if it is a good source for your inquiry project?

While you may think that you'll never find enough material to complete your project, it's often a case of the complete opposite. Finding sources is one thing – finding **good** sources is a whole other thing. Just as important as knowing a bit about the author and the intended audience of the information, it is essential that the information is relevant to your work.

TIPS: To Cite or Not To Cite?

Avoiding plagiarism can be a tricky when you are selecting information. If you are using data, findings, experiments, or any other work of others, you must give credit to that source. For example, if you are using a procedure outlining how to measure water turbidity levels in a stream, or research results about the environmental impact of high pH levels, you must cite the source. Common knowledge need not be cited as it is generally shared by all readers (e.g., water pollution can be harmful to fish populations). If you are not sure, check with a teacher or teacher-librarian, or refer to a writing handbook for more guidelines.

Planning and Practice:

1. Ask yourself if the material is closely related to your inquiry. For example, if your topic is about how turbidity and pH levels are affected by rain events, it may not be necessary to include specific information about the dissolved oxygen rates before and after rain events.
2. Use the same guidelines for measuring reliability of "experts" as you as you would in selecting sources. Nationally-known organizations, educational institutions, or recognized local community groups are the most reliable sources.
3. Is the information up-to-date or is there historical data that may be useful? Older materials may prove to be valuable but check to be sure that the data is still current and has not been replaced by newer information.
4. Is the material easy to access when you need it? Remember to record it!
5. Is there an obvious bias or does the information present a balanced view?
6. Is there enough material to help out your inquiry? Or, is there so much that you need to be selective in matching it to your work?

Select three sources of information on water quality and try to answer the guiding questions above to get a sense for how relevant or valuable the material is to you.

