Saskatchewan Learning

Science 10

A Curriculum Guide for the Secondary Level

September 1991

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Acknowledgements

Saskatchewan Education gratefully acknowledges the professional contributions and advice given by the following members of the Science Curriculum Advisory Committee:

Dr. Glen Aikenhead
Professor, Science Education
University of Saskatchewan

Ms. Ingrid Benning
Teacher
Saskatoon S.D. No. 13

Mr. Ross Derdall
Trustee (SSTA)
Outlook S.D. No. 32

Ms. Shannon Dutson
Vice-Principal
Potashville S.D. No. 80

Mr. Wayne Kiel
Principal
Buffalo Plains S.D. No. 21

Ms. Dorothy Morrow
Trustee (SSTA)
Nipawin S.D. No. 61

Mr. Larry Mossing
Teacher
Regina S.D. No. 4

Dr. Ray Rystephanick
Assistant Dean, Faculty of Science
Professor, Physics
University of Regina

Mr. William Shumay
Principal
Swift Current R.C.S.S.D. No. 11

Dr. Ron Steer
Professor, Chemistry
University of Saskatchewan

Mr. Peter Stroh
Teacher
St. Paul's R.C.S.S.D. No. 20

Mr. James Taylor
Teacher
Saskatoon S.D. No. 13

Dr. William Toews
Professor, Science Education
University of Regina

Mr. Ernest Toth
Assistant Director of Education (LEADS)
Buffalo Plains S.D. No. 21

Mr. Lyle Vinish
Executive Assistant (STF)
Saskatoon

Mr. Randy Wells
IMEAC
La Ronge

Previous Advisory Committee members: Dr. Frank Bellamy, Ms. Joan Bue, Ms. Mary Hicks, Mr. George Huczek, Mr. Vlademir Murawsky, Mr. Lynn Phaneuf.

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Foreword

Much of the foundation for curriculum renewal in Saskatchewan schools is based on *Directions* (1984). The excitement surrounding the recommendations for Core Curriculum developments will continue to build as curricula are designed and implemented to prepare students for the 21st century.

Science, as one of the Required Areas of Study, incorporates the Common Essential Learnings, the Adaptive Dimension, and other initiatives related to Core Curriculum.

As we strive to achieve the goal of scientific literacy in Saskatchewan schools, much collaboration and cooperation among individuals and groups will be required. Science teachers are a key part of the process.

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Introduction

Science Program Philosophy, Aim, and Goals

The philosophy and spirit of science education renewal in Saskatchewan is reflected not only in the program aim and goals, but in the documents developed to support the new curricula, and in the inservice packages designed and utilized for implementation. In addition, the philosophy for science education is closely related to the concept of Core Curriculum based on the *Directions* philosophy for Saskatchewan.

The major aim of the K-12 Science program is to develop scientific literacy in students. What, however, is scientific literacy?

For Saskatchewan schools, scientific literacy has been defined by seven Dimensions of Scientific Literacy that are the foundation for the renewed curriculum (Hart, 1987). Actively participating in K-12 Science will enable a student to:

- understand the **nature of science** and scientific knowledge as a unique way of knowing;
- understand and accurately apply appropriate science **concepts**, principles, laws, and theories in interacting with society and the environment;
- use the **processes of science** in solving problems, making decisions, and furthering understanding;
- understand and appreciate the joint enterprises of **science** and **technology** and the interrelationships of these to each other in the context of **society** and the **environment**;
- develop numerous manipulative **skills** associated with science and technology, especially with measurement;
- interact with the various aspects of society and the environment in ways that are consistent with the **values** that underlie science; and,
- develop a unique view of technology, society, and the environment as a result of science education, and continue to extend this **interest and attitude** throughout life.

Each of these Dimensions has been defined further by a series of factors, which delineate the Science curriculum. The factors of scientific literacy are defined and examples are given starting on page 29. Further information about them is covered in *Science Program Overview and Connections K-12.*

The study of science should help students to make better sense of the world in which they live. The objective is not to have students be able to repeat the words which teachers or scientists or others use to describe the world, although they may do that. It is to have students create their own conceptual maps of what surrounds them every day, and to realize that those concepts and the maps which describe the links between concepts are tentative, subject to questioning, and revised through investigation.

Related Documents

Saskatchewan Education has produced the following documents to support this Secondary Level science curriculum.

Science 10: A Curriculum Guide for the Secondary Level contains the specific information needed to plan and deliver the Science 10 course.

Science Program Overview and Connections K-12 contains important sections on the philosophy and rationale behind the teaching of science, and on planning for instruction in science for all teachers from kindergarten to grade 12. Sections of this document will also be useful for administrators, teacher-librarians, and others.

Science 10: An Information Bulletin for the Secondary Level – Key Resources lists the key resources which have been recommended to help achieve the factors and objectives outlined in the Science 10 Curriculum Guide. It is organized so that the resources, with page or chapter references, are listed for each topic in the Curriculum Guide.

Science 10: An Information Bulletin for Administrators has information regarding the organization of Science 10, addresses implications for its implementation, and encourages support for the science program.

Science 10: A Bibliography for the Secondary Level contains an annotated listing of resources which can be used to enrich the Science 10 program and to assist in implementing resource-based learning in the classroom. Each annotation contains a recommendation about the topic(s) for which the resource is most appropriate.

The Factors of Scientific Literacy

Before using this Curriculum Guide, teachers should be familiar with the Science Program Overview and Connections K-12, a document that provides background information about the factors of scientific literacy. A list of the factors, their definitions, and examples of instances in science where these factors are important, or can be developed, is also found beginning on page 29 of this Curriculum Guide. Nearly all of the factors which have been identified as components of the Dimensions of Scientific Literacy can be developed in Science 10.

Different students will exhibit varying degrees of sophistication in dealing with some factors of scientific literacy. Some may be at a rudimentary level in understanding; others will be advanced. The teacher will need to adapt the course to meet these student variations.

In order to emphasize as many of these factors as possible during the course, and to concentrate on those less well developed, teachers must have a thorough understanding of each factor and exhibit good lesson planning and lesson reflection skills. Lesson reflection means that, at the end of the lesson, the teacher thinks about what happened. Based on assessment of student interests, understandings, strengths and needs, the teacher identifies what was covered and what needs more work. The teacher must verify the connections among the goals, factors and objectives. The section in this Curriculum Guide on Unit Planning, beginning on page 60, provides general and specific information regarding unit and lesson planning.

The curriculum in K-12 science in Saskatchewan schools is the attainment of the factors of scientific literacy. Attainment of these factors involves understanding, ability, and appreciation. The scope and depth of Science 10 is guided by the factors.

Using This Curriculum Guide

Each of the core units in this guide follows a similar structure beginning with the **Factors of Scientific Literacy Which Should Be Emphasized**. The introduction and development of the factors of scientific literacy form the basis for the science program from kindergarten through grade 12. The factors can be thought of as the prime foundational objectives for each science course. All other elements of the curriculum support the development of these factors of scientific literacy.

The section **Factors of Scientific Literacy Which Should Be Emphasized** lists the factors which should be emphasized in each core unit. Teachers are free to emphasize what they feel are the most appropriate factors in a unit, whether or not they appear on this list. This section indicates that the factors are important and should be considered in the planning of each unit. It is not meant to restrict the coverage to those factors listed.

The **Foundational Objectives for Science and the Common Essential Learnings** are statements of what students should be able to achieve in Science 10. The stating of objectives for the Common Essential Learnings is a reminder that one of the primary foci of the Science 10 curriculum is the incorporation of the Common Essential Learnings into science instruction. They are described as foundational because they are general, guiding objectives. Since foundational objectives in the Common Essential Learnings are meant to be achieved over a student's entire school experience, students may come to science classes with some understanding of these concepts, gained in previous science classes and in other areas of study. Encourage the development of their understanding of the objectives which are listed, and others which are perceived as appropriate for that unit, during the study of science.

The foundational objectives for science describe the broad intent of the unit. They are intended to give the unit its focus and structure. **Learning Objectives** which will promote accomplishment of each foundational objective can be selected from those listed or can be developed by the teacher and students. The learning objectives define more specifically what will be dealt with during the unit of study. By giving careful consideration to the learning objectives, the Adaptive Dimension enters the classroom, and the foundational objectives for both science, and the Common Essential Learnings can be accomplished.

There are four core units in Science 10. The topics within the core units serve as the means for developing content, process, and values. Full scientific literacy cannot be attained without emphasis on all of these domains.

Science 10 consists of the following Core Units: Earth/Environmental Science, Physical Science, Life Science, and Science Challenge. The suggested topics in the first three Core Units are:

- **A-1 Water Quality;**
- **B-1 Chemical Change; and,**
- **C-1 Cell Structure and Human Body Systems.**

One topic from the **Science Challenge** unit, and at least one additional topic from any core unit must be selected.

Course Overview

The following figure introduces the organization of the Science 10 program.

Figure 1 Course Overview

Core Units	Suggested Topics	Minimum Time
A. Earth/Environmental Science	A-1 Water Quality	15 hours
B. Physical Science	B-1 Chemical Change	15 hours
C. Life Science	C-1 Cell Structure and Human Body Systems	15 hours
D. Science Challenge	Any one of D-1 to D-5	15 hours
plus	at least one additional topic from the core units	Remaining Available Time

Instead of the suggested topics, the alternate topics described in each core unit may be selected. If an alternate topic is selected, the **Foundational Objectives for Science and the Common Essential Learnings** and the **Factors of Scientific Literacy Which Should Be Emphasized**, must be developed.

The diversity and flexibility of this curriculum encourages changes in teachers' roles, variety in student activities and use of resource-based learning. *Science 10: An Information Bulletin for the Secondary Level – Key Resources* provides suggestions for the use of specific resources. *Science 10: A Bibliography for the Secondary Level* provides an annotated listing of other resources which support resource-based learning.

Any single resource will not cover all of the core units of this Curriculum Guide. Instead, teacher-selected activities and content from a variety of sources should be integrated to produce a comprehensive, activity-based program.

The specific content taught in the Science 10 units of study represents selected course content that collectively is not as critical as developing the broad goals of scientific literacy. As in all other Science courses from K-12, the main goal of Science 10 is to develop the factors within the seven Dimensions of Scientific Literacy.

The sequencing of the topics is at the discretion of the teacher. Creative rearranging of the topics is encouraged. The order in which the topics are developed could be modified, or several topics could be integrated. The examples shown subsequently, on page 6 illustrate a few alternative approaches.

There are a variety of ways that the Adaptive Dimension can be incorporated into Science 10. One way is to modify teaching strategies. A second way is to use time for remediation, reinforcement, or enrichment. Either method, or some combination of both, is acceptable. Additional ideas are given in *Instructional Approaches: A Framework for Instructional Practice* (Saskatchewan Education, 1991). Extension activities for the topics may also be included as topic D-1 of the **Science Challenge** Core Unit, allowing further accommodation of the Adaptive Dimension in the program.

Topical Overview

Core Unit A. Earth/Environmental Science	minimum of 15 hours

Select at least one of:

A-1. Water Quality*
A-2. The Greenhouse Effect
A-3. Uranium

Core Unit B. Physical Science	minimum of 15 hours

Select at least one of:

B-1. Chemical Change*
B-2. Energy Management
B-3. Teacher Selected Physical Science Topic

Core Unit C. Life Science	minimum of 15 hours

Select at least one of:

C-1. Cell Structure and Human Body Systems*
C-2. Food Additives and Human Nutrition
C-3. Teacher Selected Life Science Topic

Core Unit D. Science Challenge	minimum of 15 hours

Select at least one of:

D-1. Extension activities for the previous Core Units
D-2. Research Projects
D-3. Science Fair Projects
D-4. Science Olympics
D-5. Science Outreach Activities

Select at least one additional topic from the units for the remaining available time.

* Topics marked with an asterisk in Core Units A, B, and C are suggested. Refer to the section in this Curriculum Guide entitled *Using This Curriculum Guide* if any of the other topics in the core units are selected.

Many possible variations for arranging topics exist. This illustrates the diversity and flexibility in Science 10. The examples which follow show some possible ways that a teacher may plan for the delivery of the entire course:

Example 1

A-1 Water Quality*	20 hours
C-1 Cell Structure and Human Body Systems*	15 hours
D-3 Science Fairs	15 hours
B-1 Chemical Change*	15 hours
plus,	
A-3 Uranium	15 hours
D-1 Extension activities for Chemical Change Core Unit	Remaining Time

Example 2

A-3 Uranium	15 hours
B-3 Teacher Selected Physical Science Topic	15 hours
C-1 Cell Structure and Human Body Systems*	20 hours
D-2 Research Projects	15 hours
plus,	
A-2 The Greenhouse Effect	10 hours
D-4 Science Olympics	Remaining Time

Example 3

Integrated unit, combining objectives from A-1* and B-1*	25 hours
C-3 Teacher Selected Life Science Topic	15 hours
D-1 Extension activities from Core Unit C-3	15 hours
plus	
B-3 Teacher Selected Physical Science Topic	20 hours
D-5 Science Outreach	Remaining Time

School divisions may wish to consider what approach to topic selection should be used by teachers within the division. Nevertheless, Saskatchewan Education strongly recommends that teachers be given a high degree of freedom in developing Science 10 to make best use of the diversity and flexibility that has been designed into the curriculum.

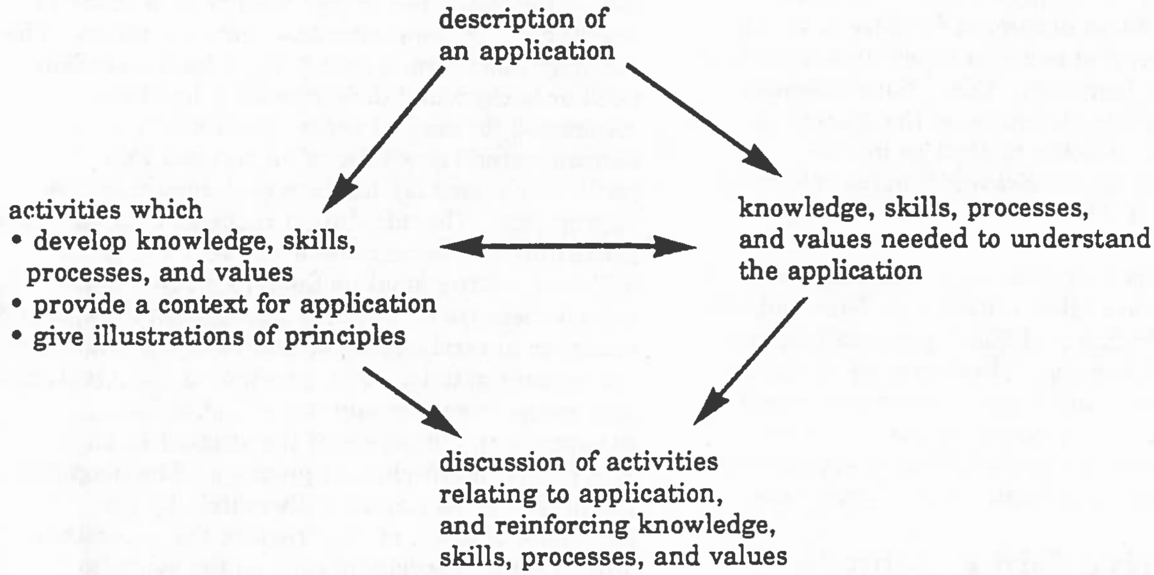
One science lesson may be suited to emphasize a large number of the factors of scientific literacy, and many of the foundational objectives in both science and the Common Essential Learnings. Another lesson may deal with only a few factors and one or two of the foundational objectives. In order to make best use of the time the teacher has with the students, each teacher should analyze the lesson before presentation to ensure that the appropriate factors and foundational objectives are developed to the maximum extent. Science 10 is a unique curriculum designed to suit the various needs and interests of students and teachers.

An STSE Approach to Science Education

The STSE approach recommended for Science 10 differs from the way science has traditionally been presented. The ideal is to introduce a topic for study through the description of an application. In order to understand the science behind the application, knowledge and skills must be developed, along with activities which give purpose to the newly acquired knowledge and skills. Alternatively, the activities may immediately follow the discussion of the application, and serve to develop the knowledge and skills needed to understand the application. The arrows on Figure 2 are meant to show the variety of paths from the description of an application to the final discussion.

Figure 2

A Science-Technology-Society-Environment (STSE) Approach to Science Education



Guidelines To Using Resource Materials

Resources for Science 10 can be "bundled" into different packages. *Science 10: An Information Bulletin for the Secondary Level — Key Resources* identifies resources appropriate for each core unit topic. *Science 10: A Bibliography for the Secondary Level* provides an annotated listing of resources which further support resource-based learning. Teachers should consider the suggestions and recommendations in these documents. Other materials may also be used.

As was indicated earlier, no single resource matches the Science 10 curriculum. To facilitate a resource-based approach, the use of a variety of resources instead of a single textbook is highly recommended.

As new resource materials become available, **Information Bulletins** may be issued as updates. They will indicate which new resources can be used, as well as those resources that are no longer available.

Teachers may wish to extend some of the topics that are not selected for Science 10 into the 20 and 30 level science courses. This should be coordinated within schools. Resources should be selected with this in mind.

A resource-based learning approach requires long-term planning and coordination within a school or school division. In-school administrators, teacher-librarians, and others need to take an active role to assist with this planning.

Instructional approaches which emphasize group work and develop independent learning abilities make it possible to utilize limited resources in a productive way.

Core Curriculum and Other Initiatives

Core Curriculum: Plans for Implementation (Saskatchewan Education, 1987) defines the Core Curriculum as including seven Required Areas of Study, the Common Essential Learnings, the Adaptive Dimension, and Locally-Determined Options. Science is one of the Required Areas of Study.

Understanding the Common Essential Learnings: A Handbook for Teachers (Saskatchewan Education, 1988), as a foundation document for Saskatchewan Education, defines and expands on an understanding of these essential learnings. Other Saskatchewan Education documents elaborate on the concept of Core Curriculum. See the references in this Curriculum Guide and in *Science Program Overview and Connections K-12*.

In addition to Core Curriculum, at Saskatchewan Education, there are other initiatives. These include Gender Equity, Indian and Métis perspectives, and Resource-Based Learning. These initiatives can be viewed as principles which guide the development of curricula as well as instruction in the classroom. The initiatives outlined in the following statements have been integrated throughout the Curriculum.

The Adaptive Dimension in Instruction

The adaptation of instruction to meet learner needs is an expectation inherent in the **Goals of Education** and is an essential ingredient of any consideration of Instructional Approaches. In *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991) the Adaptive Dimension is defined as:

> the concept of teachers exercising their professional judgement to develop an integrated plan that encompasses curricular and instructional adjustments to provide an appropriate education that is intended to promote optimum success for each child.

The continuum of curricular programs authorized by Saskatchewan Education – Regular, Transitional, and Alternative Programs – recognizes the need for variation in curriculum content and delivery mechanism. The continuum indicates that within each program, and therefore within each course of study, adaptation is required. Teachers are empowered to adjust the curriculum content in order to meet student needs; as professionals they must ensure that the instructional approaches are also adapted. This implies that teachers have at their "fingertips" a broad, strong repertoire of instructional strategies, methods, and skills and that conscious planning takes place to adapt these approaches to meet student needs.

The cues that some students' needs are not being adequately met come from a variety of sources. They may come to the perceptive teacher as a result of monitoring for comprehension during a lesson. The cue may come from a unit test, or from a student need or background deficiency that has been recognized for several years. A student's demonstrated knowledge of, or interest in, a particular topic may indicate that enrichment is appropriate. The adaptation required may vary from presenting the same content through a slightly different instructional method, to modifying the content because of a known information background deficit or to establishing an individual or small group enrichment activity. The duration of the adaptation may range from five minutes of individual assistance, to placement of the student in an alternative or enrichment program. The diagnosis of the need may be handled adequately by the classroom teacher, or may require the expertise of other support specialists such as the school's resource teacher or the regional coordinator – special education.

The recognition of the need for adaptive instruction is dependent upon the professional judgement of the teacher. The decision to initiate adaptive practices must be an informed one. While the practice of adapting instruction may occur through the placement of students in programs other than those defined as regular, the most frequent application of the Adaptive Dimension will occur as teachers in regular classroom settings adjust their use of both content and instructional approaches.

Instructional Approaches: A Framework for Professional Practice identifies a hierarchy of approaches – models, strategies, methods, and skills. The four basic **models** of instruction do not change, whether used in a "regular" class setting, or with a small group as an adaptive approach. The strategies, methods, and skills may be altered or adapted. Hence a framework for inservice, investigation, and discussion among professionals has been established.

The flexibility inherent in the Science 10 curriculum accommodates the Adaptive Dimension. Science teachers will have to take advantage of and create inservice opportunities to adjust their repertoire of instructional strategies, methods, and skills.

Common Essential Learnings

Science offers many opportunities for incorporating the Common Essential Learnings into instruction. The purpose of this incorporation is to help students better understand the subject matter under study and to better prepare students for their future learning both within and outside the K-12 educational system. The decision to focus on a particular Common Essential Learning within a lesson is guided by the needs and abilities of individual students and by the particular demands of the subject area. Throughout a core unit, it is intended that the **Foundational Objectives for the Common Essential Learnings** will have been developed to the extent possible, regardless of the topics selected.

It is important to incorporate the **Foundational Objectives for the Common Essential Learnings** in an authentic manner. For example, some topics may offer many opportunities to develop the understandings, values, skills, and processes related to a number of the foundational objectives. The development of a particular foundational objective, however, may be limited by the nature of the subject matter under study.

It is intended that the Common Essential Learnings be developed and evaluated within subject areas. Therefore, **Foundational Objectives for the Common Essential Learnings** are included in the introductory section of each core unit in this Curriculum Guide. Since the Common Essential Learnings are not necessarily separate and discrete categories, it is anticipated that working toward the achievement of one foundational objective may contribute to the development of others. For example, many of the processes, skills, understandings, and abilities required for the Common Essential Learnings of Communication, Numeracy, and Critical and Creative Thinking are also needed for the development of Technological Literacy.

Incorporating the Common Essential Learnings into instruction has implications for the assessment of student learning. Assessment in a unit which has focused on developing the Common Essential Learnings of Communication and Critical and Creative Thinking should reflect this focus. Assessment strategies can allow students to demonstrate their understanding of the important concepts in the unit and how these concepts are related to each other and to previous learning. Questions can be structured so that evidence or reasons may accompany student explanations. If students are encouraged to think critically and creatively throughout a unit, then the assessment strategies for the unit should also require students to think critically and creatively.

It is anticipated that teachers will build from the suggestions in this Curriculum Guide and from their personal reflections in order to better incorporate the Common Essential Learnings into the teaching of science.

Throughout this Curriculum Guide, the following symbols are used to refer to the Common Essential Learnings:

COM	Communication
CCT	Critical and Creative Thinki.
IL	Independent Learning
NUM	Numeracy
PSVS	Personal and Social Values and Skills
TL	Technological Literacy

Incorporating the Common Essential Learnings

The science curriculum from Kindergarten to grade 12 involves the development of the factors within the Dimensions of Scientific Literacy. The main goal is to promote an interest in and an understanding of science.

The Common Essential Learnings should be planned and developed within the context of good science lessons. As lesson planning is taking place, consideration should be given to how to incorporate the Common Essential Learnings. The **Factors of Scientific Literacy Which Should Be Emphasized**, and the **Foundational Objectives for Science and the Common Essential Learnings** outlined at the beginning of each core unit, provide appropriate starting points in planning.

Science-Technology-Society-Environment Interrelationships (Dimension D) help to develop Technological Literacy. All eleven factors within Dimension D are developing by grade 10. Technology, as it is developed within this Dimension, is studied within a social context. The connections between science and technology are elaborated. Furthermore, the impact that technology has on society, on science, and on the environment is developed. Technology is defined as more than the gadgets and gizmos that are often the only things associated with it. Most of the topics within the core units of Science 10 help to develop Technological Literacy.

Scientific and Technical Skills (Dimension E) also helps to develop Technological Literacy. Many scientific and technical skills in use today exist because of materials and instruments which have been developed through advances in technology. The impact that these new things have on our lives and on the environment is very important.

Numeracy can be developed through various factors of scientific literacy which are linked closely with this Common Essential Learning. Some of these include the empirical nature of science (A5), quantification (B8), probability (B19), accuracy (B21), measuring (C5), using numbers (C7), using mathematics (C17), and using quantitative relationships (E13). To anyone who understands science, the importance of Numeracy is readily apparent.

Problem solving can lend itself to developing Numeracy. Any other quantitative applications, of which there are many, further develop this Common Essential Learning. Students should be given many opportunities to develop ways in which quantities can be measured, recorded, manipulated, analyzed, and interpreted. Simply plugging numbers into obscure formulae is not nearly enough. Students must appreciate the importance of numeric information in the world of science. Related skills such as estimating and approximating, rounding off, graphing, tabulating, calculating, using significant figures and scientific notation, can be developed in Science 10.

Specific factors relating to the Common Essential Learning of Communication are not as easy to identify, with the notable exception of communicating (C2). The public/private nature of science (A1) reveals the underlying importance of communication in science. Scientists share their discoveries with others. This involves the use of language and of written and verbal communication. When students explore important scientific principles, and discuss their understandings orally or in writing, using their own language, their ability to communicate evolves. Skills which help to promote and develop effective communication need to be reinforced. They are important aspects of a good science program.

Values that Underlie Science (Dimension F) and Science-Related Interests and Attitudes (Dimension G) help to develop Personal and Social Values and Skills. Attaining the factors in these two Dimensions of Scientific Literacy can lead to positive attitudes about science. These Dimensions involve the affective domain. Other factors, such as working cooperatively with others (C4), scientists and technologists are human (D2), and the human/culture related nature of science (A9), further help to develop Personal and Social Values and Skills.

An activity-oriented science program will develop critical and creative thinkers. Among other things, scientific inquiry involves hypothesizing (C8), designing experiments (C16), observing and describing (C3), inferring (C9), arriving at conclusions, formulating scientific laws, developing or testing theories, etc. These kinds of activities require higher level thinking.

Science Challenge, Core Unit D of the Science 10 program, supports Critical and Creative Thinking. The emphasis on practical applications of science allows students to make meaningful connections with the real world, transferring their understanding of science to things which make their learning relevant. Problem solving activities and classroom outreach further develop the knowledge, values, skills, and processes related to Critical and Creative Thinking.

Considering controversial issues in science also leads students to develop Critical and Creative Thinking abilities when they analyze conflicting value positions. As they develop a knowledge base and begin to form their own value positions, Personal and Social Values and Skills are developed.

Independent Learning can also be developed well in Science 10 because of the emphasis being placed on variety in instructional approaches. By placing less emphasis on traditional lecture presentations, teachers transfer more of the responsibility for learning from themselves to their students. The student assumes a more active role in the classroom experience. The teacher assumes the role of the learning facilitator.

The **Science Challenge** Core Unit has potential for developing Independent Learning. By pursuing topics of interest, with direction and encouragement from their teachers, students can become highly motivated and enthusiastic about science. The **Earth/Environmental Science** Core Unit, or other topics in the course of contemporary interest, require that students keep up to date with current affairs. They may need to do independent study, using a wide variety of resources and different types of media, to investigate topics of current interest. This lends itself well to resource-based learning. As students examine issues and notice the effects that competing and conflicting points of view have on shaping those issues, an appreciation of the social impact of science will likely emerge. Making these connections helps students recognize that learning takes place throughout life, continuing after formal schooling has ended.

While some science content can be identified with specific Common Essential Learnings, quite often it can not. The Common Essential Learnings developed in any given lesson do not depend on content as much as they do on process. The teaching strategies selected, through careful unit and lesson planning, are what determine which Common Essential Learnings will be developed, and how well they will be developed. The key point is that a conscientious effort to incorporate the Common Essential Learnings can make a tremendous impact on students.

For many topics in science, any of the Common Essential Learnings can be developed. Which ones are developed, and to what extent any of the Common Essential Learnings are emphasized in a topic, depend on the goals of the new science curriculum, the foundational objectives being addressed in a particular core unit, as well as on the specific learning objectives for that topic. Just as there are many different ways to teach a lesson, so too there are many different ways of incorporating the Common Essential Learnings into that lesson. What matters is that teachers develop the Common Essential Learnings effectively, with the specific interests and needs of their students in mind. The beauty of incorporating the Common Essential Learnings into science is that, as in other subject areas, the ways in which this can be done are dynamic and flexible. The techniques used change as teachers perceive students' needs changing.

Gender Equity

Saskatchewan Education is committed to providing quality education for all students in the K-12 system. Expectations based primarily on gender limit students' ability to develop to their fullest potential. While some stereotypical views and practices have disappeared, others remain. Where schools endeavour to provide equal opportunity for male and female students, continuing efforts are required to achieve equality of benefit or outcome. It is the responsibility of schools to create an educational environment free of gender bias. This can be facilitated by increased understanding and use of gender balanced material and non-sexist teaching strategies. Both female and male students need encouragement to explore non-traditional as well as traditional options.

In order to meet the goal of gender equity in the K-12 system, Saskatchewan Education is committed to bringing about the reduction of gender bias which restricts the participation and choices of all our students. It is important that Saskatchewan curricula reflect the variety of roles and the wide range of behaviours and attitudes available to all members of our society. The new curricula strive to provide gender-balanced content, activities, and teaching approaches. It is hoped that this will assist teachers in creating an environment free of stereotyping, enabling both females and males to share in all experiences and opportunities which develop their abilities and talents to the fullest.

Indian and Métis Curriculum Perspectives

The integration of Indian and Métis content and perspectives with the K-12 curriculum fulfils a central recommendation of *Directions*, the *Five Year Action Plan for Native Curriculum Development* and the *Indian and Métis Education Policy from Kindergarten to Grade 12*. The policy states:

> Saskatchewan Education recognizes that the Indian and Métis peoples of the province are historically unique peoples and occupy a unique and rightful place in our society today. Saskatchewan Education recognizes that education programs must meet the needs of Indian and Métis peoples, and that changes to existing programs are also necessary for the benefit of all students. (page 6)

The inclusion of Indian and Métis perspectives benefits all students in a pluralistic society. Cultural representation in all aspects of the school environment empowers children with a positive group identity. Indian and Métis resources foster a meaningful and culturally identifiable experience for Indian and Métis students, and promote the development of positive attitudes in all students toward Indian and Métis peoples. This awareness of one's own culture and the cultures of others develops self-concept, enhances learning, promotes an appreciation of Canada's pluralistic society and supports universal human rights.

Saskatchewan Indian and Métis students come from different cultural backgrounds and social environments including northern, rural, and urban areas. Teachers must understand the diversity of the social, cultural, and linguistic backgrounds of Saskatchewan Indian and Métis students. All educators need cross-cultural education and increased awareness of applied sociolinguistics, first and second language acquisition theory, and standard and non-standard usage of language. Teachers must utilize a variety of teaching strategies that match and build upon the knowledge, cultures, learning styles, and strengths which Indian and Métis students possess. Responsive adaptations are necessary to all curricula for effective implementation.

Saskatchewan teachers are responsible for integrating resources that reflect accurate and appropriate Indian and Métis content and perspectives. Teachers have a responsibility to evaluate all resources for bias and to teach students to recognize such bias.

The following four points summarize the expectations for Indian and Métis content in curriculum and instruction.

- Curricula and materials will concentrate on positive images of Indian, Métis, and Inuit peoples.
- Curricula and materials will reinforce and complement the beliefs and values of Indian, Métis, and Inuit peoples.
- Curricula and materials will include historical and contemporary issues.
- Curricula and materials will reflect the legal, political, social, economic, and regional diversity of Indian, Métis, and Inuit peoples.

Instructional Approaches

The factors of scientific literacy and the development of the Common Essential Learnings are the foundations of the K-12 Science program. In order to give students a chance to develop their understandings and abilities in these foundations, it is necessary for teachers to use a broad range of instructional approaches. *Instructional Approaches: A Framework for Professional Practice* (Saskatchewan Education, 1991) provides a framework to understand and implement a variety of approaches to teaching. The Science 10 curriculum has been designed to support teachers in using such a broad-based approach in the classroom by making the curriculum flexible enough to accommodate their plans. More specific information on teaching science using a variety of strategies can be found in *Teaching Science Through a Science-Technology-Society-Environment Approach: An Instruction Guide* (Aikenhead, 1988). See also the section on the Adaptive Dimension, on page 8 of this guide.

The verbs of the **Learning Objectives** listed for the core units suggest various approaches to instruction, and reiterate some of the processes of science. Note these examples:

- analyze
- assess
- classify
- construct
- debate
- demonstrate
- determine
- develop
- discuss
- evaluate
- examine
- explain
- express
- identify
- investigate
- perform activities
- prepare
- research
- test
- utilize

Resource-Based Learning

Resource-based teaching and learning is a means by which teachers can greatly assist the development of attitudes and abilities for independent, life-long learning. Resource-based instruction means that the teacher and teacher-librarian will plan units which integrate resources with classroom assignments, and teach students the processes needed to find, analyze, and present information.

Resource-based instruction is an approach to curriculum which involves students with all types of resources. Some possible resources are: books, magazines, films, audio and video tapes, computer software and databases, manipulable objects, commercial games, maps, community resources, museums, field trips, pictures and study prints, real objects and artifacts, and media production equipment.

Resource-based learning is student-centred. It offers students opportunities to choose, to explore, and to discover. Students who are encouraged to make choices, in an environment rich in resources, where their thoughts and feelings are respected, are well on their way to becoming autonomous learners.

The following points will help teachers use resource-based teaching and learning.

- Discuss the objectives for the unit with students. Focus the discussion on how the students can relate the objectives to their environment, culture and other factors which are appropriate to their situation. Correlate needed research skills with the activities in the unit, so that skills are always taught in the context of application. Work with your teacher-librarian, if available.

- Plan in good time with the library staff so that adequate resources are available, and decisions are made about shared teaching responsibilities, if applicable.

- Use a variety of resources in classroom teaching, showing students that you are a researcher who constantly seeks out sources of knowledge. Discuss with them the use of other libraries, government departments, museums, and various outside agencies in their research.

- Ask the teacher-librarian, if available, to provide resource lists and bibliographies when needed.

- Participate in and help plan inservice programs on using resources effectively.

- Continually request good curriculum materials for addition to the library collection.

- Support the essential role of the library resource centre and the teacher-librarian in your talks with colleagues, principals, and directors.

More information on resource-based learning may be found in *Science Program Overview and Connections K-12*.

Assessment and Evaluation

Why Consider Assessment and Evaluation?

Much research in education around the world is currently focusing on assessment and evaluation. It has become clear, as more and more research findings accumulate, that a broader range of attributes need to be assessed and evaluated than has been considered in the past. A wide variety of ways of doing this are suggested. Assessment and evaluation are best addressed from the viewpoint of selecting what appears most valid in meeting prescribed needs.

In *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991) the difference between the various forms of evaluation is explained. Student evaluation focuses on the collection and interpretation of data which would indicate student progress. This, in combination with teacher self-evaluation and program evaluation, provides a full evaluation.

Information in Saskatchewan Education documents should be used to help develop an overall evaluation plan.

Phases of the Evaluation Process

Evaluation can be viewed as a cyclical process including four phases: preparation, assessment, evaluation, and reflection. The evaluation process involves the teacher as a decision maker throughout all four phases.

- In the preparation phase, decisions are made which identify what is to be evaluated, the type of evaluation (formative, summative, or diagnostic) to be used, the criteria against which student learning outcomes will be judged, and the most appropriate assessment strategies with which to gather information on student progress. The teacher's decisions in this phase form the basis for the remaining phases.

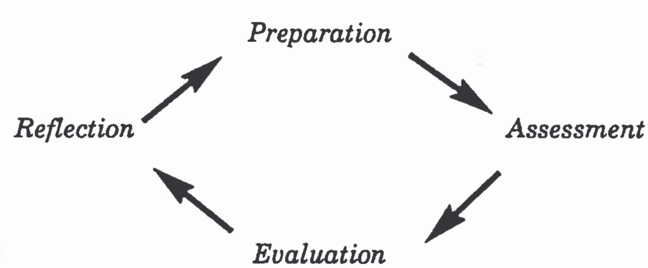
- During the assessment phase, the teacher identifies information-gathering strategies, constructs or selects instruments, administers them to the student, and collects the information on student learning progress. The teacher continues to make decisions in this phase. The identification and elimination of bias (such as gender and culture bias) from the assessment strategies and instruments, and the determination of where, when, and how assessments will be conducted are examples of important considerations for the teacher.

- During the evaluation phase, the teacher interprets the assessment information and makes judgements about student progress. Based on the judgements or evaluations, teachers make decisions about student learning programs and report on progress to students, parents, and appropriate school personnel.

- The reflection phase allows the teacher to consider the extent to which the previous phases in the evaluation process have been successful. Specifically, the teacher evaluates the utility and appropriateness of the assessment strategies used, and such reflection assists the teacher in making decisions concerning improvements or modifications to subsequent teaching and evaluation. *Science Program Overview and Connections (K-12)* contains questions which encourage teachers to reflect on student assessment, their own planning, and on the structure of the curriculum.

All four phases are included in formative, diagnostic, and summative evaluation processes. They are represented in Figure 3.

Figure 3 Process of Student Evaluation



Assessing Student Progress

Specific assessment techniques are selected in order to collect information about how well students are achieving objectives. The assessment technique used at any particular time depends on what facility with the knowledge, skills or processes the teacher wants the students to demonstrate. The appropriateness of the techniques therefore rests on the content, the instructional strategies used, the level of the development of the students, and what is to be assessed. The environment and culture of the students must also be considered.

Various assessment techniques are listed below. The techniques listed are meant to serve only for reference, since the teacher exercises professional judgement in determining which techniques suit the particular purposes of the assessment. For further information on the various assessment strategies and types of instruments that can be used to collect and record information about student learning, refer to the *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991).

A Reference List of Assessment Strategies

1. **Student Classroom Performance**

A: **Teacher observed**
- A.1 Anecdotal records
- A.2 Observation checklists
- A.3 Rating scales

B: **Student activities**
- B.1 Contracts
- B.2 Laboratory reports
- B.3 Major projects and written reports
- B.4 Portfolios
- B.5 Self- and peer-assessment
- B.6 Test stations

2. **Student Test Performance**

- 2.1 Essay
- 2.2 Matching item
- 2.3 Multiple choice
- 2.4 Oral
- 2.5 Performance test
- 2.6 Short answer
- 2.7 True/false

Student Assessment in Science

At the start of any class, a teacher has a group of new students. The students are new, even if they know each other or the teacher, because they will be dealing with different material, from a different point of view, within an evolving system of interactions. The factors of scientific literacy and the learning objectives for the curriculum become the criteria by which to assess the student. These may be attainable by the majority of students, but for some they will be outside their capabilities. Adaptations to expectations or procedures will be required.

A teacher must be aware that "graded" teaching resources and standardized tests are built on what is accepted as normal or average for a student of that age group and often for a specific segment of society. In using standardized tests a teacher is assessing how a child matches these cultural standards over a very narrow range of skills. The results must be considered in that context. This measure may be unattainable by some students. Alternately, some students may not reach full potential because they are not challenged but are allowed to remain at the acceptable "average". The Adaptive Dimension recognizes that the needs of all students must be considered for effective teaching and learning to occur.

In assessing the factors of scientific literacy, methods can be established for addressing knowledge (Dimensions A, B, D), values (Dimensions G and F), and abilities (Dimensions C and E) in ways that suit the nature of the factor.

The factors of scientific literacy in Dimensions A through E can be assessed through manipulation of factual knowledge. However, it is quite possible to assess only factual knowledge and this is a fault of much current student assessment. When examined, this assessment is often little more than simple recall or limited application of facts. When assessment does go further and appears to include abilities, often too much emphasis is still devoted to straight recall. Students deserve to be assessed on the range of abilities they have been using. The overall assessment plan should reflect the students' different learning styles, and different ways of displaying their learning and the nature of the abilities being assessed. Self-referenced assessment may be encouraged.

Assessment can be oral, written, practical, or some combination of these. Practical exercises are the best way to assess scientific and technical knowledge and skills (Dimension E). For example, reading a thermometer diagram is not the same as knowing how best to use and place the thermometer in order to measure temperature. The best way to assess whether students can perform an activity is to observe them while they are actually performing the activity. Ask them probing questions. The use of anecdotal records, observation checklists, and rating anecdotal records, observation checklists, and rating scales can assist in data collection when these observations have taken place.

The types of tasks and questions which students are expected to address influence their responses. When the tasks and questions are limited, so are the responses. Tasks and questions which elicit only one word or simple sentence answers test only basic recall of factual knowledge. It is very important to consider that once students have, for example, formulated a model in a particular context during a science activity, if that exact same context is given in the assessment, the response is only recall, and not a test of any conceptual or process ability. Assessment must require slightly different conditions so the ability is tested through a new set of events.

Good questioning is extremely important for effective teaching and testing. Avoid questions where there is only a single response. Structure questions so some type of reasoning is required. How? Why? Explain . . . Present problem solving activities. Develop Critical and Creative Thinking. All of these things promote and challenge higher level thinking.

Students may be asked to interpret a graph or photograph, or to answer a question orally. Assessment does not have to consist totally of written work. Varied formats adapt to students' differing learning styles.