Project Planner for Inquiry

Evaluating Sources

Outcome 6.1.3

My topic: _____

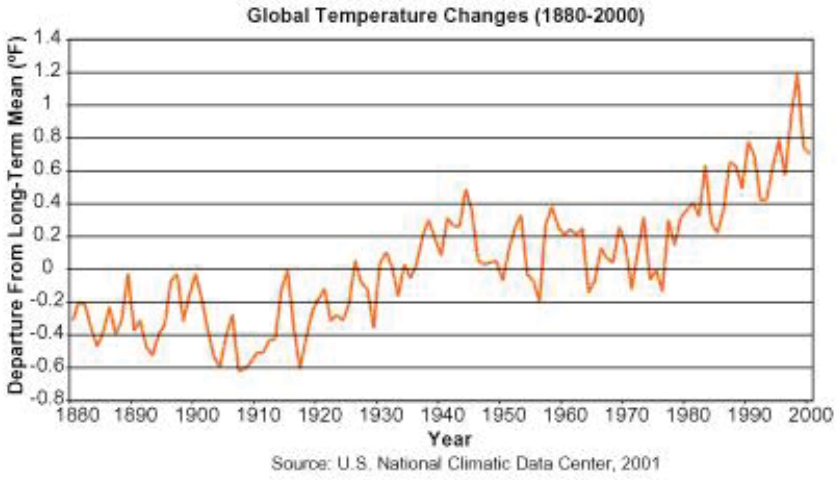
Inquiry question: _____

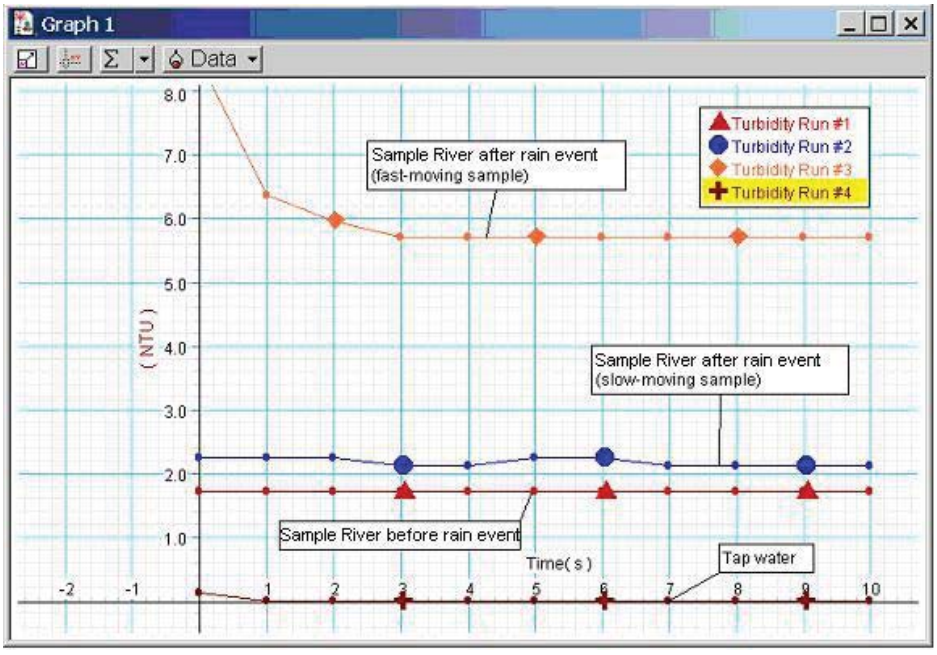
Source	Relevance Score 1-3	Reliability evidence	Timeliness current/dated	Accuracy 1-3	Bias 1-3	Quantity too much/too little

Analysing and Interpreting
Guided Practice Sheet
Outcome 6.1.3

Analysing and interpreting data:
After you have gathered and recorded information from your experiments, you will need to use tables and graphs to interpret patterns and trends in the data that will determine relationships among the variables. Analysing graphical data should help you to identify and explain sources of error and uncertainty in measurements. This will allow you to express your results in a form that acknowledges the degree of uncertainty. It will also evaluate the relevance, reliability, and adequacy of your data and data collection methods.

Planning and Practice:
1. Analyse the following graphs and share your interpretations.





Communication
Guided Practice Sheet
Outcome 6.1.4

From data collection to product communication

Now it really starts to get interesting! You are ready to transform all the research and experimental data that you've collected and started to organize into a product of your own creation. Chances are, you've already decided on (or, have been given) a particular format for your product. This is where the planning part helps immensely. Think about what components of your research will fit best into the introduction, the main body, and the conclusion. Physically move your written notes and data around, or use sticky notes to help organize your thoughts. Seeing the information fit together visually is often beneficial. Look for any gaps or areas that may need a bit more attention.

TIPS: Graphic Organizers and End-Products

Graphic organizers are a good way to sort and organize information that will form your final product. There are numerous versions of graphic organizers and it's simply a matter of deciding which one will do the best job for you. For example, if you plan to create a digital slideshow as your end-product, you might use a storyboard to figure out the sequence of slides and info on each slide. If you are doing a visual display such as a photo-essay, you might choose to practice with a concept map. An oral presentation or newscast simulation may work better using a sequence chart to plan the script or interview.
Other ideas for end-products:

- Formal Lab Report, Research Paper, Essay, Editorial, Letter
- Prototype
- Brochure, Pamphlet, Poster, Chart
- Panel Discussion, Debate, Speech, Oral Presentation, Song/Lyric
- Drama, Movie Script, Video, Digital Presentation, Web Page, Audio

Planning and Practice:

You are planning to do your project on an aspect of water quality. Decide the format for your end-product by thinking about your interests and strengths, and what might be the most effective means of communicating the information that you have gathered and analysed. Which type(s) of graphic organizers will help you?

I would choose to do _____ because I _____
_____.

The graphic organizers (select at least two) that I think would work best are _____
_____.

Project Planner for Inquiry

Communication

Outcome 6.1.4

Checklist: Getting from data collection stage to end-product.

- ☐ I've gathered sufficient data and kept records of my sources.
- ☐ I've analysed my data to ensure that it is relevant to my inquiry.
- ☐ I've used graphic organizers, or some other system to help sort out my data and analyse my findings.
- ☐ I've organized my data into an introduction, main body, and conclusion.
- ☐ I know what I want to present as an end-product and how to get there.

Select an effective graphic organizer (or, more) for your inquiry project and show how you've used them in the space below:

Communication
Guided Practice Sheet
Outcome 6.1.4

Sharing your work
Usually "sharing" work refers to an oral presentation of some sort - something that many people are uncomfortable about doing. When it comes to sharing your inquiry work with others, there are a few things that you can keep in mind to make a more effective presentation. It's not so important to include every written thought that you have put into your project – it's more effective and interesting to your audience if you summarize your findings and present the most important ideas or conclusions that you have discovered during your inquiry. Body language is another important component of presenting. Try to keep eye contact with your audience as much as possible and don't get fixated on one person or one side of the room. Speak clearly and make sure you're not chewing gum!

TIPS: Rubrics
Rubrics are tools that help both students and teachers when it comes to big projects or small tasks. These are usually grids with 3-5 columns with descriptions of criteria which are used to evaluate a task or a product. Obviously, it is most helpful to the presenter if he or she knows in advance which criteria will be used to evaluate the work and presentation. Students and teachers can create a rubric together at the beginning of a project or use a pre-existing one and adapt the criteria to fit. Rubrics do not have to be complicated and can be designed to suit every circumstance whether it is to evaluate part of the inquiry process such as an individual task, or an end-product such as a presentation or exhibit.

Planning and Practice:
You are tasked with evaluating a poster product that has been created to raise awareness of water quality issues in a local stream. With a partner, or within in a small group, create an evaluation rubric that will measure the most significant components of the poster (message, clarity, visual appeal, accuracy of information, variety of sources, etc.) Use the following template to get started:

POSTER	Limited	Developing	Proficient	Advanced
Provides ample sources of info				

Project Planner for Inquiry

Communication

Outcome 6.1.4

Use the following template to create a rubric for the end-product that you have selected to present your inquiry findings and conclusions. Add more rows if necessary or make changes to headings if you wish.

Product to be Evaluated	Limited	Developing	Proficient	Advanced

Evaluating and Reflecting

Guided Practice Sheet

Outcome 6.1.4

Evaluating and Reflecting on the Inquiry Process

You've reached the finish line of your inquiry ... or, have you? Not really, and that's because an inquiry process is cyclical rather than linear. It's all about thinking and then rethinking about the new information you have uncovered, putting it together with what you already know, and reaching new levels. Although you've learned a lot by the time you reach this stage, you probably raised some new questions too. Ask yourself about what you have learned, what more you would like to learn, and how you might proceed differently the next time. A good inquiry should lead to more inquiry!

TIPS: Self-Assessment

At this stage it is also important to think about how you learned as well as what you learned. If you worked independently, were you able to stay on task and meet the checkpoint deadlines? What were your strengths and weaknesses and how can you work on improving some of these things. If you worked in a group, what did you learn about your work style in that situation or the types of tasks that you like or dislike doing. How could you be more effective to the group? A project work report is a good way to keep track of ideas and progress during a project and it allows you to reflect back on how far you came from the launch of the project.

Planning and Practice:

1. Complete the End-of-Project Self Assessment sheet.

Project Planner for Inquiry

Communication and Teamwork

Outcome 6.1.4

End-of-Project Self Assessment

Title of inquiry project:_____ During the project I completed a number of tasks including: • • • As a result, I learned the following about...	
Subject Matter (name the most important things that you learned...)	
Conducting an Experiment	
Following an Inquiry Process	
Presenting to an Audience	
How I Like to Learn	