Summative assessment items following the completion of a unit can cover more scope and depth than formative assessment items. Apart from the scope and depth of the activities selected, the format of summative assignments can be just as varied, including practical tasks (to reflect practical knowledge and abilities), interpretation of graphs and photographs, and investigative problems and assignments.

Multiple choice, true or false, or fill-in-the-blank tests usually assess only basic factual recall. Such tests should be used as little as possible and fewer "marks" should be awarded them in comparison with those items that require process abilities.

Essay questions are more useful tests. They can promote the processes of science and can be used in both formative and summative assessment. For those students who have difficulty writing, discuss the essay topic for the assessment. Illustrations or art projects, an oral report, a concept map, a project, journal writing, or a Science Challenge activity may serve as innovative alternatives to the written essay.

Projects are useful items for recording as summative assessments, because they usually cover a topic in depth as well as scope. They also involve the use of a range of process abilities. Difficulties might arise in assessing the individual participation of each child, if the project is a group effort. The contributions and participation of individuals within a group can often be determined by observing the ways in which the group members interact with one another and with other members of the class or by using student self-assessment. The number and type of assignments completed in a learning centre can also be recorded as a summative assessment. Test stations are particularly useful for allowing students to demonstrate competence.

Assessing values is the most difficult of all the areas of assessment and evaluation. At one time, values were not considered a part of the school's written curriculum. Parents and society certainly required that students develop acceptable behaviours and attitudes, but these were promoted through the "hidden curriculum" – the teachers' and school's influences. Now, specific attitudes and values are to be openly promoted in students, so the teacher's influence must be directed to these objectives. Accordingly, they must be assessed. For further information on values review Chapter VI in *Understanding the Common Essential Learnings: A Handbook for Teachers* (Saskatchewan Education, 1988).

There are valid reasons to assess students' value and attitude outcomes at school and to attempt to promote these with effective teaching methods and individual student reflection. Since the values listed in Dimensions F and G of the factors of scientific literacy may be developed over time, teachers should be emphasizing many of the same values through the grades, but developing them to higher levels. This reinforcement helps to take students to a point where the level achieved may become a feature of their characters, and may continue to develop further in adult life.

Through the school years, students display their current values and attitudes by what they say, write, and do. These three actions can be used for assessment purposes. When a value or attitude is observed, record the observation.

Record-Keeping

To aid data collection in order for the factors of scientific literacy to be addressed in student assessment, checklists have been included in the *Science Program Overview and Connections K-12* and in this guide. Teachers should adapt these to suit their needs.

Teachers often differ in the way they like to collect data. Some prefer to have a single checklist, naming all the students in the class (or in one work group) across the top and listing the criteria to be assessed down the side. The students' columns are then marked if a criterion is met. In this case some information would have to be transferred later to a student's individual profile.

Other teachers prefer to have one assessment sheet per student, which is kept in the profile. That sheet would list the factors for assessment down the side, but along the top might be a series of dates indicating when assessment took place. Such an individual file would illustrate development over the year. In this case, information might have to be transferred from the profile to the official class mark book, as required.

Examples of these types of assessment sheets are also given in *Science Program Overview and Connections K-12.*

Program Evaluation

Program evaluation is a systematic process of gathering and analyzing information about some aspect of a school program in order to make a decision, or to communicate to others involved in the decision-making process. Program evaluation can be conducted at two levels: relatively informally at the classroom level, or more formally at the classroom, school, or school division levels.

At the classroom level, program evaluation is used to determine whether the program being presented to the students is meeting both their needs and the objectives prescribed by the province. Program evaluation is not necessarily conducted at the end of the program, but is an ongoing process. For example, if particular lessons appear to be poorly received by students, or if they do not seem to demonstrate the intended learnings from a unit of study, the problem should be investigated and changes made. By evaluating their programs at the classroom level, teachers become reflective practitioners. The information gathered through program evaluation can assist teachers in program planning and in making decisions for improvement. Most program evaluations at the classroom level are relatively informal, but they should be done systematically. Such evaluations should include identification of the areas of concern, collection and analysis of information, and judgement or decision making.

Formal program evaluation projects use a step-by-step problem-solving approach to identify the purpose of the evaluation, draft a proposal, collect and analyze information, and report the evaluation results. The initiative to conduct a formal program evaluation may originate from an individual teacher, a group of teachers, the principal, a staff committee, an entire staff, or central office. Evaluations are usually done by a team, so that a variety of background knowledge, experience, and skills are available and the work can be shared. Formal program evaluations should be undertaken regularly to ensure programs are current.

To support formal school-based program evaluation activities, Saskatchewan Education has developed the *Saskatchewan School-Based Program Evaluation Resource Book* (1989) to be used in conjunction with an inservice package. Further information on these support services is available from the Evaluation and Student Services Division, Saskatchewan Education.

Curriculum Evaluation

During the decade of the 1990's, new curricula will be developed and implemented in Saskatchewan. Consequently, there will be a need to know whether these new curricula are being effectively implemented and whether they are meeting the needs of students. Curriculum evaluation, at the provincial level, involves making judgements about the effectiveness of provincially authorized curricula.

Curriculum evaluation involves the gathering of information (the assessment phase) and the making of judgements or decisions based on the information collected (the evaluation phase), to determine how well the curriculum is performing. The principal reason for curriculum evaluation is to plan improvements to the curriculum. Such improvements might involve changes to the curriculum document and/or the provision of resources or inservice to teachers. It is intended that curriculum evaluation be a shared, collaborative effort involving all of the major education partners in the province. Although Saskatchewan Education is responsible for conducting curriculum evaluations, various agencies and educational groups will be involved. For instance, contractors may be hired to

design assessment instruments; teachers will be involved in instrument development, validation, field testing, scoring, and data interpretation; and the cooperation of school divisions and school boards will be necessary for the successful operation of the program.

In the assessment phase, information will be gathered from students, teachers, and administrators. The information obtained from educators will indicate the degree to which the curriculum is being implemented, the strengths and weaknesses of the curriculum, and the problems encountered in teaching it. The information from students will indicate how well they are achieving the intended objectives and will provide indications about their attitudes toward the curriculum. Student information will be gathered through the use of a variety of strategies including paper-and-pencil tests (objective and open-response), performance (hands on) tests, interviews, surveys, and observation.

As part of the evaluation phase, assessment information will be interpreted by representatives of all major education partners including the Curriculum and Evaluation Divisions of Saskatchewan Education and classroom teachers. The information collected during the assessment phase will be examined, and recommendations, generated by an interpretation panel, will address areas in which improvements can be made. These recommendations will be forwarded to the appropriate groups such as the Curriculum and Instruction Division, school divisions and schools, universities, and educational organizations in the province.

All provincial curricula will be included within the scope of curriculum evaluation. Evaluations will be conducted during the implementation phase for new curricula, and regularly on a rotating basis thereafter. Curriculum evaluation is described in greater detail in the document *Curriculum Evaluation in Saskatchewan* (Saskatchewan Education, 1991).

Program Organization

Facilities and Materials

Facilities and materials, by themselves, do not create a science course. They are essential, but proper use of the facilities and materials is what is critical. Generally, the facilities which exist in most schools offering Secondary Level science courses will be adequate for teaching Science 10.

Since a wide range of teaching strategies is desirable in this course, more flexible teaching areas are useful. This might be a well designed laboratory which can be reconfigured to accommodate small group discussions, small group and large group laboratory activities, lectures, research work or other activities. Or, it may be a combination of two or more existing rooms.

Some features of a good science laboratory/facility are:

- two exits, remote from each other;
- master shut-off controls for the water, natural gas, and electrical systems. These should be easily accessible and easy to operate;
- a spacious activity area where students can work without being crowded or jostled;
- safety equipment which is visible and accessible to all;
- a ventilation system which maintains negative pressure in the lab;
- enough electrical outlets to make the use of extension cords unnecessary. The plugs should be on a ground fault interruptor system or individually protected;
- emergency lighting;
- separate, locked storage rooms and preparation rooms to which students' access is restricted;
- adequate shelving so that materials do not have to be stacked, unless it is appropriate to store them that way;
- a separate chemical storage cabinet with provisions for proper storage of all classes of chemicals;
- an audiovisual storage area for charts, video and audio tapes, slides, and journals;
- areas for plant and animal care; and,
- a storage area for student assignments.

Materials which are normally available in a Secondary Level science laboratory will be adequate for doing most of the activities in Science 10. Other materials may be needed, but they are readily available from suppliers of science materials.

Science equipment and supplies are valuable resources. Not only are they becoming more expensive, but they are also indispensable to the proper presentation of science. There are several reasons for having an efficiently operating inventory system. Such a system can prevent running short of a consumable supply, prevent ordering something already in adequate supply, and save time when ordering. It can act as a quick reference to determine whether a particular item is available. It may also be useful for insurance purposes.

In addition to inventory control, maintenance and storage are important considerations. A regular procedure for maintenance ensures that the equipment is ready for use when it is needed and is in safe operating condition. Adequate storage space ensures that the equipment can be preserved in good condition and that it is safely away from unauthorized use. It also helps convey the message that laboratory equipment and supplies are not toys, and that a lab is not a place to play with equipment.

Safety

Safety in the classroom is of paramount importance. Other components of education – resources, teaching strategies, facilities – attain their maximum utility only in a safe classroom. Safety is no longer simply a matter of common sense. To create a safe classroom requires that a teacher be informed, be aware, and be proactive. There are several ways the teacher can become informed. Check these reading materials.

Safety in the Secondary Science Classroom. (1978). National Science Teachers Association, 1742 Connecticut Avenue North West, Washington, D.C. 20009.

A Guide to Laboratory Safety and Chemical Management in School Science Study Activities.

(1987). Saskatchewan Environment and Public Safety, Regina.

Safety sessions are often offered at science teachers' conventions. Many articles in science teachers' journals provide helpful hints on safety. Professional exchange may provide teachers with an outside viewpoint on safety.

Awareness is not something that can be learned as much as it is developed through a visible safety emphasis: safety equipment such as a fire extinguisher, a fire blanket, and an eye wash station prominently displayed; safety posters on the wall; a "safety class" with students at the start of the year; and regular emphasis on safety precautions while preparing students for activities.

Proaction is accomplished by acting on what is known and on what one is aware of. Six basic principles guide the creation and maintenance of a safe classroom.

- Model safe procedures at all times.
- Instruct students about safe procedures at every opportunity. Stress that they should remember to use safe procedures when experimenting at home.
- Close supervision of students at all times during activities, along with good organization, can avert situations where accidents and incidents can occur. Inappropriate behaviours in a classroom, and more particularly in a laboratory, can result in physical danger to all present and destroy the learning atmosphere for the class.
- Be aware of any health or allergy problems that students may have.
- Display commercial, teacher-made, or student-made safety posters.
- Take a first aid course. If an injury is beyond your level of competence to treat, wait until medical help arrives.

To compile a complete list of safety tips is impossible. To compile a comprehensive list would be to duplicate the materials which have been referenced previously. To compile a "highlights" list would be to risk leaving out something important. To compile no list would be negligent. What follows is a highlight list. This list does not diminish the responsibility of each teacher to be functioning at the highest level with respect to creating a safe classroom climate.

- Check your classroom for hazards on a regular basis.
- Create a bulletin board with a safety theme.
- Make a rule that all accidents must be reported to the teacher.
- In case of a serious accident, pick one person who is present and send that person for expert, professional, or additional help. Then, take action. Remember, you are in charge of the situation.
- Become familiar with the school division's accident policy.
- Do not give medical advice.
- Move an injured person as little as possible until the injury assessment is complete.
- Emphasize that extra caution is needed when using open flames in the classroom.
- Require the use of goggles when using open flames, corrosive chemicals or other identifiable hazards.
- In case of fire, your first responsibility is to get students out of the area. Send **a specific person** to give an appropriate alarm. Then assess the situation and act.
- Avoid overloading shelves and window sills.
- Properly label all containers of solids, liquids, and solutions.
- Separate broken glass from other waste.
- Advise students not to touch, taste, or smell chemicals unless instructed to do so.
- Each laboratory should have one first aid kit which is not accessible to students, but is only for the teacher's or administrator's use.
- Master shut-off controls for gas, electricity, and water should be tested periodically to ensure that they are operable.
- Safety equipment such as fire extinguishers, fire blankets, eye wash stations, goggles, fume hoods, test tube spurt caps, and explosion shields must be kept in good order and checked regularly.

- Electrical cords must be kept in good condition, and removed from outlets by grasping the plug.

- Students should use safety equipment – protective eye wear, protective aprons or coats, fume hoods, etc. – whenever practical and necessary.

- Students should tie back long hair and refrain from wearing loose and floppy clothing in the laboratory.

- Students should not taste any materials, eat, drink, or chew gum in a laboratory.

- Students should follow recommended procedures and check with teachers before deviating from such procedures.

- Students should be required to return laboratory equipment to its proper place.

- Chemicals or solutions should never be returned to stock bottles.

- Pipetting should be done only with a safety bulb, never by mouth.

- Acids or oxidizers should never be mixed with compounds containing chlorine (e.g., bleach).

- Mercury thermometers should be replaced with alcohol thermometers.

- Asbestos centred wire mats should be replaced with plain wire mats or with ceramic centred mats.

- The use of human biological fluids in laboratory activities should be closely monitored.
    - Students should use only materials from their own body – blood, saliva, epithelial cells – when doing lab activities requiring those materials.
    - Students should have no contact with bodily fluids from another student.
    - The lancets used to obtain blood samples must be the disposable type, and must be used only once.
    - The lancets must be immediately and properly disposed.
    - Alcohol prep pads should not be used more than once.
    - Students should wash their hands thoroughly with soap and water after handling any bodily fluids.

- Specimens for dissection, dissecting tools and equipment, and chemicals used in biology must be kept under locked storage.

- When field materials such as pond or slough water, plants, soil, or insects are collected, assume that they are contaminated by pathogens and treat them as such.

- Known pathogens should not be cultured. Exposure plates and culture plates with unknown bacterial colonies must be treated as though they are contaminated by pathogens until it can be shown otherwise.

- Make sure that autoclaves are in good operating condition.

- Adequate ventilation is essential when working with specimens preserved in formalin or formaldehyde.

- Proper care must be given to animals kept in a classroom. Refer to a good animal care book, if needed.

- Use rubber gloves and take great care when handling any plant growth hormones such as colchicine, gibberellic acid, indole acetic acid, or Rootone(TM).

- Chemicals should be stored in a locked area, to which access is restricted.

- Be prepared to handle all chemical spills rapidly and effectively.

- Inspect glassware (e.g., beakers, flasks) for cracks and chips before using them to heat liquids or hold concentrated corrosive liquids or solutions.

- Many plants may contain toxins or allergens. Students should be cautioned not to taste or handle plants. Teachers are responsible for familiarizing themselves with any local, provincial, or federal legislation pertaining to plants and animals. If in doubt, inquire.

- Chemical storage should be organized by groups of compatible compounds, rather than by alphabetical order. (Within a group of compatible compounds, alphabetizing can be used.)

- Electrical equipment (e.g., transformers, induction coils, electrostatic generators, oscilloscopes, discharge tubes, Crookes tubes, magnetic effects tubes, lasers, fluorescent effects tubes and ultraviolet light sources) must be kept in locked storage.

- Discharge tubes can produce x-rays which may penetrate the glass of the tube if operating voltages higher than 10 000 volts are used.

- Lasers are capable of causing eye damage. The lens of the eye may increase the intensity of light by 1 000 000 times at the retina compared to the pupil. To reduce risk, lasers rated at a maximum power of 0.5 mW should be used.

  - Lasers should be used in normal light conditions so pupils are not dilated.
  - Everyone should stay clear of the primary and reflected paths.
  - Everyone should be alert to unintended reflections.

- Contact lenses complicate eye safety. Dust and chemicals may become trapped behind a lens. Gases and vapours may cause excessive watering of the eyes and enter the soft material of the lens. Chemical splashes may be more injurious due to the inability to remove the lens rapidly and administer first aid. The loss or dislodging of a contact lens may caus . safety problem if it happens at a crucial moment.

  On the other hand, contacts, in combination with safety eye wear, are as safe as eyeglasses in most cases. Contacts may prevent some irritants from reaching the cornea, thus giving the eye some measure of protection. The Saskatchewan Association of Optometrists feels that, as long as proper, vented safety goggles are worn, there is no greater risk in a lab situation for a person wearing contacts than for one not wearing contacts. The Association recommends that:

  - teachers know which students wear contact lenses;

  - teachers know how to remove contact lenses from students' eyes should the need occur;

  - there be access to adequate areas for the removal and maintenance of contact lenses; and,
  - contact lens wearers have a pair of eye glasses to use in case the contact lenses must be removed.

A Broader Look at Safety

Normally, safety is understood to be concerned with the physical safety and welfare of persons, and to a lesser degree with personal property. The definition of safety can also be extended to a consideration of the well-being of the biosphere. The components of the biosphere – plants, animals, earth, air and water – deserve the care and concern which we can offer. From knowing what wild flowers can be picked to considering the disposal of toxic wastes from Secondary Level laboratories, the safety of our world and our future depends on our actions and teaching in science classes.

The Workplace Hazardous Materials Information System (WHMIS) under the **Hazardous Products Act** governs storage and handling practices of chemicals in school laboratories. All school divisions should be complying with the provisions of the Act.

Disposing of Chemicals

Some precautions should be followed when disposing of chemicals.

- The disposal of liquid or aqueous wastes from categories 1 and 2 should involve dilution before pouring them down the drain, then running tap water down the drain to further dilute their strength. See *A Guide to Laboratory Safety and Chemical Management in School Science Study Activities.*

- Solid wastes should be rinsed thoroughly with water. They should be disposed of in a specially marked waste container – not the general class waste basket. The janitor should be alerted to the existence of this container and be assured that none of the materials are hazardous.

If, for any reason, substitutions are made for materials, it is the responsibility of the teacher to research the toxicity, potential hazards, and the appropriate disposal of these substituted materials.

Federal, provincial, and municipal regulations regarding the labelling, storage, and disposal of hazardous substances should be followed. Under current Workplace Hazardous Materials Information System (WHMIS) regulations, all employees involved in handling hazardous substances must receive training by their employer. For more information, contact the Canadian Centre for Occupational Health and Safety, or Saskatchewan Human Resources, Labour and Employment.

Measurement

An understanding of the importance of measurement in science is critical for each student to acquire. The importance of measurement can be seen when it is viewed as one component of the Common Essential Learning of Numeracy. There is an implicit assumption in science, and in society, that quantitative statements are more authoritative than are qualitative statements. Yet, many important advances in science are made through intuition and through creative leaps. Advances in science are not restricted to data analysis. Students must see that measurement is important, but important in its context.

To make quantitative statements, measurements must be made. The accuracy of the measurements determines the confidence placed in the facts which are derived from the measurements. If the facts are represented as being accurate, the measurements must be equally accurate. But accuracy is not the only factor to consider when measurement is discussed.

The ability to make measurements depends on the technology available. A metre stick can be used to measure the length of a table. What technology is available to measure the diameter of an atom? Such measurements require a greater degree of faith in the technology. At the furthest reaches of scientific inquiry, technology must be devised so that the results of exotic experiments can be detected, measured, and interpreted. What is measured depends upon the assumptions made in the design, and on the limitations of the technology.

The ability to make measurements depends on the correct use of the technology. Proper procedures must be followed, even with the use of simple devices such as thermometers, if measurements which accurately represent the system under observation are to be made. In addition to proper procedures, the measurement devices must be used appropriately. Even though a thermometer has a ruled scale, to measure the length of a pencil in degrees Celsius is not a useful way to represent length.

There must be as little interaction as possible between the technology, or application of it, and the object being measured. If the device used to measure the temperature of a system changes the temperature of that system by a significant amount, how useful is the measurement? Heisenberg faced a similar problem in attempting to determine the momentum and the position of the electron in the atom. Precision in determining one results in less information about the other.

Before the matter of accuracy is addressed, the student must have an understanding of what technology is available, its appropriateness for the situation, the proper use of that technology, and the limits which are inherent in the technology. Once that is understood, the student can then manipulate the technology to give the most accurate and precise results.

One aspect of accuracy pertains to the matter of uncertainty in measurement. The percentage error in a measurement, or the absolute error, is a concept which students must deal with. No measuring instrument has zero margin of error. No operator is capable of using an instrument so that no measurement error is introduced. Measurement error exists and must be accounted for in recording and interpreting data. A particular balance may have an uncertainty of measurement of 0.01 g, for example, if the balance is levelled, properly adjusted, and working well. This balance has a suitable accuracy for measuring a mass of 142.87 g but not for measuring a mass of 0.03 g. Calculate the percentage error in each case and the point is clear. However, the 0.007% measuring error for the 142.87 g mass which is due to the balance may be made entirely insignificant by operator errors such as having the balance pan on the wrong hook, misreading the scale, not zeroing the balance before starting, stopping the oscillation of the beam with a finger, using a wet or dirty pan, and so on. Accuracy requires both good technology and good technique.

Another concern is that of significant figures. Measuring instruments can only supply a limited degree of accuracy. The problem most often encountered with students is to have them make use of the maximum precision possible, without having them overstate their case. If seven identical marbles have a total mass of 4.23 g, the average mass of a marble is not 0.604 285 714 g. A more reasonable report would express the average mass rounded off to two decimal places.

Many science texts have sections dealing with the reporting of uncertainty in measurement and significant figures. Each teacher of Science 10 should find an approach that is

comfortable for both the teacher and the students and then adopt and emphasize that approach.

Data analysis is an important related topic. Often, in order to make sense of measurements, data must be organized and interpreted. Students must learn to organize their data collection and recording so that it is ready for analysis. Graphical analysis is often useful and should be stressed. The use of computer software is also an option for recording and analysis. Databases can be used to store and then manipulate large amounts of data. Spreadsheets are also useful for organizing data. Many database and spreadsheet programs, as well as integrated software packages, contain graphing utilities and may contain statistical analysis options. Graphing and statistical analysis packages may also be purchased as stand-alone software. The use of computer analysis should be encouraged wherever possible.

In addition to the use of computer analysis, hardware interfaces to allow the input of data through sensors, which the software then interprets as measurements, are a valuable addition to a science lab. It should be emphasized that the use of a computer does not mean that the results will be error free. Accuracy is mainly a function of the technician and, to a lesser degree, of the technology.

Measurements should be expressed using SI units, or SI acceptable units, whenever this is realistic or feasible to do so. Common non-metric units may be used if necessary. Conversion factors from non-SI to SI or within the non-SI units may be necessary. Each teacher should follow the recommendations of the Canadian Metric Commission with respect to the basic and derived units of measurement and the proper symbols for those units.

If detailed information is required, refer to the *Canadian Metric Practice Guide* (CAN3-Z234.1-79 from the Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario M9W 1R3), the *International System of Units (SI)* (CAN3-Z234.2-76 from the CSA) or the *SI Metric Guide for Science* (Saskatchewan Education, 1978).

Scientific notation should be used so that students become familiar with reading, manipulating, and writing numbers in that format. In addition to the value of SI-notation for ease in handling very large or very small numbers, students must be able to use this notation to express the number of significant figures in a large number, and to perform calculations using scientific notation.

Organizing a Field Trip

Field trips can and should be valuable learning experiences which allow students to apply their classroom learnings to an actual or "real" situation. Field trips also allow students the opportunity to learn directly rather than indirectly. Learning is enhanced through direct experience. Field trips are fun for everyone involved!

The key to successful field trip experiences is careful and thorough planning. This planning takes time and patience. Make sure to check to see if the school division has any special policies regarding field trips.

The simplest approach when planning a field trip is to treat the experience like the writing of a newspaper article, using the five Ws.

Why do you want to take your class on this particular trip?

- Is this mainly a science activity or does it integrate activities in other subjects as well?
- Are the planned activities valid learning experiences?

What learnings do you expect your students to gain from and apply to this experience?

- Have objectives for the field trip been established?
- Have appropriate activities and instructional approaches been selected?
- Have you and your students done your background research?
- Are expectations about student behaviour on the trip clear and realistic?

Where do you plan on going with your class?

- Is it accessible to all students?
- Is permission of landowners or officials required in order to visit this site?
- Does the site have facilities such as bathrooms, lunch areas, shelters, appropriate emergency facilities, etc.?
- Is it possible for you to visit the site beforehand?
- Are locations established at which various activities will occur?

When do you plan on taking this field trip?

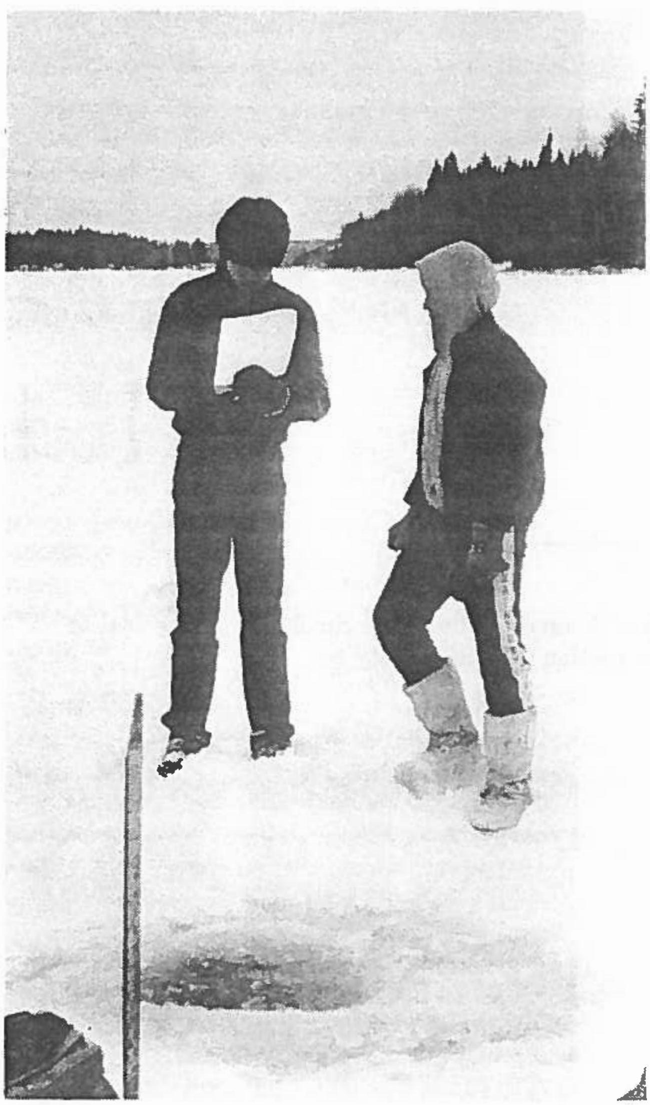
- Is there adequate time to plan the trip?
- Will relevant information be provided to students **before** the field trip?

- Is there adequate time **after** the field trip to do a wrap-up?
- Are there any potential conflicts with the selected date?
- Does the selected date indicate the need for special clothing or supplies?
- Is there a contingency plan in case of bad weather?
- Has parental consent been obtained?

How are you going to get to the site?

- Will transportation be required?
- Is appropriate transportation available and affordable?

- Can the students be learning during the trip to the site?



How long will this particular trip be?

- Can time be used efficiently and effectively?
- Is there too much to do and too little time?

How does the field trip affect the rest of the school?

- Will someone else have to do additional supervision duties?
- Will others have to change their planned activities?
- Will a substitute teacher be required?

Who is coming with you on the field trip?

- Are there sufficient supervisors for the number of students involved?
- Have the people in your community been utilized for their expertise?
- Has the class been divided into working groups?
- Have leaders responsible for coordinating the groups' activities been selected for the working groups?

Although this may seem like a great deal of work, planning should be done **before** embarking on a field trip. The more concrete and detailed the planning is, the more likely it is that the trip will be a success.

Once the groundwork has been set and administrative approval has been obtained, approach the parents and the students about the trip. It is advisable to send a letter home to the parents which details the proposed field trip. Include information on such things as the times of departure and return, the location of the field trip, the people responsible for supervision, clothing requirements, lunch plans, required materials, anticipated costs, and contingency plans. This letter could also include a request for parental help and a separate permission slip to be returned to the teacher. It is a good idea to have the letter signed by both the teacher and the principal before sending it to parents.

The parental consent form which follows serves as an example of one that could be used. Note that the use of a consent form does not remove the teacher or the school division from the possibility of incurring liability during the trip.

Sample Permission Form for Field Trips

Date:

Dear Parent/Guardian:

As a part of the Science 10 program, we will be going on a field trip to ____________. This field trip will provide your child with the opportunity to experience the following: (provide a brief list of the activities you have planned).

An itinerary and a schedule of our proposed activities during the field trip is included for your information. Please review this material and contact the school if you have any questions about our plans.

Your child should bring the following supplies on the field trip: (list any special needs). If your child has any special physical or medical problems (e.g., allergies), please bring this to our attention. Contact the school if you feel that these problems may interfere with your child's participation in this activity.

We would like you to come along on this exciting learning experience. We encourage you to sign up as a volunteer. Thank you for your cooperation.

____________________ ____________________

Teacher Principal

Consent Form

I will be able to take part in this field trip as volunteer.

Yes __ No __

Comments: ____

I permit my child to take part in the field trip described above. I have notified the school of any physical or medical problems which might interfere with my child's participation in this activity.

Date:

Signature:

Aids for Planning

Scope and Sequence of the Factors Forming the Dimensions of Scientific Literacy[1]

Dimensions; Factors	Elementary						Middle				Secondary		
	K	1	2	3	4	5	6	7	8	9	10	11	12
A Nature of Science													
1. public/private	—	—	—	—	—	—	—	—	—	—	—	—	—
2. historic	—	—	—	—	—	—	—	—	—	—	—	—	—
3. holistic	—	—	—	—	—	—	—	—	—	—	—	—	—
4. replicable	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
5. empirical	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
6. probabilistic			- -	- -	- -	- -	- -	- -	- -	—	—	—	—
7. unique				- -	- -	- -	- -	- -	—	—	—	—	—
8. tentative							- -	—	—	—	—	—	—
9. human/culture related							- -	- -	- -	- -	—	—	—
B Key Science Concepts													
1. change	—	—	—	—	—	—	—	—	—	—	—	—	—
2. interaction	—	—	—	—	—	—	—	—	—	—	—	—	—
3. orderliness	—	—	—	—	—	—	—	—	—	—	—	—	—
4. organism	—	—	—	—	—	—	—	—	—	—	—	—	—
5. perception	—	—	—	—	—	—	—	—	—	—	—	—	—
6. symmetry	—	—	—	—	—	—	—	—	—	—	—	—	—
7. force	- -	- -	—	—	—	—	—	—	—	—	—	—	—
8. quantification	- -	- -	—	—	—	—	—	—	—	—	—	—	—
9. reproducibility of results	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
10. cause-effect	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
11. predictability	- -	- -	- -	- -	—	—	—	—	—	—	—	—	—
12. conservation	- -	- -	- -	- -	- -	—	—	—	—	—	—	—	—
13. energy-matter		- -	- -	—	—	—	—	—	—	—	—	—	—
14. cycle		- -	- -	—	—	—	—	—	—	—	—	—	—
15. model		- -	- -	—	—	—	—	—	—	—	—	—	—
16. system		- -	- -	—	—	—	—	—	—	—	—	—	—
17. field		- -	- -	—	—	—	—	—	—	—	—	—	—
18. population				- -	—	—	—	—	—	—	—	—	—
19. probability				- -	- -	- -	- -	- -	- -	—	—	—	—
20. theory				- -	- -	- -	- -	- -	- -	- -	—	—	—
21. accuracy						- -	- -	- -	- -	—	—	—	—
22. fundamental entities							- -	—	—	—	—	—	—
23. invariance							- -	—	—	—	—	—	—
24. scale							- -	—	—	—	—	—	—
25. time-space							- -	- -	—	—	—	—	—
26. evolution							- -	- -	- -	—	—	—	—
27. amplification									- -	—	—	—	—
28. equilibrium										- -	—	—	—
29. gradient										- -	—	—	—
30. resonance										- -	—	—	—
31. significance										- -	—	—	—
32. validation										- -	—	—	—
33. entropy										- -	- -	—	—
C Processes of Science													
1. classifying	—	—	—	—	—	—	—	—	—	—	—	—	—
2. communicating	—	—	—	—	—	—	—	—	—	—	—	—	—
3. observing and describing	—	—	—	—	—	—	—	—	—	—	—	—	—
4. working cooperatively	—	—	—	—	—	—	—	—	—	—	—	—	—
5. measuring	—	—	—	—	—	—	—	—	—	—	—	—	—
6. questioning	- -	- -	—	—	—	—	—	—	—	—	—	—	—
7. using numbers	- -	- -	—	—	—	—	—	—	—	—	—	—	—
8. hypothesizing		- -	- -	—	—	—	—	—	—	—	—	—	—
9. inferring		- -	- -	—	—	—	—	—	—	—	—	—	—
10. predicting		- -	- -	—	—	—	—	—	—	—	—	—	—
11. controlling variables		- -	- -	—	—	—	—	—	—	—	—	—	—
12. interpreting data			- -	—	—	—	—	—	—	—	—	—	—
13. formulating models			- -	- -	- -	- -	- -	—	—	—	—	—	—
14. problem solving			- -	- -	- -	- -	- -	- -	- -	—	—	—	—
15. analyzing				- -	- -	- -	—	—	—	—	—	—	—
16. designing experiments				- -	- -	- -	- -	- -	- -	—	—	—	—
17. using mathematics							- -	—	—	—	—	—	—
18. using time-space relationships							- -	- -	—	—	—	—	—
19. consensus making							- -	- -	- -	—	—	—	—
20. defining operationally								- -	- -	- -	—	—	—
21. synthesizing										- -	- -	—	—

[1]Adapted from: Hart, E.P. (1987). *Science for Saskatchewan Schools: Proposed Directions. Field Study, Part B. A Framework for Curriculum Development.* A Saskatchewan Instructional Development Research Unit project funded by Saskatchewan Education.

Dimensions; Factors	Levels												
	Elementary						Middle				Secondary		
	K	1	2	3	4	5	6	7	8	9	10	11	12
D Science-Technology-Society-Environment Interrelationships													
1. science and technology	- -	- -	- -	——	——	——	——	——	——	——	——	——	——
2. scientists and technologists are human		- -	- -	- -	- -	- -	- -	——	——	——	——	——	——
3. impact of science and technology				- -	- -	- -	——	——	——	——	——	——	——
4. science, technology, and the environment				- -	- -	- -	——	——	——	——	——	——	——
5. public understanding gap				- -	- -	- -	- -	- -	- -	——	——	——	——
6. resources for science and technology				- -	- -	- -	- -	- -	- -	——	——	——	——
7. variable positions				- -	- -	- -	- -	- -	- -	- -	——	——	——
8. limitations of science and technology							- -	- -	- -	——	——	——	——
9. social influence on science and technology								- -	- -	- -	——	——	——
10. technology controlled by society										- -	——	——	——
11. science, technology, and other realms										- -	——	——	——
E Scientific and Technical Skills													
1. using magnifying instruments	——	——	——	——	——	——	——	——	——	——	——	——	——
2. using natural environments	——	——	——	——	——	——	——	——	——	——	——	——	——
3. using equipment safely	——	——	——	——	——	——	——	——	——	——	——	——	——
4. using audio-visual aids	——	——	——	——	——	——	——	——	——	——	——	——	——
5. computer interaction	——	——	——	——	——	——	——	——	——	——	——	——	——
6. measuring distance	- -	- -	——	——	——	——	——	——	——	——	——	——	——
7. manipulative ability	- -	- -	- -	——	——	——	——	——	——	——	——	——	——
8. measuring time		- -	——	——	——	——	——	——	——	——	——	——	——
9. measuring volume		- -	——	——	——	——	——	——	——	——	——	——	——
10. measuring temperature		- -	——	——	——	——	——	——	——	——	——	——	——
11. measuring mass			- -	——	——	——	——	——	——	——	——	——	——
12. using electronic instruments						- -	- -	- -	- -	——	——	——	——
13. using quantitative relationships						- -	- -	- -	- -	- -	——	——	——
F Values That Underlie Science													
1. longing to know and understand	——	——	——	——	——	——	——	——	——	——	——	——	——
2. questioning	——	——	——	——	——	——	——	——	——	——	——	——	——
3. search for data and their meaning	——	——	——	——	——	——	——	——	——	——	——	——	——
4. valuing natural environments	——	——	——	——	——	——	——	——	——	——	——	——	——
5. respect for logic	- -	- -	- -	——	——	——	——	——	——	——	——	——	——
6. consideration of consequence	- -	- -	- -	- -	- -	- -	——	——	——	——	——	——	——
7. demand for verification				- -	- -	- -	——	——	——	——	——	——	——
8. consideration of premises										- -	——	——	——
G Science-Related Interests and Attitudes													
1. interest	——	——	——	——	——	——	——	——	——	——	——	——	——
2. confidence	——	——	——	——	——	——	——	——	——	——	——	——	——
3. continuous learner	——	——	——	——	——	——	——	——	——	——	——	——	——
4. media preference	- -	- -	- -	——	——	——	——	——	——	——	——	——	——
5. avocation				- -	- -	- -	——	——	——	——	——	——	——
6. response preference				- -	- -	- -	——	——	——	——	——	——	——
7. vocation				- -	- -	- -	- -	- -	- -	——	——	——	——
8. explanation preference							- -	- -	- -	- -	——	——	——
9. valuing contributors							- -	- -	- -	- -	——	——	——

KEY: - - - - Preparation. Emerging in these grades. Limited focus.
—— Development. Addressed in full, and appropriate to the grade level. Emphasized.

Explanations of the Factors in the Dimensions of Scientific Literacy

A. Nature of Science

The scientifically literate person understands the nature of science and scientific knowledge.

Science is both public and private. Science experiences should introduce students to the private and intuitive aspects of scientific inquiry and discovery as well as to the more formal public aspects of science.

The nature of scientific knowledge is such that it is:

A1 public/private D(K-12)

Science is based on evidence, developed privately by individuals or groups, that is shared publicly with others. This provides other individuals with the opportunity to attempt to establish the validity and reliability of the evidence.

Examples:

After scientists have gathered and organized evidence for their ideas, they publish the evidence and the methods by which it was obtained, so that other scientists may test the validity and reliability of the evidence.

When Pons and Fleischman withheld some of the evidence and procedures for their cold-fusion discovery in order to protect their claims for patent, the principle of public disclosure was violated.

A2 historic D(K-12)

Past scientific knowledge should be viewed in its historical context and not be degraded on the basis of present knowledge.

Examples:

Each refinement of the model of the atom by Thompson, Rutherford, Bohr, and the quantum theorists has relied on the previous work of others.

Selective breeding of corn by the Indian peoples of North America produced a high quality food plant.

A3 holistic D(K-12)

All branches of science are interrelated.

Example:

The structure of molecules is a topic of interest for physicists, chemists, and biologists.

A4 replicable P(K-2), D(3-12)[1]

Science is based on evidence which could be obtained by other people working in a different place and at a different time under similar conditions.

Examples:

Any procedure which is repeated should give similar results.

A group of students all perform the same experiment and discover similarities in their results.

A5 empirical P(K-2), D(3-12)

Scientific knowledge is based on experimentation or observation.

Examples:

The gravitational field strength of the Earth can be determined in the laboratory.

Scientific theories must always be tested experimentally.

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[1] The code **P(K-2)** means that preparation for development of this factor is to take place from kindergarten until grade 2. Development, coded **D(3-12)**, of the factor takes place from grades 3 to 12. Preparation involves such things as the teacher using the term or its concepts and the students being exposed to phenomena which illustrate or involve the factor. Development occurs when the student are encouraged to use the term or its concepts correctly.

A6 probabilistic P(2-8), D(9-12)

Science does not make absolute predictions or explanations.

Examples:

An electron orbital is a region in space where there is the greatest likelihood of finding an electron.

A weather forecaster predicts a 20% chance of precipitation tomorrow.

A7 unique P(3-7), D(8-12)

The nature of scientific knowledge and the procedures for generating new scientific knowledge are unique and different from those in other fields of knowledge such as philosophy.

Examples:

Compare the methods used for weather forecasting by meteorologists and those used by the people producing the forecasts for the Farmer's Almanac.

Compare Galileo's experimental approach to investigating the rate at which heavy and light objects fall and Aristotle's approach, based on reason alone.

A8 tentative P(6), D(7-12)

Scientific knowledge is subject to change. It does not claim to be truth in an absolute and final sense. This does not lessen the value of knowledge for the scientifically literate person.

Example:

As new data become available, theories are modified to encompass the new and the old data. Our understanding of atomic structure has changed considerably for this reason.

A9 human/culture related P(6-9), D(10-12)

Scientific knowledge is a product of humankind. It involves creative imagination. The knowledge is shaped by and from concepts that are a product of culture.

Examples:

Vertebrates, and specifically humans, are regarded as being at the pinnacle of evolution by some people.

The use of biotechnology has resulted in changes in rapeseed to remove erucic acid. This has led to the development of improved varieties of canola oil for human consumption.

B. Key Science Concepts

The scientifically literate person understands and accurately applies appropriate science concepts, principles, laws, and theories in interacting with society and the environment.