Project Based Learning Rubric

	4	3	2	1
Inquiry Question	I describe my inquiry question clearly, completely, and in great detail. I make pertinent predictions that can be researched and tested. My hypothesis is based on conjectures with various conditions.	I describe my inquiry question clearly. I make reasonable predictions that can be researched and tested. My hypothesis is based on conjectures with some conditions.	I describe my inquiry question but some elements are missing. My predictions may be difficult to research or test. My hypothesis lacks some conjectures or conditions.	My inquiry question is missing, flawed, or incompletely described. My predictions are not testable. My hypothesis is missing or not based on conjectures
Information Gathering	My collection of relevant scientific background information focuses on the inquiry question. My search of the literature includes many diverse, relevant sources, including books, magazines, the Internet, and community contacts. My gathered information is described completely, with no content errors, misstatements of fact, or misconceptions.	My collection of scientific background information is related to the inquiry question. My search of the literature includes an adequate amount of relevant, diverse sources. My gathered information is described completely, with only minor content errors, misstatements of fact, or misconceptions.	My collection of scientific background information includes some information that is not relevant to the inquiry question. My search of the literature includes some diversity of sources but the quantity may be minimal. My gathered information is not described completely, or my descriptions include major content errors, misstatements of fact, or misconceptions.	My collection of scientific background information is not relevant to the inquiry question. My search of literature is limited by lack of diversity and quantity of sources. I provide a limited description of the background information.
Experimental Investigation	My investigation is a well-constructed test of the hypothesis and includes a detailed experiment that answers the inquiry question completely. I include a clear step-by-step description of the experimental procedures. I identify, address, and control all relevant independent and dependent variables; include materials with labeled diagrams and drawings of any equipment used to carry out the experiment; and describe safety measures in detail. My investigation can be replicated exactly as described.	My investigation is a reasonably constructed test of the hypothesis and includes an experiment that answers the inquiry question. I include a step-by-step description of the experimental procedures. I identify and address most of the independent and dependent variables; include control of variables; include materials, diagrams, and drawings (but they are not always clearly labeled); and mention safety measures employed. I organized the information so that my investigation can be replicated.	My investigation is an incompletely constructed test of the hypothesis, which has errors. I include a step-by-step description of the experimental procedure that misses some key details. I identify and address some of the independent and dependent variables, give some attention to the control of variables, include materials, mention equipment (but it is not shown), and describe some safety measures. I organized the information, but some parts of my investigation are missing, making it difficult to replicate.	My investigation is not relevant to the hypothesis or has serious errors. My description of the experimental procedure lacks key details. I do not address key independent and dependent variables, do not provide adequate attention to control of variables, do not mention equipment used to carry out experiment, or do not mention safety measures. My information is not sufficient to replicate my investigation.

Project Based Learning Rubric (continued…)

	4	3	2	1
Data Collection and Display	I have a detailed description of my methods for collecting data, and data has been collected in the most efficient and appropriate ways.	I have a description of my methods of collecting data, and a reasonable amount of data has been collected in a sufficient manner.	My description of the methods of data collection is incomplete, and a minimum amount of data has been collected.	My description of the methods of data collection is absent, and insufficient data has been collected.
	My statistical analysis procedures are clearly organized, and I explain my reasons for choosing them. All of my original data is included.	My statistical analysis procedures are valid, organized, and contain few errors. Most of my original data is included.	I include some statistical analysis procedures and some original data.	I do not include statistical analysis of the data.
	My data is accurately recorded and displayed, and all variables are labeled.	My data is recorded and displayed, but my variables are not labeled.	My data is recorded and displayed but may not include labels.	My data has not been recorded or displayed or it has been done so incorrectly.
Analysis and Conclusion	My conclusion includes a restatement of the hypothesis, supports or refutes the hypothesis, and explains the role of the experiment in making the decision.	My conclusion includes a restatement of the hypothesis and supports or refutes the hypothesis.	My conclusion provides some relationship to the hypothesis.	My conclusion shows no relationship to the hypothesis.
	My analysis includes identification of patterns, concepts, meanings, or structures in the data and is used as evidence to support my statements.	My analysis includes some identification of patterns, concepts, meanings, or structures in the data and is used as evidence to support my statements.	My analysis includes minimal identification of patterns, concepts, meanings, or structures in the data, but these are not used as evidence to support my statements.	My analysis does not use data to support my arguments.
	My analysis includes identification of sources of error and explains the effect on results.	My analysis includes identification of sources of error.	My analysis suggests the possibility of error but identifies no sources.	My analysis does not address the possibility of error.
	My conclusion includes comparisons, interpretations, inferences, or deductions from the research information and prior knowledge.	My conclusion includes comparisons and interpretations, and makes some inferences or deductions.	My conclusion compares or interprets some of the information but does not make inferences or deductions.	My conclusion does not interpret information or make inferences or deductions.
	I recognize and discuss the scientific or societal implications of my project, propose solutions, and recommend new avenues of experimentation.	I discuss how the project is useful and propose solutions or recommend new avenues of experimentation.	I state that the project is useful but provide no reasoning, and I suggest some solutions or further investigations but the reasons may not completely relate to the conclusion.	I do not discuss the usefulness of the project and do not recognize solutions that follow from the knowledge gained.

Total: /20

Oral Presentation Rubric

	LIMITED The presentation is at a beginning stage.	DEVELOPING The presentation may show flashes of quality, but could be improved in several important ways.	PROFICIENT The presentation is acceptable, but could be improved in a few important ways.	ADVANCED The presentation is exemplary
Content	The presentation does not include information on the major points.	Important information is missing, or there are few supporting details.	Information is complete with basic supporting details, increasing audience knowledge at least to some degree.	Information is complete and well supported by detail, significantly increasing the audience's knowledge of the topic.
Thinking and Communication	The presentation does not express main points clearly, thoroughly, or persuasively.	The presentation seems to convey only limited understanding of the topic. The main points are not clearly stated or persuasive.	The presentation conveys good understanding of the topic, with some lapses. The speaker's main points are clear but are not persuasive.	The presentation conveys deep and thorough understanding of the topic. The speaker's main points are logical and persuasive.
Organization, Mechanics, and Vocabulary	No introduction is used to capture audience attention. The body of the presentation needs organization and supporting details. A suitable closing is missing. The speaker has not mastered key words and phrases relevant to the topic.	The introduction is unclear or fails to capture audience attention. The body of the presentation is confusing with limited supporting details. The closing is unclear or does not include many of the major points. The speaker's topic related vocabulary is limited.	The introduction states the purpose but does not capture the attention of the audience. The main part of the presentation is organized and sequential with some supporting details. The closing provides a basic summary of the most major points. Vocabulary is appropriate to the topic, with some lapses.	The introduction captures audience attention and gives a clear statement of purpose. The main part of the presentation is well organized, sequential, and well supported by detail. The closing provides a thorough summary of all of the major points. The speaker demonstrates a rich vocabulary appropriate to the topic.
Illustration	No presentation aids.	Presentation aids do not enhance audience understanding or are confusing.	Presentation aids are appropriate to the topic but are not well integrated into the overall presentation.	Presentation aids are clearly linked to the material, well executed, and informative to the audience.
Presentation	Control of speaking tone, clarity, and volume is not evident. No evidence of creativity. Speaker does not convey interest in the topic. Speaker does not make eye contact with audience. Physical gesture and awareness of facial expression are absent.	Clarity of speech is uneven; delivery is halting. Limited evidence of creativity. Speaker is not completely sure of topic and appears disengaged. Limited or sporadic eye contact with audience. Limited or inappropriate use of physical gesture and facial expression.	Good speaking voice; recovers easily from speaking errors. Creativity apparent, but is not well integrated into presentation. Speaker is in command of the topic but has slight problems with delivery. Good eye contact with audience throughout most of the presentation. Use of physical gesture and facial expression is good, but appears forced or artificial at times.	Strong, clear speaking voice easily understood by audience. Use of creativity keeps audience engaged. Speaker conveys confidence in talking about the topic. Excellent eye contact with audience throughout presentation. Use of physical gesture and facial expression conveys energy and enthusiasm.