Among the key concepts of science are:

B1 change D(K-12)

It is the process of becoming different. It may involve several stages.

Examples:

An organism develops from a egg, matures, and eventually dies.

Stars use up their fuel and thus undergo change.

B2 interaction D(K-12)

This happens when two or more things influence or affect each other.

Example:

Within an ecosystem some animals have to compete for available food and space.

B3 orderliness D(K-12)

This is a regular sequence which either exists in nature or is imposed through classification.

Examples:

Crystal structures can be identified by diffraction techniques because of the regular arrangement of their atoms.

The periodic table of the elements displays an orderly arrangement of elements.

B4 organism D(K-12)

An organism is a living thing or something that was once alive.

Examples:

Whether or not a virus is a living organism is an interesting topic for scientific scrutiny.

Fossils found in sedimentary rock provide evidence of organisms which became extinct a long time ago.

B5 perception D(K-12)

Perception is the interpretation of sensory input by the brain.

Example:

Jet lag may impair the judgement of pilots during landing and takeoff.

B6 symmetry D(K-12)

This is a repetition of a pattern within some larger structure.

Example:

Some molecular structures and living organisms exhibit properties of symmetry.

B7 force P(K-1), D(2-12)

It is a push or a pull.

Example:

The weight of an object decreases at higher altitudes.

B8 quantification P(K-1), D(2-12)

Numbers can be used to convey important information.

Example:

The gravitational force of attraction between two objects can be calculated by using Newton's Law of Universal Gravitation.

B9 reproducibility of results P(K-2), D(3-12)

Repetition of a procedure should produce the same results if all other conditions are identical. It is a necessary characteristic of scientific experiments.

Example:

Heating a pure sample of paradichlorobenzene should cause it to melt at about 50 °C

B10 cause-effect P(K-2), D(3-12)

It is a relationship of events that substantiates the belief that natural phenomena do not occur randomly. It enables predictions to be made. The advent of chaos theory has caused some rethinking of this principle.

Examples:

The acceleration of a cart depends on the unbalanced force acting upon the cart.

Every event has a cause. It does not happen by itself.

B11 predictability P(K-3), D(4-12)

Patterns can be identified in nature. From those patterns inferences can be made.

Example:

When sodium metal reacts with water, the resulting solution turns red litmus paper blue.

B12 conservation P(K-4), D(5-12)

An understanding of the finite nature of the world's resources, and an understanding of the necessity to treat those resources with prudence and economy, are underlying principles of conservation.

Examples:

Insulating a home may reduce the amount of energy needed to heat it in the winter.

Smaller, more efficient internal combustion engines can be designed to use less fuel.

B13 energy-matter P(1-2), D(3-12)

It is the interchangeable and dependent relationship between energy and matter.

Example:

When a candle burns, some of the energy stored in the wax is released as heat and light.

B14 cycle P(1-2), D(3-12)

Certain events or conditions are repeated.

Examples:

The water cycle, nitrogen cycle, and equilibrium all serve as examples of cycles.

Change occurring in cycles or patterns is one of the twelve principles of Indian philosophy.

B15 model P(1-2), D(3-12)

It is a representation of a real structure, event, or class of events intended to facilitate a better understanding of abstract concepts or to allow scaling to a manageable size.

Example:

Watson and Crick developed a model of the DNA molecule which allowed people to gain a better understanding of genetics.

B16 system P(1-2), D(3-12)

A set of interrelated parts forms a system.

Example:

Chemical equilibrium can be established only in a closed system.

B17 field P(1-2), D(3-12)

A field is a region of space which is influenced by some agent.

Examples:

Similarly charged objects have a tendency to repel one another when they are in close proximity.

The sun is the source of a gravitational field which fills space. The Earth's motion is affected by the influence of this field.

B18 population P(3), D(4-12)

A population is a group of organisms that share common characteristics.

Example:

Wildlife biologists monitor white tail deer to determine the number of permits for hunting that will be issued in a particular zone.

B19 probability P(3-8), D(9-12)

Probability is the relative degree of certainty that can be assigned to certain events happening in a specified time interval or within a sequence of events.

Example:

The probability of getting some types of cancer increases with prolonged exposure to large doses of radiation.

B20 theory P(3-9), D(10-12)

A theory is a connected and internally consistent group of statements, equations, models, or a combination of these, which serves to explain a relatively large and diverse group of things and events.

Example:

As new experimental evidence becomes available, atomic theory undergoes further change and refinement.

B21 accuracy P(5-8), D(9-12)

Accuracy involves a recognition that there is uncertainty in measurement. It also involves the correct use of significant figures.

Example:

A stopwatch which measures to the nearest 1/10th of a second would be an inappropriate instrument for determining the duration of a spark discharge.

B22 fundamental entities P(6), D(7-12)

They are units of structure or function which are useful in explaining certain phenomena.

Examples:

The cell is the basic unit of organic structure.

The atom is the basic unit of molecular structure.

B23 invariance P(6), D(7-12)

This is a characteristic which stays constant even though other things may change.

Example:

Mass is conserved in a chemical reaction.

B24 scale P(6), D(7-12)

Scale involves a change in dimensions. This may affect other characteristics of a system.

Example:

A paper airplane made from a sheet of notebook paper may fly differently than a plane of identical design made from a poster-sized sheet of the same paper.

B25 time-space P(6-7), D(8-12)

It is a mathematical framework in which it is convenient to describe objects and events.

Examples:

An average human being has an extension in one direction of approximately 1 3/4 metres and in another direction of about 70 years.

According to general relativity, gravity is not a force, but a property of space itself. It is a curvature in time-space caused by the presence of an object.

B26 evolution P(6-8), D(9-12)

Evolution is a series of changes that can be used to explain how something got to be the way it is or what it might become in the future. It is generally regarded as going from simple to complex.

Example:

Organic evolution is thought to progress in small, incremental changes. Similarly, scientific theories undergo change to accommodate new data as they become available.

B27 amplification P(8), D(9-12)

Amplification is an increase in magnitude of some detectable phenomenon.

Example:

A loudspeaker produces an amplification of sound.

B28 equilibrium P(9), D(10-12)

Equilibrium is the state in which there is no change on the macroscopic level and no net forces on the system.

Examples:

Chemical equilibrium exhibits no change on the macroscopic level.

A first class lever in a condition of static equilibrium remains at rest. The sum of all of the moments of the forces acting is zero.

B29 gradient P(9), D(10-12)

A gradient is a description of a pattern or variation. The description includes both the magnitude and the direction of the change.

Examples:

Light intensity decreases in a predictable manner as the distance from the light source increases.

On a mountain, the direction in which the change of slope is smallest is the most desirable route to build a railroad line.

B30 resonance P(9), D(10-12)

It is an action within one system which causes a similar action within another system.

Examples:

A hollow wooden box can be used to amplify the sound of a tuning fork.

A wine glass can be made to shatter by sound vibrations due to mechanical resonance.

B31 significance **P(9), D(10-12)**

It is the belief that certain differences exceed those that would be expected to be caused by chance alone.

Example:

An analysis of Brahe's data led to the development of Kepler's First Law.

B32 validation **P(9), D(10-12)**

Validation is a belief that similar relationships obtained by two or more different methods reflect an accurate representation of the situation being investigated.

Example:

Carbon-14 dating can be used to check the authenticity of archaeological artifacts.

B33 entropy **P(9-10), D(11-12)**

Entropy is the randomness, or disorder, in a collection of things. It can never decrease in a closed system.

Example:

When solid sodium chloride dissolves in water, its particles are dispersed randomly.

C. Processes of Science

The scientifically literate person uses processes of science in solving problems, making decisions, and furthering understanding of society and the environment.

Complex or integrated processes include those which are more basic. Intellectual skills are acquired and practised throughout life so that eventually some control over these processes can facilitate learning.

This can provide information processing and problem solving abilities that go beyond any curriculum.

Process skills such as accessing and processing information, applying knowledge of scientific principles to the analysis of issues, identifying value positions, and reaching consensus are believed to include the more basic processes of science.

The basic processes of science are:

C1 classifying **D(K-12)**

Classifying is a systematic procedure used to impose order on collections of objects or events.

Example:

Grouping animals into their phyla or arranging the elements into the periodic table are examples of classifying.

C2 communicating **D(K-12)**

Communicating is any one of several procedures for transmitting information from one person to another.

Example:

Writing reports, or participating in discussions in class are examples of communicating.

C3 observing and describing **D(K-12)**

This is the most basic process of science. The senses are used to obtain information about the environment.

Example:

During an investigation, a student writes a paragraph recording the progress of a chemical reaction between hot copper metal and sulphur vapour.

C4 working cooperatively **D(K-12)**

This involves an individual working productively as a member of a team for the benefit of the team's goals.

Example:

Students should share responsibilities in the completion of an experiment.

C5 measuring D(K-12)

An instrument is used to obtain a quantitative value associated with some characteristic of an object or an event.

Example:

The length of a metal bar can be determined to the nearest millimetre with an appropriate measuring device.

C6 questioning P(K-1), D(2-12)

It is the ability to raise problems or points for investigation or discussion.

Example:

A student should be able to create directed questions about observed events. When migratory birds are observed, questions such as, "Why do birds flock to migrate?", "Do some birds migrate singly?", and "How do birds know where to go?" should direct further inquiry.

C7 using numbers P(K-1), D(2-12)

This involves counting or measuring to express ideas, observations, or relationships, often as a complement to the use of words.

Example:

1 litre contains 1 000 millilitres.

C8 hypothesizing P(1-2), D(3-12)

Hypothesizing is stating a tentative generalization which may be used to explain a relatively large number of events. It is subject to immediate or eventual testing by experiments.

Example:

Making predictions about the importance of various components of a pendulum which may influence its period is an example of hypothesizing.

C9 inferring P(1-2), D(3-12)

It is explaining an observation in terms of previous experience.

Example:

After noticing that saline sloughs have a different insect population than fresher sloughs, one might infer that small changes in an environment can affect populations.

C10 predicting P(1-2), D(3-12)

This involves determining future outcomes on the basis of previous information.

Example:

Given the results of the hourly population counts in a yeast culture over a 4 hour period, one could attempt to predict the population after 5 hours.

C11 controlling variables P(1-2), D(3-12)

Controlling variables is based on identifying and managing the conditions that may influence a situation or event.

Examples:

If all other factors which may be important in plant growth are identified and made similar (controlled), the effect of gibberellic acid can be observed.

In order to test the effect of fertilizer on plant growth, all other factors which may be important in plant growth must be identified and controlled so that the effect of the fertilizer can be determined.

C12 interpreting data P(2), D(3-12)

This important process is based on finding a pattern in a collection of data. It leads to a generalization.

Example:

Concluding that the mass of the pendulum bob does not affect the period of a pendulum might be based on the similarity of periods of 100 g, 200 g, and 300 g pendulums.

C13 formulating models P(2-6), D(7-12)

Models are used to represent an object, event, or process.

Example:

Vector descriptions of how forces interact are models.

C14 problem solving **P(2-8), D(9-12)**

Scientific knowledge is generated by, and used for, asking questions concerning the natural world. Quantitative methods are frequently employed.

Example:

A knowledge of genetics and the techniques of recombinant DNA are used to create bacteria which produce insulin.

C15 analyzing **P(3-5), D(6-12)**

It is examining scientific ideas and concepts to determine their essence or meaning.

Examples:

Determining whether a hypothesis is tenable requires analysis.

Determining which amino acid sequence produces insulin requires analysis.

C16 designing experiments **P(3-8), D(9-12)**

Designing experiments involves planning a series of data-gathering operations which will provide a basis for testing a hypothesis or answering a question.

Example:

Automobile manufacturers test seat belt performance in crash tests.

C17 using mathematics **P(6), D(7-12)**

When using mathematics, numeric or spatial relationships are expressed in abstract terms.

Example:

Projectile trajectories can be predicted using mathematics.

C18 using time-space relationships **P(6-7), D(8-12)**

These are the two criteria used to describe the location of things or events.

Example:

Describe the migratory paths of the barren lands caribou.

C19 consensus making **P(6-8), D(9-12)**

Consensus making is reaching an agreement when a diversity of opinions exist.

Examples:

A discussion of the disposal of toxic waste, based on research, gives a group of students the opportunity to develop a position they will be using in a debate.

Scientists were initially divided regarding the cold fusion debate. They held conferences but were still unable to agree on this issue. Further experimental results were needed.

C20 defining operationally **P(7-9), D(10-12)**

It is producing a definition of a thing or event by giving a physical description or the results of a given procedure.

Example:

An acid turns blue litmus paper red and tastes sour.

C21 synthesizing **P(9-10), D(11-12)**

Synthesizing involves combining parts into a complex whole.

Examples:

Polymers can be produced through the combination of simpler monomers.

A student essay may involve the synthesis of a wide variety of knowledge, skills, attitudes, and processes.

D. Science-Technology-Society-Environment Interrelationships

The scientifically literate person understands and appreciates the joint enterprises of science and technology and the interrelationships of these with each other.

Some of the factors involved in the interrelationships among science, technology, society, and the environment are:

D1 science and technology **P(K-2), D(3-12)**

There is a distinction between science and technology, although they often overlap and depend on each other. Science deals with generating and ordering conceptual knowledge. Technology deals with design and development, and the application of scientific or technological knowledge, often in response to social and human needs.

Example:

The invention of the microscope led to new discoveries about cells.

D2 scientists and technologists are human P(1-6), D(7-12)

Outside of their specialized fields, scientists and technologists may not exhibit strong development of all or even most of the Dimensions of Scientific Literacy. Vocations in science and technology are open to most people.

Example:

By researching the biographies of famous scientists, students can begin to appreciate the human elements of science and technology.

D3 impact of science and technology P(3-5), D(6-12)

Scientific and technological developments have real and direct effects on every person's life. Some effects are desirable; others are not. Some of the desirable effects may have undesirable side effects. In essence, there seems to be a trade-off principle working in which gains are accompanied by losses.

Example:

As our society continues to increase its demands on energy consumption and consumer goods, we are likely to attain a higher standard of living while allowing further deterioration of the environment to occur.

D4 science, technology, and the environment P(3-5), D(6-12)

Science and technology can be used to monitor environmental quality. Society has the ability and responsibility to educate and to regulate environmental quality and the wise usage of natural resources, to ensure quality of life for this and succeeding generations.

Example:

Everyone should share in the responsibility of conserving energy.

D5 public understanding gap P(3-8), D(9-12)

A considerable gap exists between scientific and technological knowledge, and public understanding of it. Constant effort is required by scientists, technologists, and educators to minimize this gap.

Examples:

Some people mistakenly believe that irradiation causes food to become radioactive.

Buttermilk is often mistakenly regarded as having a high caloric content.

Folklore has it that the best time to plant potatoes in the spring is during the full moon.

Many believe that technology is simply applied science.

D6 resources for science and technology P(3-8), D(9-12)

Science and technology require considerable resources in the form of talent, time, and money.

Example:

Further advances in space exploration may require the collective efforts of many nations working together to find the necessary time, money and resources.

D7 variable positions P(3-9), D(10-12)

Scientific thought and knowledge can be used to support different positions. It is normal for scientists and technologists to disagree among themselves, even though they may invoke the same scientific theories and data.

Examples:

The debate about the possibility of cold fusion illustrated variable positions among scientists.

There is a debate about whether or not controlled burning techniques should be used in national parks.

D8 limitations of science and technology P(6-8), D(9-12)

Science and technology can not guarantee a solution to any specific problem. In fact, the ultimate solution of any problem is usually impossible, and a partial or temporary solution is all that is ever possible. Solutions to problems can not necessarily be legislated, bought, or guaranteed by the allocation of resources. Some things are not amenable to the approaches of science and technology.

Example:

The solutions that technology now proposes for nuclear waste storage often have significant limitations and are, at best, only short-term solutions until better ones can be found.

D9 social influence on science and technology P(7-9), D(10-12)

The selection of problems investigated by scientific and technological research is influenced by the needs, interests, and financial support of society.

Example:

The race to put a person on the moon illustrates how priorities can determine the extent to which the study of particular scientific and technological problems are sanctioned and thus allowed to be investigated.

D10 technology controlled by society P(9), D(10-12)

Although science requires freedom to inquire, applications of scientific knowledge and of technological products and practices are ultimately determined by society. Scientists and technologists have a responsibility to inform the public of the possible consequences of such applications. A need to search for consequences of scientific and technological innovations exists.

Examples:

Einstein's famous letter to President Roosevelt, warning about the possibility of developing nuclear weapons, and his pacifist views, illustrate the responsibility that scientists must have as members of society.

Governments must make decisions regarding the support and funding of important scientific research.

D11 science, technology, and other realms P(9), D(10-12)

Although there are distinctive characteristics of the knowledge and processes that characterize science and technology, there are many connections to, and overlaps with, other realms of human knowledge and understanding.

Example:

The Uncertainty Principle in science, the Verstehen Principle in anthropology, and the Hawthorne Effect in social psychology all express similar types of ideas within the realm of their own disciplines.

E. Scientific and Technical Skills

The scientifically literate person has developed numerous manipulative skills associated with science and technology.

The list of skills that follows represents manipulative skills important to the achievement of scientific literacy:

E1 using magnifying instruments D(K-12)

Some magnifying instruments include the magnifying lens, microscope, telescope, and overhead projector.

Examples:

Fine dissections of earthworms are done with the aid of stereoscopic microscopes.

A student uses a microphone to make an announcement to a large group over the public address system.

E2 using natural environments D(K-12)

The student uses natural environments effectively and in appropriately sensitive ways (e.g., collecting, examining, and reintroducing specimens).

Example:

Students can do a study of the margin of a pond by observing and describing a particular section at two week intervals for three months. After they collect and examine specimens, they should reintroduce them to their natural environment.

E3 using equipment safely D(K-12)

The student demonstrates safe use of equipment in the laboratory, in the classroom, and in everyday experiences.

Example:

A student recognizes a situation where goggles should be worn, and puts them on before being instructed to wear them.

E4 using audiovisual aids D(K-12)

The student independently uses audiovisual aids in communicating information. (Audiovisual aids include such things as: drawings, photographs, collages, televisions, radios, video cassette recorders, overhead projectors.)

Examples:

A student shows the teacher how to operate the VCR.

A student uses a camera to record natural phenomena.

E5 computer interaction D(K-12)

The student uses the computer as an analytical tool, a tool to increase productivity, and as an extension of the human mind.

Examples:

Using photocells connected to the proper interface, the computer can be used as a timing device.

Logging on to an information service gives students an opportunity to perform a keyword search of a chemical database.

Computer software can be used to simulate a natural event or process which may be too dangerous or impractical to perform in the laboratory.

E6 measuring distance P(K-1), D(2-12)

The student accurately measures distance with appropriate instruments or techniques such as rulers, metre sticks, trundle wheels, or rangefinders.

Examples:

The length and width of a room can be determined using a metre stick.

Large distances can be determined using parallax or triangulation methods.

E7 manipulative ability P(K-2), D(3-12)

The student demonstrates an ability to handle objects with skill and dexterity.

Example:

A student uses a graduated cylinder to measure 35 mL of liquid. The liquid is then transferred into a flask and heated.

E8 measuring time P(1), D(2-12)

The student accurately measures time with appropriate instruments such as a watch, an hourglass, or any device which exhibits periodic motion.

Example:

A student uses an oscilloscope to measure a short time interval accurately.

E9 measuring volume P(1), D(2-12)

The student measures volume directly with graduated containers. The student also measures volume indirectly using calculations from mathematical relations.

Examples:

The volume of a graduated cylinder is read at the curve inflection point of the meniscus.

Archimedes' principle is used to determine the volume of an irregular solid.

E10 measuring temperature P(1), D(2-12)

The student accurately measures temperature with a thermometer or a thermocouple.

Example:

Thermometers must be properly placed to record accurate measurements of temperature.

E11 measuring mass P(2), D(3-12)

The student accurately measures mass with a double beam balance or by using other appropriate techniques.

Example:

Balances may be used to determine the mass of an object, within the limits of the precision of the balance.

E12 using electronic instruments P(5-8), D(9-12)

The student can use electronic instruments that reveal physical or chemical properties, or monitor biological functions.

Example:

Following the recommended procedures allows an instrument to be used to the maximum extent of its precision (e.g., ammeter, oscilloscope, pH meter, camera).

E13 using quantitative relationships P(5-9), D(10-12)

The student uses mathematical expressions correctly.

Examples:

To calculate instantaneous acceleration, find the slope at one point on a velocity versus time graph.

Calculate the volume of a cube given the length of one side.

F. Values That Underlie Science

The scientifically literate person interacts with society and the environment in ways that are consistent with the values that underlie science.

The values that underlie science include:

Fl longing to know and understand D(K-12)

Knowledge is desirable. Inquiry directed toward the generation of knowledge is a worthy investment of time and other resources.

Example:

A group of four students asks the teacher if they can do a Science Challenge project on a topic that they are all interested in.

F2 questioning D(K-12)

Questioning is important. Some questions are of greater value than others because they lead to further understanding through scientific inquiry.

Example:

Students ask questions which probe more deeply than the normal class or text presentation.

F3 search for data and their meaning D(K-12)

The acquisition and ordering of data are the basis for theories which, in turn, can be used to explain many things and events. In some cases these data have immediate practical applications of value to humankind. Data may enable one to assess a problem or situation accurately.

Example:

In a **Science Challenge** activity, a group of students asks a question about a natural occurrence. They then design an experiment in an attempt to answer the question. Variables which may influence the results of the experiment are controlled. Careful observations are made and recorded. Data are collected and analyzed to test the hypothesis that is under scrutiny. Further testing then takes place.

F4 valuing natural environments D(K-12)

Our survival depends on our ability to sustain the essential balance of nature. There is intrinsic beauty to be found in nature.

Example:

On a field trip the actions of the participants should be considerate toward and conserving of all components of the ecosystem.

F5 respect for logic P(K-2), D(3-12)

Correct and valid inferences are important. It is essential that conclusions and actions be subject to question.

Example:

Errors in logic are recognized. Information is viewed critically with respect to the logic used.

F6 consideration of consequence **P(K-5), D(6-12)**

It is a frequent and thoughtful review of the effects that certain actions will have.

Example:

Experimental procedures can affect the outcome of an experiment.

Transporting oil by tankers might cause an oil spill with very serious environmental consequences.

F7 demand for verification **P(3-5), D(6-12)**

Supporting data must be made public. Empirical tests must be conducted to assess the validity or accuracy of findings or assertions.

Example:

Media reports and research are reviewed critically and compared to other sources of information before being accepted or rejected.

F8 consideration of premises **P(9), D(10-12)**

A frequent review should occur of the basic assumptions from which a line of inquiry has arisen.

Examples:

In a lab investigation into the rate of chemical reactions, the control of variables is examined.

A critical examination is made of the factors under consideration in explaining the extinction of dinosaurs.

G. Science-Related Interests and Attitudes

The scientifically literate person has developed a unique view of science, technology, society and the environment as a result of science education, and continues to extend this education throughout life.

Science-related interests and attitudes include:

G1 interest **D(K-12)**

The student exhibits an observable interest in science.

Example:

Students and teachers who spend a great deal of time outside of class on science fair projects exhibit a keen interest in science.

G2 confidence **D(K-12)**

The student experiences a measure of self-satisfaction by participating in science and in understanding scientific things.

Example:

Students and teachers read science literature and are interested in discussing with others what they read.

G3 continuous learner **D(K-12)**

The individual has gained some scientific knowledge and continues some line of scientific inquiry. This may take many forms.

Example:

A person joins a natural history society to learn more about wildlife.

G4 media preference **P(K-2), D(3-12)**

The student selects the most appropriate media, depending on the information needed, and on his or her present level of understanding.

Examples:

Students and teachers who watch science-related television programs demonstrate a real interest in science.

When researching a science project, a student might have to determine which sources of information are most appropriate. The choice could include such things as television programs, newspaper articles, books, public displays, and scientific journals.

G5 avocation P(3-5), D(6-12)

The student pursues a science-related hobby.

Example:

By pursuing a hobby such as bird watching, astronomy, or shell collecting, a student demonstrates a keen interest in science.

G6 response preference P(3-5), D(6-12)

The way in which people behave can be an indication of whether or not they are striving to attain scientific literacy.

Example:

In an election, voters might consider the candidates' positions on environmental issues.

G7 vocation P(3-8), D(9-12)

The student considers a science-related occupation.

Example:

By modelling appropriate behaviours, teachers can encourage their students to become interested in science education or other science-related fields.

G8 explanation preference P(6-9), D(10-12)

The student chooses a scientific explanation over a nonscientific explanation when it is appropriate to do so. The student also recognizes that there may be some circumstances in which it may not be appropriate to select a scientific explanation.

Example:

By resorting to logic in a debate, students demonstrate logical thinking similar to that used in science.

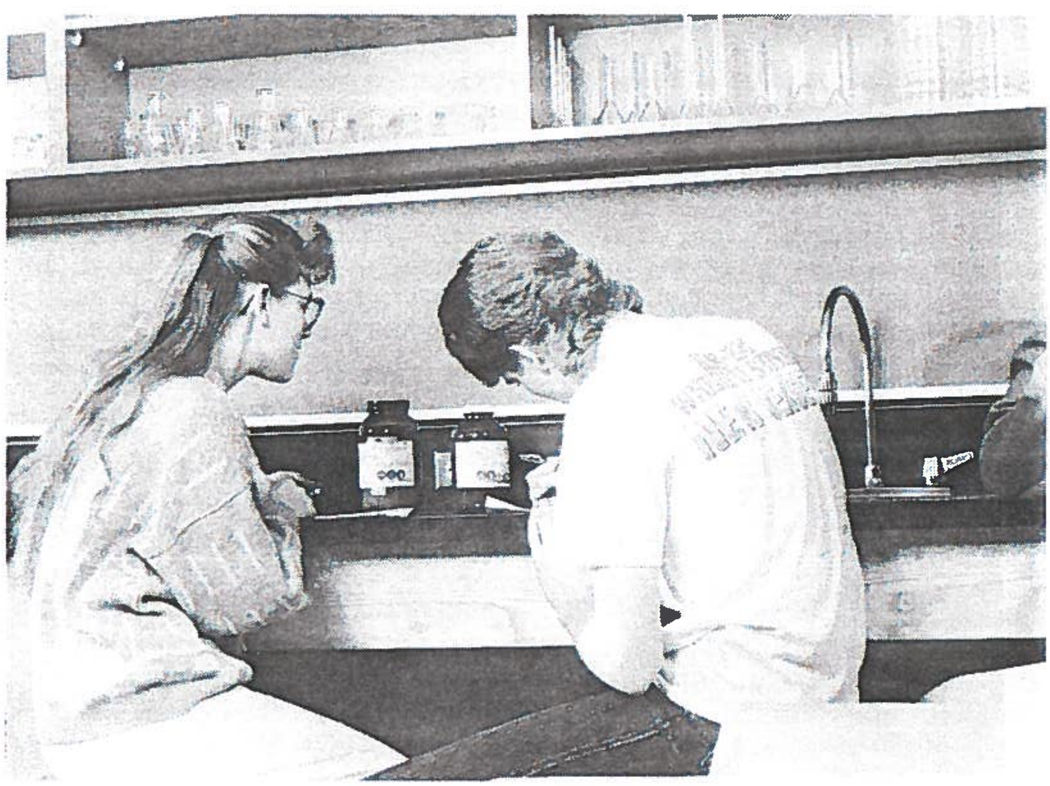
G9 valuing contributors P(6-9), D(10-12)

The student values those scientists and technologists who have made significant contributions to humanity.

Examples:

A person wears a T-shirt bearing the image of some famous scientist.

Some students may hold the science teacher in very high regard.



Templates for Assessment and Evaluation

Rating Scale Template

1) ______________________	1 2 3 4 5
2) ______________________	1 2 3 4 5
3) ______________________	1 2 3 4 5
4) ______________________	1 2 3 4 5
5) ______________________	1 2 3 4 5
6) ______________________	1 2 3 4 5
7) ______________________	1 2 3 4 5
8) ______________________	1 2 3 4 5
9) ______________________	1 2 3 4 5
10) ______________________	1 2 3 4 5
11) ______________________	1 2 3 4 5
12) ______________________	1 2 3 4 5
13) ______________________	1 2 3 4 5
14) ______________________	1 2 3 4 5

Anecdotal Record Template

Report | Subject

Student | School

Teacher | Date

Teacher's Signature

Correspondence Template

Checklist of Laboratory Procedures

____________________ __________
Name Date

____
Activity

Key: 1 = Rarely 2 = Occasionally 3 = Frequently

	1	**2**	**3**
Instructions followed	___	___	___
Safety precautions observed	___	___	___
Equipment handled correctly	___	___	___
Equipment cleaned thoroughly	___	___	___
Equipment stored properly	___	___	___
Lab area kept clean	___	___	___
Spills cleaned promptly	___	___	___
Chemical disposed of properly	___	___	___
Cooperation with others	___	___	___
Improvisation	___	___	___
Appropriate use of time	___	___	___
Observations noted and recorded	___	___	___
Other: ________________	___	___	___
________________	___	___	___
________________	___	___	___

Group Self-Assessment of Laboratory Activities

Group ______________________ Date ____________

Activity ______________________________________

Use these descriptors to assess how effectively your group performed a specific activity. Choose one or several numbers from the list of criteria.

1 = yes	2 = no	3 = we think so
4 = needs improvement	5 = satisfactory	6 = excellent

Things to consider	
Did we develop a clear plan before we began?	
Did each group member have specific things to do?	
Were we able to work together as a team?	
Did we discuss the purpose for doing the activity?	
Was a hypothesis developed and recorded?	
How well did we predict what took place?	
Were instructions followed correctly?	
How well did we use equipment and materials?	
Did we observe all safety precautions?	
Were measurements made accurately?	
How well were data recorded?	
Did we clean up thoroughly after the activity?	
Were the data examined closely to search for meaning?	
Did we use accepted techniques for data analysis?	
Were the conclusions consistent with the data?	
Did we re-examine our initial hypothesis?	
Did we account for experimental error?	
Was relevant research used to support our work ?	
Other:	

Project Presentation — Individual Questionnaire

Your name ____________________ Topic ____________________

Group Members ________________________________ Date ____________________

Circle the following on working within the group. Additional written responses may be included.

1.	I encouraged others.	Seldom	Sometimes	Often
2.	I shared ideas and information.	Seldom	Sometimes	Often
3.	I checked to make sure that others in the group knew what they were doing.	Seldom	Sometimes	Often
4.	I was willing to help others.	Seldom	Sometimes	Often
5.	I accepted responsibility for completing the work properly and on time.	Seldom	Sometimes	Often
6.	I was willing to listen to others in the group.	Seldom	Sometimes	Often
7.	I was willing to receive help from others in the group.	Seldom	Sometimes	Often
8.	I offereu encouragement and support to others in the group.	Seldom	Sometimes	Often
9.	Others in the group shared ideas and information.	Seldom	Sometimes	Often
10.	The group checked with the teacher to make sure we knew what we were supposed to be doing.	Seldom	Sometimes	Often
11.	All members of the group contributed equally to this project.	Seldom	Sometimes	Often

Answer the following questions about working in a group.

12. How did you distribute the workload within your group?

13. What problems, if any, arose within your group?

14. What would you do differently next time?

15. How is working in a group different from working by yourself?

Science Report Evaluation Form*

Name:		Date:
Activity:		
Written Presentation	Weight	Score
Title Page	5	
Introduction	10	
Body	30	
Conclusion	20	
Supporting References	5	
Neatness	10	
Organization	20	
Content		
Communication Skills	25	
Originality	25	
Accuracy	20	
Appropriateness	30	
Creativity	25	
Overall Impression	10	
Total Score	185	
Other Comments:		

* Criteria for an oral presentation may be developed. Teachers are encouraged to develop criteria for each element on this page (e.g, Title page must include title centered left/right and vertically, student's name and class number) and share those with the students before they do their report.

Laboratory Report Evaluation

Name ____________________ Date __________

Activity ____

	Excellent	Good	Satisfactory	Unsatisfactory
Completeness				
Accuracy				
Organization				
Presentation				

Comments: ____

Overall Report Grade: __________

Data Collection/Notebook Checklist*

Name ______________________ Date ____________

A checkmark indicates that the criterion is satisfactory. No mark indicates that the criterion is either missing or unsatisfactory.

Documentation is complete.	
The information or data collected is accurate.	
Written work is neat and legible.	
Tables and diagrams are completed neatly.	
Each new section begins with an appropriate heading.	
Errors are crossed out but not erased.	
Spelling and language usage are edited and corrected.	
Information is recorded in a logical sequence.	
Technological aids are used appropriately.	
Notes are collected in a folder or binder.	
Colour or graphics are used to enhance the appearance.	
Rough work is done separately.	

Comments/Overall Impressions:

____

____

____

____

____

* This checklist may be used by teachers, or by students for self-evaluation. It may be used to evaluate notebooks, laboratory data collection done during investigations, or more formal written laboratory reports. Students should be made aware of these criteria at the start of the term.

Observation of Group Behaviours

____
Student or Group

Activities:

a ______________________________

b ______________________________

c ______________________________

d ______________________________

e ______________________________

f ______________________________

1 = rarely   2 = occasionally   3 = frequently   4 = consistently

	a	b	c	d	e	f
Remains on task						
Follows directions						
Exhibits leadership						
Respects the ideas of others						
Works cooperatively						
Communicates effectively						
Shares tasks equitably						
Works safely						
Handles equipment correctly						
Displays initiative						
Exhibits scientific curiosity						

Science Challenge Suggested Marking Scheme

Name ______________________________

Description of Activity ______________________________

____

____

____

Due Date ______________

	Weight	Score
Content		
Accuracy	5	____
Completeness	10	____
Range of coverage	10	____
Concept attainment	30	____
Presentation of Material		
Layout	5	____
Neatness	5	____
Organization of ideas	10	____
Language usage	10	____
Originality	10	____
Sources acknowledged	5	____
Graphs, tables, and charts	10	____
Supporting exhibits (models, etc.)	10	____
Deadline met	5	____
Interest level	10	____
	____	____
Oral Report	25	
	____	____
Bonus (submitted before due date)	**5**	____
Total		____

Factors of Scientific Literacy Developed in Science 10

These checklists may be used in a variety of ways. Teachers may wish to use them to determine which factors have been covered throughout the entire year to ensure that adequate coverage has been provided for them. The checklists could also be used when covering a particular topic. Once factors which have not been emphasized in that topic have been identified, teachers can then use that information in their planning of subsequent topics to ensure that all of the factors have been given sufficient coverage by the end of the course. Columns for core and optional topics are shown.

Dimension A Nature of Science

Factors							
1. public/private							
2. historic							
3. holistic							
4. replicable							
5. empirical							
6. probabilistic							
7. unique							
8. tentative							
9. human/culture related							

Dimension B Key Science Concepts

Factors							
1. change							
2. interaction							
3. orderliness							
4. organism							
5. perception							
6. symmetry							
7. force							
8. quantification							
9. reproducibility of results							
10. cause-effect							
11. predictability							
12. conservation							
13. energy-matter							
14. cycle							
15. model							
16. system							
17. field							
18. population							
19. probability							
20. theory							
21. accuracy							
22. fundamental entities							
23. invariance							
24. scale							
25. time-space							
26. evolution							
27. amplification							
28. equilibrium							
29. gradient							
30. resonance							
31. significance							
32. validation							

Dimension C Processes of Science

Factors							
1. classifying							
2. communicating							
3. observing and describing							
4. working cooperatively							
5. measuring							
6. questioning							
7. using numbers							
8. hypothesizing							
9. inferring							
10. predicting							
11. controlling variables							
12. interpreting data							
13. formulating models							
14. problem solving							
15. analyzing							
16. designing experiments							
17. using mathematics							
18. using time-space relationships							
19. consensus making							
20. defining operationally							

Dimension D Science-Technology-Society-Environment Interrelationships

Factors							
1. science and technology							
2. scientists and technologists are human							
3. impact of science and technology							
4. science, technology, and the environment							
5. public understanding gap							
6. resources for science and technology							
7. variable positions							
8. limitations of science and technology							
9. social influence on science and technology							
10. technology controlled by society							
11. science, technology, and other realms							

Dimension E Scientific and Technical Skills

Factors							
1. using magnifying instruments							
2. using natural environments							
3. using equipment safely							
4. using audiovisual aids							
5. computer interaction							
6. measuring distance							
7. manipulative ability							
8. measuring time							
9. measuring volume							
10. measuring temperature							
11. measuring mass							
12. using electronic instruments							
13. using quantitative relationships							

Dimension F Values that Underlie Science

Factors							
1. longing to know and understand							
2. questioning							
3. search for data and their meaning							
4. valuing natural environments							
5. respect for logic							
6. consideration of consequence							
7. demand for verification							
8. consideration of premise							

Dimension G Science-Related Interests and Attitudes

Factors							
1. interest							
2. confidence							
3. continuous learner							
4. media preference							
5. avocation							
6. response preference							
7. vocation							
8. explanation preference							
9. valuing contributors							

Unit Planning

What follows is one of many ways to plan a unit. No one method of planning is prescribed for use. What is important is that units be planned. Through planning, the maximum benefit for the students in each classroom can be achieved. The topics can be tailored to the interests, needs, and conditions which prevail within each class. Unit planning is an important part of adapting the curriculum to the classroom.

Unit Planning Guide

- Select the topics to be covered in Science 10 for the year. Decide in what order they will be presented. Consult with teachers from other areas of study to see if team teaching or integration of the units is possible. If the Teacher Selected Topic option is picked in Core Unit B or Core Unit C, write learning objectives for the topic chosen. Talk to the teacher-librarian about your yearly plan and the resources you are likely to need.

- Scan the unit - the **Factors of Scientific Literacy to Be Emphasized**, the **Foundational Objectives for Science and the Common Essential Learnings**, the **Learning Objectives** for the topic which has been selected - to give yourself an idea of the scope of the unit.

- Use **Science 10: An Information Bulletin for the Secondary Level - Key Resources** to identify the resources which have been correlated to this unit. Refer to **Science 10: A Bibliography for the Secondary Level** to select additional resources. Check with the teacher-librarian in your school or division and in the resource centre of your school. Public libraries may have useful resources. Media House Productions and the National Film Board are two sources of video and film resources. List any people who may act as resources, or sites which may be appropriate for field trips. Retrieve any activities, lesson plans, or information from your or colleagues' files which you can use in the unit.

  Consider the special initiatives of Gender Equity, Indian and Métis perspectives, and Agriculture in the Classroom. How can they be stressed during this unit?

- Analyze both the foundational and the learning objectives. Decide which learning objectives you will use to develop the foundational objectives and factors of Scientific Literacy. Create any new learning objectives which you feel will enhance the unit.

  Develop, or select from the resources, activities which are appropriate for the objectives. Then, analyze those activities to determine which of the factors of scientific literacy are present. Modify, adapt, or extend the activities so that the factors of scientific literacy which should be emphasized in that unit will be addressed.

  When selecting activities, consider which instructional methods are appropriate for the activities, and ensure a selection which allows for the use of a variety of methods.

- Consider each activity to determine how it might be linked to topics in other areas of study. Modify the activities to strengthen these connections.

- Organize the activities into lessons. A lesson need not be a specific length. It may extend over a number of days or weeks, using a variable amount of time each day. If a teacher-librarian is available for team teaching, those parts of the lessons which require research may be taught together.

- Analyze how the Common Essential Learnings can be developed within the activities of each lesson. In some cases the activity will dictate which Common Essential Learnings are developed. In other cases, the activity may be such that the instructional approaches used to guide the learning can be selected to emphasize particular Common Essential Learnings.

- Create a time schedule for the unit, which shows the lesson structure within the unit. Consider splitting the unit into sections which could be taught over an extended period of the school year.

- Develop an evaluation plan for the unit. Help on this aspect of planning is available elsewhere in this guide and in *Student Evaluation: A Teacher Handbook* (Saskatchewan Education, 1991). Just as a variety of activities should be chosen to accomplish the objectives, a variety of evaluation strategies should be employed so that all aspects of learning can be assessed.

Model Unit: Water Quality

Unit Overview

This model unit is designed to be taught after Topic B-1, Chemical Change. If Chemical Change is not one of the topics you have chosen or if it will be dealt with later, the entry level of the students' knowledge of chemicals, reactions, and solubility must be assessed. Once the new Middle Level curriculum is being used, core units in grades 6 and 9 dealing with chemicals and reactions should give all grade ten students enough background to handle this unit. Until then, using the Chemical Change unit first or teaching concepts as they are needed will support this unit.

There are many approaches which may be taken in dealing with this topic. Municipal acquisition, use, and disposal of water is the approach chosen. Industrial, agricultural or wildlife habitat use could also serve as the central organizer in a teacher-developed unit. Alternatively, specific resources could be used to give structure to this unit. Two examples of excellent resources are *ChemCom Chemistry in the Community*, Unit 1 "Supplying Our Water Needs" (American Chemical Society) and **Water**, a component of the *Perspectives in Science* interactive video series (National Film Board of Canada). Either of these resources could form the core of a unit which would be appropriate for the foundational objectives outlined and could be adapted for Saskatchewan classrooms.