Appendix B

Project Based Learning Agreement Form

PROJECT BASED LEARNING
AGREEMENT FORM

Date _____

Part A: Parties to the Agreement

Name of student _____
Homeroom _____
Age _____ Date of birth _____
Home address _____
Home phone number _____ Email address _____
Name of parent(s)/guardian(s) _____
Contact number(s) for parent(s)/guardian(s) _____

Part B: Responsibilities of the Parties to the Agreement

The student will:

- agree to fulfill the expectations set out in the project based learning outcomes of Environmental Science 621A.
- respect all policies of the community contact (if applicable), especially with regard to dress code, participation and safety regulations.
- agree to not work alone in any potentially hazardous situation.
- identify hazards that the student may be exposed to during the project by itemizing any hazardous equipment, situations, or machinery the student will be exposed to (e.g., heights, confined spaces, chemicals or biological or infectious agents, power tools, motorized vehicles, working alone).
- model a work ethic and maintain confidentiality.
- immediately inform the teacher and community contact (if applicable) of any concerns, injuries, accidents, or errors.
- if applicable, ensure that safe and reliable transportation to and from any project site has been secured.

_____

Student's signature Date

The parent(s)/guardian(s) will:

- ensure that the student has appropriate and safe transportation to and from the project site.
- support and encourage the student in his/her learning opportunity and responsibilities.
- become informed about the associated risks with the project.
- express concerns regarding the student project to the supervising teacher.
- accept responsibility for the consequences that result from the personal conduct of the student during the project based learning experience.

_____

Signature of parent or guardian Date Phone number

The school/teacher will:

- provide a safe learning environment that engages the student with meaningful and progressive tasks that allow for scientific inquiry and skill development.
- provide a guided, in-class component to prepare and support the student for the project based learning outcomes.
- provide equipment-specific training to the student before any observations, measurements, or experiments are performed.
- ensure that the student has the proper safety equipment required for all tasks to be performed.
- ensure that supervision will be provided, provide continuous observation of how the student is performing the task, provide regular feedback when tasks are not performed properly or safely, and provide opportunities for the student to ask questions.
- if applicable, work with the community contact on all issues concerning the operation of the project.
- keep all student records of the project based learning experience according to school board policy.

_____

Teacher's signature Date

Appendix C

Parent/Guardian Consent Form

School Logo

Date _____
Dear Parent/Guardian,

As you are aware, your son/daughter is enrolled in the Environmental Science 621A course here at school. Environmental Science 621A seeks to promote an appreciation and understanding of the environment and sustainable development. This course integrates classroom theory with guided inquiry. A significant portion of the course is dedicated to Project Based Learning where critical thinking, problem-solving, and decision-making skills will be developed in the process of examining and analyzing environmental issues. With guidance and teacher-directed models, your son/daughter will learn to follow a scientific inquiry process within their own investigation of an environmental issue. Although most inquiry projects can be completed on school grounds, your son/daughter may choose to complete a project based learning experience at a site off of school grounds. If so, this project would have to be completed outside of regular school hours and outside of normal teacher supervision.

Risk of injury at project sites is always a concern. Although students are trained and equipped with proper safety equipment, accidents may happen. Please be advised that the school board/district has limited medical insurance coverage in place for all students. The insurance which has been purchased by the school board/district also provides limited coverage for Death, Dismemberment and Disability while your son/daughter is participating in school activities/programs. Should your son/daughter be injured while participating in this course please contact the school who will provide you with the necessary information and forms in which to submit a claim.

If you have questions about the Environmental Science 621A course or about the insurance policy, please contact the school or the secondary science consultant at the Department of Education and Early Childhood Development.

Please review and sign the attached Participation, Release and Indemnification form and return it to the Environmental Science 621A teacher at your earliest convenience. Your son/daughter cannot participate in the Environmental Science 621A course unless this form has been properly completed and returned.

Sincerely,

_____
Environmental Science 621A teacher

School Logo

PARTICIPATION, RELEASE AND INDEMNIFICATION

_____ (name of school) has arranged for a project based learning experience as part of the Environmental Science 621A course. The inquiry project will consist of the student investigating and analyzing a relevant environmental issue. All activities or events in which a student participates could cause injury or property damage to the student or others.

THIS FORM MUST BE READ AND SIGNED BY EVERY STUDENT AGE 13 AND OVER WHO WISHES TO PARTICIPATE AND BY A PARENT OR GUARDIAN OF A PARTICIPATING STUDENT UNDER THE AGE OF 18.