Key purposes are for students to acquire an understanding of how a particular water quality issue affects them and of how their lifestyle influences water quality. The unit also offers students a chance to be actively involved in investigating their environment. The interrelationships among science, technology, society, and the environment stand out clearly in this unit.

Student working groups should be structured to maximize the benefits to the students. Heterogeneous groups in which each student has particular responsibilities, and strategies for enhancing interaction within groups and between groups are important. Suggestions for organizing a class to make best use of group work can be found in *Together We Learn* (Clarke, 1990).

The purpose of the model unit is not to create an expectation that all units must be planned and recorded in this detail, but to give an example of how the initiatives of the Core Curriculum – the Adaptive Dimension, Common Essential Learnings, Gender Equity, Indian and Métis perspective, and Resource-Based Learning – can be incorporated into the Science 10 curriculum. If you decide to use this model unit, adapt, modify, and select from the activities outlined according to the resources, interests, facilities, and time which define your situation.

This unit has been divided into four parts as described in the outline.

Unit Outline

- Importance of Water (5 hours)
- Detecting Contaminants (7 hours)
- Preserving Water Quality (8 hours)
- Conserving Water and Aquatic Habitat (3 hours)

Objectives

The **Foundational Objectives for Science and the Common Essential Learnings** which are outlined at the start of Core Unit A are the foundational objectives for this topic. Stating particular foundational objectives for the Common Essential Learnings does not preclude the development of other Common Essential Learnings objectives during this unit. The foundational objectives will provide a framework for planning.

Listed in this model unit are learning objectives selected or adapted from those under **Topic A-1** Water Quality in the Curriculum Guide, from additional learning objectives created to enhance this unit, and from learning objectives for the Common Essential Learnings.

Most objectives are from this Curriculum Guide, page 85, reorganized to match the structure of this model unit. Those which have been adapted or created for this unit are so described. Learning objectives which help develop the Common Essential Learnings are labelled with the code for Common Essential Learnings which is used throughout this guide.

Activities

Three lines of cross-references accompany each of the activities suggested for use in the unit. Learning objectives, factors of the Dimensions of Scientific Literacy, and assessment strategies are listed to help you become familiar with the range of strategies desirable in teaching Science 10. This is not meant to imply that these are the only learning objectives which can be achieved, evaluation techniques which can be used or factors which can be developed. They are meant to suggest that the reasons activities are done are to achieve objectives and to develop an understanding of science in all its facets.

Adjust the time allotted, add, delete, or modify activities as appropriate. Customize this unit to fit the needs of your students and the facilities and resources with which you work.

Resources (from *Science 10: An Information Bulletin for the Secondary Level – Key Resources, Science 10: A Bibliography for the Secondary Level*, and other sources.)

- municipal employees
- school yard
- water and wastewater treatment facilities
- Andrews, W. *Investigating Aquatic Ecosystems*. Toronto: Prentice-Hall.
- Caduto, M. *Keepers of the Earth*. Saskatoon: Fifth House.
- Candido, J. *Heath Science Connections*. Toronto: D.C. Heath.
- Donavon, T. *Chemicals in Action*. Toronto: Holt, Rinehart, Winston.
- Keethanow School Staff. *The Stanley Mission Water Unit*. La Ronge: Holland-Dalby Educational Consulting.
- *Perspectives in Science: Water*. Ottawa: National Film Board.
- *Project WILD (1990) Activity Guide*. Ottawa: Canadian Wildlife Federation.
- Richards, J. *Atlas of Saskatchewan*. Saskatoon: Modern Press.
- Saskatchewan Education. *A Fine Science*. Regina.

References

- Clarke, J. (1990). *Together We Learn*. Toronto: Prentice-Hall.
- Novak, J. (1984). *Learning How to Learn*. New York: Cambridge University Press.
- Saskatchewan Education (1988). *Understanding the Common Essential Learnings: A Handbook for Teachers*. Regina.
- Saskatchewan Education (1991). *Student Evaluation: A Teacher Handbook*. Regina.

Importance of Water

Learning objectives

A-1.1 Recognize the importance of water for the survival of life

A-1.2 Value water as an important renewable resource

COM-1 Explore and express the purpose for and the meaning of what they are studying

COM-2 Use questions as tools to further their own and others' understanding

Activities	In order to highlight the volume and mass of rain which falls, adapt "Where Does the Water Go After School" from the *Project WILD (1990) Activity Guide*. Emphasize that all water, whether surface water or ground water is replenished by rain. Use the background information to start to raise students' awareness of water quality issues. Time can be saved by having a map of the schoolyard available at the beginning of the activity. Alternatively, if the weather is pleasant it may be a good opportunity to go out into the schoolyard, learn some of the difficulties mapmakers face, and observe or predict how water drains in the schoolyard during a rain. A map of Saskatchewan showing the drainage basins, available in *Atlas of Saskatchewan* (p.62), may provide an opportunity for more discussion.	Either in three or four person groups, or as a whole class, draw concept maps which describe the students' knowledge of water use and of the water cycle. Some information about concept maps can be found in *Understanding the Common Essential Learnings: A Handbook for Teachers* (p. 16). Detailed descriptions can be found in *Learning How to Learn*. Post the concept maps in the classroom so that they can be revised at various points during this unit. Identify questions or areas for investigation which arise from an analysis of the maps.	Read the story "Koluscap and the Water Monster" from *Keepers of the Earth*. Use the discussion notes and questions which follow to help start a discussion of the students' ideas about water supply and water quality issues. As an extension to this activity, information from the *Churchill River Study: Missinipe Probe* might be used to take a more extensive look at the key role water plays in that region of Saskatchewan. While the complete report contains many volumes, schools which have access to it may find it contains valuable materials.
Objectives	A-1.2 Value water as an important renewable resource COM-1 Explore and express the purpose for and the meaning of what they are studying COM-2 Use questions as tools to further their own and others' understanding	A-1.2 Value water as an important renewable resource COM-1 Explore and express the purpose for and the meaning of what they are studying COM-2 Use questions as tools to further their own and others' understanding	A-1.1 Recognize the importance of water for the survival of life A-1.2 Value water as an important renewable resource COM-1 Explore and express the purpose for and the meaning of what they are studying
Factors	B16 system C4 working cooperatively C12 interpreting data F2 questioning F6 consideration of consequence G1 interest	A1 public/private A3 holistic A8 tentative A9 human/culture related B16 system C2 communicating C6 questioning D7 variable positions E4 using audio visual aids F4 valuing natural environments	A3 holistic A9 human/culture related B10 cause-effect C2 communicating C12 interpreting data F1 longing to know and understand F4 valuing natural environments
Assessment	2.6 short answer items	A.1 anecdotal records B.5 self- and peer-assessment	2.1 essays

Activities	Use the "How Wet Is Our Planet?" activity from the *Project WILD (1990) Activity Guide*. This activity helps students understand the percentage of Earth's water which is available for human use and highlights the need for water conservation.	Ask students to form working groups of three or four to design a data collection table on which they can record all the water which they use in a day. In order to facilitate group work, teachers may want to implement many of the suggestions made in *Together We Learn*. When each group has a table prepared, ask them to consult with one other group to compare the tables. Some questions they might ask about their table and the one they are comparing are: • Is it comprehensive? Does it list most activities which require water use at school, home, and elsewhere?	• Have activities in which the individual shares a part (e.g., washing and cooking food, washing clothes, watering house plants, flooding the ice before public skating) been included? If no, why? If so, how have the individual shares been estimated? • Does it provide accurate estimates of the volume of water per use? Are the estimates made using litres? The activity "Alice in Waterland" in the *Project WILD (1990) Activity Guide* has a chart which provides volume estimates of typical usages. How can estimates of other usages be made? How could these estimates be checked? • Does it have provision for recording uses not listed? • Is it easy to use? Allow them some additional time to revise their tables after this consultation. Ask them to submit a good copy of the revised table to you so that you can duplicate it for all members of the group. Duplicate enough so that each group member has seven copies. When these copies are returned to the students next class, ask each student to complete these data sheets during the next seven days. In addition, ask them to read their home water meter (if their water is metered) and record the water meter reading along with date and time of reading on one of the sheets. What units does the water meter measure- cubic metres, cubic feet, litres? Assign a student or ask the janitor to read the school's water meter. Record that reading along with time and date in your planning book. (An extension of this activity might be to read the school water meter at the same time each day during this unit and record that reading on a bulletin board or blackboard chart in the classroom.)
Objectives	A-1.2 Value water as an important renewable resource COM-1 Explore and express the purpose for and the meaning of what they are studying	A-1.1 Recognize the importance of water for the survival of life A-1.2 Value water as an important renewable resource COM-1 Explore and express the purpose for and the meaning of what they are studying COM-2 Use questions as tools to further their own and others' understanding	
Factors	B10 cause-effect B12 conservation C2 communicating C12 interpreting data D3 impact of science and technology D7 variable positions E4 using audio visual aids F4 valuing natural environments G1 interest	A1 public/private B12 conservation C4 working cooperatively C6 questioning D4 science, technology, and the environment E5 computer interaction F1 longing to know and understand F6 consideration of consequence G1 interest	
Assessment	2.3 multiple choice 2.6 shor answer items	A.1 anectotal records B.5 portfolios	

Activities	Instead of the previous activity, "Water's Going On" from the *Project WILD (1990) Activity Guide* might be substituted. It focuses on the water use by the individual students at school, and the discussion centres around conserving water there.	**The Stanley Mission Water Unit: Activities and Ideas** contains an interesting activity entitled "Water Music Activities" which can be used as a way of getting students to think about the wide range of uses for water. The unit is designed as a thematic unit on water, with applicability from kindergarten through grade 12 in a variety of areas of study. There are ideas which may be used in other units of Science 10.	
Objectives	A-1.1 Recognize the importance of water for the survival of life A-1.2 Value water as an important renewable resource COM-1 Explore and express the purpose for and the meaning of what they are studying COM-2 Use questions as tools to further their own and others' understanding	A-1.2 Value water as an important renewable resource COM-1 Explore and express the purpose for and the meaning of what they are studying	
Factors	A9 human/culture related B12 conservation C2 communicating C4 working cooperatively C6 questioning D3 impact of science and technology E4 using audio visual aids F2 questioning G1 interest	A9 human/culture related B10 cause-effect C4 working cooperatively C6 questioning F1 longing to know and understand F2 questioning G1 interest	
Assessment	A.2 observation checklists B.4 portfolios	A.3 rating scales	

Detecting Contaminants

Learning objectives

A-1.4	Investigate mixtures and solutions
A-1.6	Distinguish between hard and soft water
A-1.7	Investigate the way in which a water softener works
A-1.12	Demonstrate an ability to separate water from dissolved and suspended material
A-1.13	Investigate the presence of ions in water
A-1.14	Test the pH of different water samples
A-1.24	new Identify sources of ions in water
A-1.25	new Compare levels of ions in a municipal water source with levels in surface waters and wells from the area
CCT	Consider all evidence before drawing conclusions and developing generalizations
TL	Understand the impact of ion or contaminant detection technology on the recognition of these substances in water supplies
IL	Plan, manage, and evaluate one's own learning experiences

Activities

Provide each working group of three or four students with a small (5 g) sample of soil, salt, corn starch, and sawdust. Ask them to determine the mass of each sample using the analytical balances. Then, mix each of the samples in turn with about 15 mL of water in a 16 x 150mm test tube, shaking vigorously for 10-15 seconds. (These masses and volumes are not critical. Use whatever is appropriate for the size of test tubes available.)

Compare the appearance and what happens in each test for a two minute period after the shaking stops. Assign each group to design and carry out procedures to separate and determine the dry mass of the suspended solids and dissolved solids in one of the samples. Sections 4.7, 6.4 and 6.5 in *Investigating Aquatic Ecosystems* may be used for guidance in adapting, explaining, or discussing this activity.

Ask each group to write a summary of its findings to present to the class.

Demonstrate the use of conductivity apparatus to determine the presence of ions in a solution.

Objectives

A-1.4	Investigate mixtures and solutions
A-1.12	Demonstrate an ability to separate water from dissolved and suspended material
A-1.24	new Identify sources of ions in water
IL	Plan, manage, and evaluate one's own learning experiences

Factors

A1	public/private
A8	tentative
B10	cause-effect
C6	questioning
F2	questioning
G1	interest

Assessment

B.2	laboratory reports
B.4	portfolios
2.4	oral tests

Activities

Supply each group with samples of 0.1 M solutions of sodium carbonate, calcium chloride, potassium hydroxide, and copper nitrate. Remind the students to treat all solutions with care. Advise them on how to dispose of their used chemicals.

Ask them to observe and describe the effect of mixing one or two drops of each possible pair of solutions. Use the results of their observations to introduce the terms 'precipitation' and 'precipitate'. Discuss how a precipitation reaction caused by the addition of a known solution to a water sample can act as a chemical indicator of specific ions in the sample.

An extension of this activity could be to discuss the use of various spectroscopic methods to determine the presence and levels of ions in solution.

Objectives

A-1.4	Investigate mixtures and solutions
A-1.13	Investigate the presence of ions in water
CCT	Consider all evidence before drawing conclusions and developing generalizations

Factors

B10	cause-effect
B16	system
C4	working cooperatively
D3	impact of science and technology
D4	science, technology, and the environment
F1	longing to know and understand

Assessment

B.6	test stations
2.5	performance tasks

Activities	Instruct students on proper procedures for transferring solutions. If pipettes are used, ensure that bulbs and not mouths are used to draw the solution into the pipette. Droppers or pipettes should be rinsed with distilled water between each use. Mixing should be done carefully so that no chemicals contact the skin or clothes of the students. Supply each group with approximately 2 mL of 0.1 M sodium thiocyanide (NaSCN) solution and 10 mL of 0.1 M iron (III) nitrate $[Fe(NO_3)_3]$ solution. Ask each group to label five 16 x 150mm test tubes from 1 to 5. Make a serial dilution of the iron (III) nitrate by removing 1 mL from the 10 mL in test tube 1 and placing it in test tube 2. Add 9 mL of water to the 1 mL iron (III) nitrate in test tube 2 and mix thoroughly. Then remove 1 mL of the solution from test tube 2, place it in test tube 3 and add 9 mL water. Repeat this process until there is 10 mL of solution in test tube 5.	Add three drops of the sodium thiocyanide solution to each test tube of iron (III) nitrate solution and record the observations they make. Ask students to account for the results. Discuss the use of colour change reactions as indicators of the presence of ions in the sample. *Note: Some teachers may wish to replace this activity with those found in sections 1.5 to 1.10 in Chemicals in Action.*	Assign for reading sections 5.1, 5.3, 5.4, 5.6, 6.1, 6.2 and 6.3 from *Investigating Aquatic Ecosystems* as background information about ions and molecules commonly present in water. Extend this activity by creating a class list of all ions or molecules commonly present in water. Ask the students over the next two or three days to look through articles in newspapers and periodicals to find the names of other ions or molecules to add to the list. When the list has been extended so that there are at least two contaminants per working group, assign two to each group. Ask the students to produce reports for the class which describe what the contaminant is, its common source or sources, and how it affects water quality. Discuss with the class where to find information, how to gain access to the information at its source, and the various ways they can report what they find back to the class.
Objectives		A-1.4 Investigate mixtures and solutions A-1.13 Investigate the presence of ions in water CCT Consider all evidence before drawing conclusions and developing generalizations IL Plan, manage, and evaluate one's own learning experiences	A-1.13 Investigate the presence of ions in water A-1.24 new Identify sources of ions in water TL Understand the impact of ion or contaminant detection technology on the recognition of these substances in water supplies
Factors		B10 cause-effect B16 system C12 interpreting data F1 longing to know and understand	B16 system C2 communicating F1 longing to know and understand G1 interest
Assessment		A.3 rating scales B.5 self- and peer-assessment	2.2 matching items

Activities	Obtain water samples from a variety of sources. These may include the taps in the school, wells from the surrounding area, surface water or snow/rain water. Do any of the samples contain suspended solids? What is the level of dissolved solids in each sample? Use precipitation and colour change reactions to determine the concentration of various ions in the water from each source. Hach, Hydrion, Lab-Aids, and LaMotte make kits which contain all chemicals and apparatus needed for water testing. Some of the tests can be done using solutions prepared by the students, especially if qualitative rather than quantitative analysis is expected. "Water Canaries" from the *Project WILD (1990) Activity Guide* may be integrated with this activity if an extension to the relationship between water quality and forms of aquatic life is desired.		Read section 14.3 from *Heath Science Connections 10*. Do activities 14-3 and 14-4 which deal with hard water and water softening processes. Can any students devise an apparatus to create stalagmites or stalactites?
Objectives	A-1.13 Investigate the presence of ions in water A-1.14 Test the pH of different water samples A-1.25 new Compare levels of ions in a municipal water source with levels in surface waters and wells from the area CCT Consider all evidence before drawing conclusions and developing generalizations	TL Understand the impact of ion or contaminant detection technology on the recognition of these substances in water supplies	A-1.6 Distinguish between hard and soft water A-1.7 Investigate the way in which a water softener works A-1.13 Investigate the presence of ions in water A-1.24 new Identify rources of ions in water IL Plan, manage, and evaluate one's own learning experiences
Factors		A1 public/private A8 tentative B16 system C2 communicating C12 interpreting data D4 science, technology, and the environment D7 variable positions F2 questioning	A3 holistic A9 human/culture related B12 conservation C2 communicating C6 questioning D4 science, technology, and the environment F4 valuing natural environments G1 interest
Assessment		B.2 laboratory reports 2.5 performance tasks	A.2 observation checklists 2.3 multiple choice

Preserving Water Quality

Learning objectives

A-1.19 Recognize the role of wetlands in the water cycle

A-1.20 Examine the processes used in municipal water purification or in wastewater treatment

A-1.26 new Identify sources of water contaminants

A-1.27 new Describe how contaminants affect non-aquatic plant and animal life

A-1.28 new Use aquatic life as indicators of pollution

COM Use a wide variety of resources to research the impact of human activity on the quality of surface water

IL Form small research/working groups based on common interest and present information discovered through investigation

TL Use probabilistic reasoning regarding the risk related to water treatment systems

Activities	Distribute copies of the article from the *SRC News* found on page 79. Ask the students to write a one paragraph summary of the type of research which is being done at the new facility. This research is of importance to industry and large municipalities in Saskatchewan. Why? When you find a newspaper article which you think would be useful in your class, phone the paper to get permission to reproduce it for your students. If they will grant free permission, newspaper articles are a valuable resource in science teaching.	Tour a municipal water treatment plant, or have a technician or the manager come into the classroom to describe the process. Ask the tour leader or classroom guest to explain how the water is changed at each phase of the treatment process. Ask if a chemical analysis of the treated water is available. From the analysis, determine if the water is hard or soft. Is the hardness temporary or permanent? Does the municipality soften the water? What percentage of homes in the community have water softeners? Are the suspended solids or precipitated solids removed? If so, what kind of disposal system is used? What is the total volume of water used by the municipality in a day? What are the peak times of day for water use? Are there weekly, monthly or seasonal peaks? Is the rate of water use changing? Does the volume of water use change at the same rate as the population changes?	Brainstorm with the students to generate more questions. Ask each working group of three or four students to summarize the treatment of the water, from the time it is removed from its source until it is in the municipal distribution lines. (This could be combined with the study of the waste treatment plant.) Each group should then select some medium to report their summary: a poster, a newspaper article, a video report, a rap song, an essay, developing an analogy, etc.
Objectives	A-1.26 new Identify sources of water contaminants A-1.28 new Use aquatic life as indicators of pollution TL Use probabilistic reasoning regarding the risk related to water treatment systems	A-1.19 Recognize the role of wetlands in the water cycle A-1.26 new Identify sources of water contaminants COM Use a wide variety of resources to research the impact of human activity on the quality of surface water	IL Form small research/working groups based on common interest and present information discovered through investigation TL Use probabilistic reasoning regarding the risk related to water treatment systems
Factors	A3 holistic A9 human/culture related B12 conservation C2 communicating D4 science, technology, and the environment F4 valuing natural environments G4 media preference	A3 holistic A9 human/culture related B10 cause-effect C2 communicating C4 working cooperatively C12 interpreting data	D3 impact of science and technology D4 science, technology, and the environment E4 using audio visual aids F6 consideration of consequence
Assessment	B.4 portfolios		B.3 major projects and written reports

Activities	Repeat the previous activity, but with a focus on the municipal wastewater treatment plant. Are any special treatments required? Examples of such could be tertiary treatment to prevent eutrophication, removal of heavy metal ions from industrial wastes, dealing with high levels of salt from home water softener use and so on. How does the chemical analysis of the effluent water compare with the analysis of the water taken into the water treatment plant? How is the sludge disposed of? Are there other waste products? What percentage of the water processed by the water treatment plant is also processed by the wastewater treatment plant? Brainstorm with the students to produce more questions to ask. Perhaps half the groups in the class could work on reports of the wastewater treatment plant and half on reports of the water treatment plant.		"Wetlands Metaphor" in the *Project WILD (1990) Activity Guide* highlights the function of wetlands in both water quality and habitat quality preservation.
Objectives	A-1.19 Recognize the role of wetlands in the water cycle A-1.26 new Identify sources of water contaminants COM Use a wide variety of resources to research the impact of human activity on the quality of surface water	IL Form small research/working groups based on common interest and present information discovered through investigation TL Use probabilistic reasoning regarding the risk related to water treatment systems	A-1.19 Recognize the role of wetlands in the water cycle A-1.27 new Describe how contaminants affect non-aquatic plant and animal life A-1.28 new Use aquatic life as indicators of pollution COM Use a wide variety of resources to research the impact of human activity on the quality of surface water
Factors	A3 holistic A9 human/culture related B10 cause-effect B16 system C2 communicating C4 working cooperatively	D4 science, technology, and the environment D7 variable positions E4 using audio visual aids F2 questioning F4 valuing natural environments F6 consideration of consequence	A3 holistic B12 conservation C2 communicating D4 science, technology, and the environment E4 using audio visual aids F2 questioning F6 consideration of consequence
Assessment		B.3 major projects and written reports	2.1 essays

Activities

Read section 20.1 in *Heath Science Connections 10*. View stories #2 and #4 from Program 5 of *A Fine Science*, dealing with water and wastewater treatment. The Buffalo Pound Filtration Plant which treats water for both Moose Jaw and Regina, the iron removal plant at Qu'Appelle, the Wastewater Treatment Plant in Regina, the lagoon system of secondary treatment at Wolseley, and effluent irrigation at both Wolseley and Moose Jaw are explained.