ELEMENTS OF RISK - Educational activities or programs as described above involve certain elements of risk. Accidents may occur while participating in or travelling to and from such activities. These accidents may cause injury and occur without fault on the part of the school board/district, its employees, agents, or the facility where the activity or event is taking place. By participating, the student or his parent or guardian assumes the risk associated with an accident occurring.

The chance that an accident will occur will be reduced by following instructions and guidance provided, as well as using appropriate protective equipment as needed for the activity noted.

ACKNOWLEDGEMENT AND PERMISSION - We have read the above and recognize the potential for injury or property damage exists by allowing _____to participate in the activity noted. We agree to assume the risks associated with the activity or event and give permission for _____ to participate/attend.

_____ _____

Signature of Student (to be signed by all students 13 years of age and older)

Signature of Parent or Guardian (to be signed by parent/guardian for students under the age of 18)

_____ _____

DATE DATE

RELEASE and INDEMNIFICATION - In consideration of the above-noted school allowing the student to participate in the activity described above, we hereby agree to release, and hold harmless, the school, the school board/district, its employees, volunteers, agents, heirs, executors, and administrators from actions, causes of action, claims, suits and demands of whatever nature including negligence, except for the gross negligence of the school or the _____(name of school board/district) and its employees, volunteers and agents. We understand that this release applies to any injury, loss or damages sustained while participating in or being transported to or from said activity.

_____

Signature of Parent or Guardian (to be signed by parent/guardian for students under the age of 18) or Student (to be signed by student age 18 or over)

_____

DATE

Appendix D

Community Based Learning Photo
Consent Form

Community Based Learning Photo Consent Form

Date _____

Dear Parent/Guardian,

This permission form permits us to use the pictures of/interviews with your son/daughter in promotional material used to promote community based learning for students.

Sincerely yours,

_____
Community based learning teacher's signature

CONSENT AND RELEASE

In accordance with the *Freedom of Information and Protection of Privacy Act*, I hereby grant my consent to the use and publication of photographs, names, name of school attended, and achievement of my son/daughter,

_____
(Student's name and school)

as part of a program and/or advertising that recognizes their scholastic, athletic, artistic or educational achievements and community contributions. I hereby release and hold harmless the school, the school board, its employees, volunteers, agents, heirs, executors and administrators from actions, cause of action, claims, suits and demands of whatever nature by reason of any act, neglect or default, except for the gross negligence of the school or the school board and its employees, volunteers and agents arising out of my son/daughter's participation and involvement in this school event. I also grant permission for the use of the name of my son's/daughter's school for publication, as well as his/her name, achievements, and photographs.

Signature of Student _____ Date_____

Signature of Parent/Guardian_____ Date_____

Appendix E

Suggested Core Investigations

Suggested Core Investigations

Name / Description	Curriculum Section	Outcome(s) Addressed
Turbidity and Thermal Pollution Investigate the relationship between turbidity and water temperature	Ecological Principles (Ecosystem Components)	Conduct an experiment to measure abiotic factors of an ecosystem (3.6)
Water Quality Lab Determine the concentration / presence of DO, coliform bacteria, pH, temperature, conductivity, turbidity, nitrates, and phosphates of water samples	Ecological Principles (Ecosystem Components) Environmental Challenges and Successes (Air and Water Pollution)	Conduct an experiment to measure abiotic factors of an ecosystem (3.6) Conduct an experiment to determine water pollutants (6.12)
Nitrates Lab Investigate nitrate levels in ground water	Natural Resources (Water Resources)	Demonstrate an understanding of sustainable water use at local, national, and global levels (5.8)
Soil pH Lab Investigate pH levels of various soil samples	Ecological Principles (Ecosystem Components) Natural Resources (Soil Resources)	Conduct an experiment to measure abiotic factors of an ecosystem (3.6) Describe the environmental impacts from agriculture (5.7)
Soil Salinity Lab Investigate salinity levels of various soil samples	Ecological Principles (Ecosystem Components) Natural Resources (Food Resources) Natural Resources (Soil Resources)	Conduct an experiment to measure abiotic factors of an ecosystem (3.6) Demonstrate an understanding of strategies that affect the state of global food production (5.3) Demonstrate an understanding of soil conservation, erosion, and degradation (5.6)
Soil Erosion Lab Investigate turbidity effects of soil erosion	Natural Resources (Soil Resources)	Demonstrate an understanding of soil conservation, erosion, and degradation (5.6)
Soil Runoff Lab Investigate eutrophication and groundwater contaminants	Natural Resources (Soil Resources) Environmental Challenges and Successes (Air and Water Pollution)	Describe the environmental impacts from agriculture (5.7) Summarize the main types. Sources, and effects of water pollution (6.10) Explain strategies that reduce air and water pollution (6.11)
Greenhouse Effect Lab Investigate the relationship between greenhouse gases (e.g., CO2) and atmospheric temperature	Environmental Challenges and Successes (Climate Change)	Demonstrate an understanding of the greenhouse gases found in the troposphere and stratosphere (6.3)
Plant Respiration and Photosynthesis Lab Investigate the relationship between O2 and CO2 concentrations for plants undergoing cellular respiration and photosynthesis	Environmental Challenges and Successes (Air and Water Pollution) Environmental Challenges and Successes (Climate Change) Natural Resources (Forest Resources)	Explain strategies that reduce air and water pollution (6.11) Demonstrate an understanding of the greenhouse gases found in the troposphere and stratosphere (6.3) Identify the role forests have as natural capital, as well as their economic, ecological, and social value (5.14)

Appendix F

Living in the Environment DVD Correlations

Living in the Environment DVD Correlations

Title (CBC News Clip)	Run Time	Description	Curriculum Correlations
Bison Babies	4:44	Discusses repopulating a habitat with a displaced, native species. Mentions Aboriginal land use.	2.4, 3.4, 3.7, 3.9, 3.9
Female Feticide	5:02	Discusses aborting female fetuses in India. Could be used to discuss viewpoints and ethics that differ from North American ones.	2.4, 2.6, 4.1
Mangy Wolves	3:22	Highlights attempts to care for wolves in the wild. Could be used to discuss whether humans should interfere with wild animal populations.	3.4, 3.7, 3.9, 3.10
Floor Mapping	2:42	Issues pertaining to Canadian land rights in the Arctic.	
Bowhead Whales	3:16	Western science working with Traditional Ecological Knowledge.	2.4, 4.4
Flood Context	5:28	Impacts of climate change and flooding on the environment.	6.5, 6.6
Surf Power	3:59	Discusses using wave power to create electricity, and the societal and economic effects that it could have on a local community.	2.2, 5.1, 5.17
Green Houses	7:17	Discusses photo-voltaic solar panels and energy efficient homes.	2.1, 5.17, 5.18
Smog Science	7:00	Introduces the science behind smog, ground level ozone, and their global consequences.	3.2, 3.7, 6.9
California Emissions	7:57	Discusses California policy for reducing emission levels and their potential effects on the economy.	2.2, 2.3, 6.9
Ice Pak	2:00	Climate change in the North West passage.	6.5, 6.8
Abandoned Wells	9:13	Discusses the consequences of abandoned wells on ground water quality. Mentions the Walkerton tragedy.	3.7, 5.7, 5.8, 6.10, 6.11
Dumpster Diving	3:54	Discusses food waste.	2.3, 6.13, 6.14, 6.15
Sherbrooke Bus	3:29	Free public transit for university students in Sherbrooke. Could be used to promote discussion on sustainable cities and transportation.	2.2, 2.3, 6.8
Green Town	3:34	Highlights environmental awareness and action in a small town. Could be used to discuss sustainable living at a local level.	2.2, 2.3, 6.8
Climate Costs	2:29	Discusses the impact of climate change on the global economy.	2.2, 2.4, 2.6, 6.8
Arctic Sovereignty	5:40	Issues pertaining to Canadian land rights in the Arctic.	