Compare the information from these sources with the water and wastewater treatment processes observed. Perhaps this will raise further questions which officials at the local plants may be able to answer. A good way to present these questions might be to record them on paper and submit them to the plant operators. How they will answer can then be arranged.

Alternatively, the questions could form the basis for a research project on which the groups will cooperate. The use of a research outline, such as the one at the end of this model unit, on page 82, may be useful.

Objectives

A-1.19	Recognize the role of wetlands in the water cycle
A-1.27	new Describe how contaminants affect non-aquatic plant and animal life
A8	tentative
COM	Use a wide variety of resources to research the impact of human activity on the quality of surface water

Factors

B10	cause-effect
B12	conservation
C4	working cooperatively
C6	questioning
C12	interpreting data
D3	impact of science and technology
D4	science, technology, and the environment
D7	variable positions
F1	longing to know and understand
F4	valuing natural environments

Assessment

2.1	essays

Activities	If tours of the local water and wastewater treatment plants cannot be arranged, the previous activity with modifications as outlined below could be substituted. All questions generated about water and wastewater treatment could form the basis of a cooperative group research project. In such a project each working group would be assigned a portion of the questions. The class would decide about reporting how and what each group discovers about the questions. The groups would then write letters to, or interview, experts and use library research to answer the questions. A report to the class, in the format decided, would give all class members access to all the information.	
Objectives	A-1.19 Recognize the role of wetlands in the water cycle A-1.26 new Identify sources of water contaminants COM Use a wide variety of resources to research the impact of human activity on the quality of surface water	IL Form small research/working groups based on common interest and present information discovered through investigation TL Use probabilistic reasoning regarding the risk related to water treatment systems
Factors	A8 tentative B10 cause-effect B12 conservation C2 communicating C4 working cooperatively C6 questioning C12 interpreting data	D3 impact of science and technology D4 science, technology, and the environment D7 variable positions F4 valuing natural environments G1 interest
Assessment		B.4 portfolios B.5 self- and peer-assessment

Conserving Water and Aquatic Habitat

Learning objectives

A-1.2 Value water as an important renewable resource

A-1.16 altered Explain some of the ways in which water contaminants threaten aquatic life

A-1.21 Suggest ways in which water consumption can be reduced

A-1.22 Assess various water conservation strategies

CCT Relate, compare and evaluate what is being read, heard, or viewed

IL Learn through synthesizing understandings, experiences, and needs

Activities	While the unit is in progress remind students to complete their own water use surveys. Two or three classes before this activity is done, ask them to reread their home water meter at about the same time of day as their initial reading, and record that reading along with the date on one of their water survey sheets. Working in the groups formed when they created the water use survey, have the students create a summary chart listing the seven-day-average data for each member of their group. Let the students decide how detailed the summary chart should be. From the water meter data, if available, calculate the average daily use per household. How does each student's individual use compare with the total household use? Make sure that litres are being compared to litres. What household uses are there which do not appear on the survey sheet?	Read the school's water meter and calculate the volume of daily water use. Calculate each person's share of that volume. List all the ways that water is used in the school. Calculate the average use per day by residents in the municipality from the volume of water treated and the population of the area served by the plant. What other uses are there for water in a community than home or school use? Suggest ways that each individual can lessen water use. Create a plan to put some of the suggestions into practice.	Use the activity "Living Research: Aquatic Heroes and Heroines" from the *Project WILD (1990) Activity Guide* if it is possible in your community.
Objectives		A-1.2 Value water as an important renewable resource A-1.21 Suggest ways in which water consumption can be reduced CCT Relate, compare and evaluate what is being read, heard, or viewed IL Learn through synthesizing understandings, experiences, and needs	A-1.2 Value water as an important renewable resource A-1.22 Assess various water conservation strategies CCT Relate, compare and evaluate what is being read, heard, or viewed
Factors		A8 tentative B12 conservation C2 communicating D7 variable positions F1 longing to know and understand G1 interest	A9 human/culture related B12 conservation C2 communicating D7 variable positions F1 longing to know and understand G1 interest
Assessment		B.3 major projects and written reports 2.6 short answer items	B.3 major projects and written reports B.5 self- and peer-assessment

Activities	Adapt "Deadly Waters" from the *Project WILD (1990) Activity Guide*. Instead of the bar graphing activity, supply each group with the background information and the pollution information sheet provided with that activity. Ask them to discuss and identify how their personal activities and activities of those in the community contribute to contaminating or putting stress on the surface and ground water of the local area. Have them summarize what they have identified, and make recommendations about how each of them individually and the community as a whole can act to lessen the pressure on the aquatic environment.	Use the drama segment from *Perspectives on Science: Water* to initiate discussion on the value of water and the need for conservation.	
Objectives	A-1.2 Value water as an important renewable resource A-1.16 altered Explain some of the ways in which water contaminants threaten aquatic life A-1.21 Suggest ways in which water consumption can be reduced IL Learn through synthesizing understandings, experiences, and needs	A-1.16 altered Explain some of the ways in which water contaminants threaten aquatic life CCT Relate, compare and evaluate what is being read, heard, or viewed IL Learn through synthesizing understandings, experiences, and needs	
Factors	A3 holistic A9 human/culture related B10 cause-effect B12 conservation C2 communicating C12 interpreting data D4 science, technology, and the environment F2 questioning F4 valuing natural environments F6 consideration of consequence G1 interest	A3 holistic B12 conservation C6 questioning C12 interpreting data E4 using audio visual aids F2 questioning F6 consideration of consequence	
Assessment	B.4 portfolios	B.5 self- and peer-assessment 2.6 short answer items	

New Aquatic Lab Opens at SRC

SRC will begin the new year in style by opening a new facility. The former SRC fish hatchery, just off Preston Avenue near Circle Drive in Saskatoon, has been transformed into a highly specialized Aquatic Biology Laboratory.

The laboratory will enhance research aimed at developing certain types of toxicity tests. The tests use early life-stages of fish, particularly larvae and eggs. "Our goal is to come up with 'recipes' for reliable toxicity tests that, for the first time, use species native to Saskatchewan, such as walleye and lake trout," says Guy Melville, Lead Scientist of SRC's Aquatic Biology Section.

SRC is investing in the facility and research initiative in response to industry's increased efforts to ensure sustainable development. "Our objective is to enable industry to do their part in maintaining a clean and healthy environment," says Michel Mellinger, Director of SRC's Environment Technology Division.

"Biological tests are used to assess the toxicity of surface water, such as lakes, rivers and ponds, as well as that of liquid wastes, or effluent, that are discharged into surface water bodies," explains Melville.

"We selected walleye, because it is the most important game and commercial fish species in Saskatchewan. It is a very desirable species, since it makes for excellent eating," Melville explains.

"We will also use lake trout, an important game fish, because of its more specific cold-water habitat requirements. Lake trout are an important indicator of the health of far-northern water systems. With this new facility we will be able to simulate the temperatures of such systems. In this respect, our work will be applicable to most of the boreal region of Canada," explains Melville.

Currently, standard biological tests can, within limitations, reveal whether water is toxic and to what extent. The aim of this research is to develop test procedures that will also determine how toxicity levels affect selected fish species in the surrounding area.

In addition to the public and the environment, primary benefactors of this research will be the pulp and paper industry, metallic mineral (uranium, gold) mine and mill operators, as well as larger municipalities. Larger municipalities, with industries that use the sewer system for discharging their effluent, will be particularly interested.

"Our research is not entirely lab oriented," says Melville. "Trials will be done on-site, as well. The lab and field approaches go hand-in-hand. In the field, you meet with conditions that are real but beyond your control. Conditions in the laboratory can be controlled. This combined approach will enable us to correlate results between the two situations, which contributes greatly to the reliability of the results."

In addition to setting up the new lab and carrying out extensive research, Melville states that, "we have a continued interest in the area of environmental impact assessments. We are working with industry, government and private sector environmental consultants to ensure responsible management of our aquatic ecosystem."

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Lesson Schedule

The Importance of Water

This group of activities can be completed in a block of about five hours in the classroom. Depending on the skills, interests and abilities of the students, from three to six hours may actually be used.

The sequence and coordination is a decision which must be made according to the situation in each class. In one classroom, it may be appropriate to start with the story from *Keepers of the Earth* and then draw concept maps during the first class period. In another class the "How Wet Is Our Planet?" activity may be used to kick off the unit.

Detecting Contaminants

While the average class may spend about seven hours completing the activities of this section of the unit, time economies may be produced. Collecting water samples outside of class time and division of reading assignments among working groups who would provide written or oral reports of their reading to the other groups are techniques which may free time to be used to test the water samples in more detail or to shorten the length of the unit.

Preserving Water Quality

This portion of the unit is the one which is most applicable to the students' daily activities. They all consume water and products produced using or containing water. They all produce waste water. For this reason seven to ten hours are allotted for this section.

Conserving Water and Aquatic Habitat

Designed as a three hour segment to emphasize the contribution that everyone in society makes to the water quality problem, these three activities can also be used to bridge into a teacher-developed Life Science unit which examines the relationship between aquatic organisms and water quality. Three hours should be adequate to accomplish the objectives of this section.

Sample Lesson Plans

These sample lesson plans are intended to show how the Common Essential Learnings, the factors of scientific literacy, and evaluation can be integrated into Science 10 lessons.

The Importance of Water

Lesson 1 (1 hour)

Engaging the students' minds:

Two minute open discussion on:

- What is a drought?
- What are the signs of a drought?
- What causes precipitation amounts to be low? What role does evaporation play?

Read "Koluscap and the Water Monster" from *Keepers of the Earth*. Discuss the story, drawing out students' ideas on the significance of the story. Three important points should emerge from the discussion:

- During a drought, there is not much people can do to end it.
- Life is completely dependent on water.
- No one owns the water.

People have always sought to explain the way the world operates by making observations and drawing inferences. The methods of science are one way to help in the search for understanding.

Exploring the ideas:

Divide the students into heterogeneous working groups. Assign roles for each group member. (Suggestions for organizing small group work can be found in *Together We Learn.*)

Ask each group to produce a concept map dealing with the concept 'water'. There should be group consensus on the associated concepts and on the links. If students have no experience, or limited experience, with concept mapping, the rest of this period and half of the next should be used to introduce the technique. Ideas about concept mapping can be found in *Understanding the Common Essential Learnings: A Handbook for Teachers* and in *Learning How to Learn*. The maps for the concept water would then be drawn in the second half of next class.

Evaluating what has happened:

Post the concept maps in the classroom. Students will have a chance to reconstruct their maps at various points during this unit and finally at the end of the unit. Each time a map is drawn, it should be dated. The latest version can be posted and the previous ones kept in a group portfolio.

In this way, the group members are constantly reevaluating their ideas about water. At the end of the unit, by reviewing all their maps, they can trace the evolution of their thinking about water.

Lesson 2 (1 hour)

Engaging the students minds:

Ask each student to write an estimate (as a percent or a fraction) of:

- the portion of the earth's surface which is covered by water; and,
- the portion of earth's water which is fresh water.

"How Wet Is Our Planet?" from the *Project WILD (1990) Activity Guide* provides some statistics which can help students appreciate that even though water is abundant, the fresh water supply is more tenuous. Use 1, 2, and 8 from the Procedures section of this activity to stimulate a discussion of the Earth's freshwater supply. Emphasize that wise use of water involves preserving its quality and conserving the volume which is available to us.

Assign Extension 1 (mural of the water cycle), to be worked on in the groups established for lesson 1, as an ongoing assignment for this unit.

Exploring the ideas:

In their working groups, ask the students to construct a water use data collection table.

Evaluating what has happened:

If a list of criteria for creation of the table has been distributed or discussed before the groups have begun work, the tables which are submitted for duplication could be graded against these criteria.

Sample criteria:

- Is the list of typical uses complete?
- Is there space to record the number of typical uses per day?
- Is provision made for estimating uses during which the volumes vary, such as length of shower, method of washing cars, and use of humidifiers?
- Is there space to record atypical (one-time or rare) uses?
- Is there space to record the date of the observations?
- Is the table easy to use?
- Has the table been generated by computer?

Have the group fill in a group self-evaluation form, such as the one on the following page.

Group self-evaluation

Group members: ________________ ________________ ________________ ________________

By group consensus, decide how to rate your group with respect to each criterion below. Use the numbers 1-3 to represent the terms indicated in the key.

1. Yes 2. Somewhat 3. No

We allocated responsibilities fairly. ______

We considered everyone's ideas. ______

We made sure everyone participated in group discussions. ______

We helped each other fulfil our assignments. ______

The best thing about our group was ____

____

____

We could make our group work better by ____

____

____

Research Planning Guide

- Identify a general question or area of interest.
- List what you know about that question or topic. List some questions which you have, or can create, about the topic.
- Select something which you think would be an interesting area for a report from the list.
- List all sources of information such as libraries and other organizations, and gather together what information is available. Ask your teacher or teacher-librarian for help when you need it.
- Start examining the information available from each of the sources. If too much is available for use from any source, either narrow your topic or come up with some criteria (e.g., published 1990 or later, from Saskatchewan or Canadian sources, etc.) for selecting what to use. Use these sources to give you leads to other sources.
- Establish how you will record and organize the information you are finding (e.g., jot notes, index cards, information matrix).
- Synthesize the information in a form which complements your abilities to present it. Some ways are with posters, written text, charts, dramatic skit, and orally.
- Reflect on what you have done. Record in two or three points what knowledge and skills you have learned and what you would like to improve.

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Core Units

Core Unit A: Earth/Environmental Science

Factors of Scientific Literacy Which Should Be Emphasized

A1 public/private
A3 holistic
A8 tentative
A9 human/culture related

B10 cause-effect
B12 conservation
B16 system

C2 communicating
C4 working cooperatively
C6 questioning
C12 interpreting data

D3 impact of science and technology
D4 science, technology, and the environment
D7 variable positions

E4 using audiovisual aids
E5 computer interaction

F1 longing to know and understand
F2 questioning
F4 valuing natural environments
F6 consideration of consequence

G1 interest
G4 media preference

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

A-1 appreciate the complexity within natural systems;

A-2 examine the impact of historical and contemporary human activity on the biosphere;

A-3 examine the impact of human activity on traditional lifestyles;

A-4 identify ways that the impact of human activity can be reduced;

A-5 analyze the environmental impact of personal activities and lifestyles;

A-6 analyze the effect/impact of the environment on personal activities and lifestyles, and the effect of personal activities on the environment;

A-7 use a wide range of language experiences to develop their knowledge of natural systems (COM);

A-8 promote both intuitive, imaginative thought and the ability to evaluate processes, experiences, and objects in the context of understanding the impact humans have on the biosphere (CCT);

A-9 understand that technology both shapes, and is shaped by, society (TL); and,

A-10 meet personal learning needs (IL).

Topic A-1 Water Quality

Learning Objectives

Students should be provided with opportunities to:

A-1.1 recognize the importance of water for the survival of life;

A-1.2 value water as an important renewable resource;

A-1.3 appreciate the importance of water in food production;

A-1.4 investigate mixtures and solutions;

A-1.5 classify mixtures and solutions;

A-1.6 distinguish between hard and soft water;

A-1.7 investigate the way in which a water softener works;

A-1.8 develop a generalization for the solubility of most solids in water at different temperatures;

A-1.9 recognize that the solubility of oxygen in water decreases with increasing temperature;

A-1.10 recognize the importance for aquatic life of dissolved oxygen in water;

A-1.11 express the concentration of a solution using acceptable units;

A-1.12 demonstrate an ability to separate water from dissolved and suspended material;

A-1.13 investigate the presence of ions in water;

A-1.14 test the pH of different water samples;

A-1.15 identify some contaminants commonly found in water;

A-1.16 explain some of the ways in which water pollution threatens aquatic life;

A-1.17 discuss how water contamination affects human life and activity;

A-1.18 explain the movement of water through the hydrologic cycle;

A-1.19 discuss the role of soil/water/wetlands conservation projects in the hydrologic cycle;

A-1.20 examine the processes used in municipal water purification or in wastewater treatment;

A-1.21 suggest ways in which water consumption can be reduced around the home;

A-1.22 assess various water conservation strategies; and,

A-1.23 debate an issue related to water quality in the local region.

Teacher's notes

Topic A-2 The Greenhouse Effect

Learning Objectives

Students should be provided with opportunities to:

A-2.1 develop an operational definition of the Greenhouse Effect;

A-2.2 explain how a model of a greenhouse helps illustrate the Greenhouse Effect;

A-2.3 state some of the more common "greenhouse gases";

A-2.4 consider opposing positions by scientists regarding the validity of the theory of the Greenhouse Effect;

A-2.5 explain how a build-up of greenhouse gases in the atmosphere might contribute to the Greenhouse Effect;

A-2.6 develop a model of the carbon cycle which helps explain the Greenhouse Effect;

A-2.7 suggest how deforestation may contribute to the Greenhouse Effect;

A-2.8 explain the importance of ozone in the Earth's atmosphere;

A-2.9 investigate predictions regarding climatic changes resulting from the Greenhouse Effect;

A-2.10 suggest how agriculture in Saskatchewan might be affected by global warming;

A-2.11 research existing policies or legislation which attempt to reduce the production of greenhouse gases; and,

A-2.12 suggest some measures which might reduce the severity of the Greenhouse Effect.

Teacher's notes

Topic A-3 Uranium

Learning Objectives

Students should be provided with opportunities to:

A-3.1 recognize the importance of uranium for Saskatchewan;

A-3.2 conceptualize the time frame of human history and nonrenewable resource formation in the Earth;

A-3.3 identify geological formations where uranium is found in Saskatchewan;

A-3.4 research the processes for mining and milling uranium;

A-3.5 identify environmental concerns regarding uranium mining and the use of nuclear energy;

A-3.6 investigate the stages in the nuclear fuel cycle;

A-3.7 explain why precautions are needed to minimize the risk of exposure to radiation;

A-3.8 assess the health and safety considerations involved in the mining and processing of uranium, and in the nuclear industry;

A-3.9 evaluate the methods used in handling and transporting uranium products;

A-3.10 explain some of the acute effects that radiation has on humans and on other life forms;

A-3.11 evaluate the impact of uranium mining on northern communities and traditional northern lifestyles;

A-3.12 identify ways in which processed uranium is used;

A-3.13 explain how electricity is produced in a CANDU nuclear reactor;

A-3.14 identify natural and human-created sources of radiation;

A-3.15 explain the types of radiation emitted by radioactive materials;

A-3.16 recognize some of the technical difficulties in nuclear waste disposal;

A-3.17 distinguish between fact and opinion;

A-3.18 develop the concept of risk-benefit analysis;

A-3.19 use risk analysis to compare the risks and benefits of peaceful uses of nuclear energy;

A-3.20 develop personal value positions regarding the use of nuclear energy; and,

A-3.21 debate the future use of uranium and nuclear energy in Saskatchewan.

Teacher's notes

Core Unit B: Physical Science

Factors of Scientific Literacy Which Should Be Emphasized

A4 replicable
A5 empirical
A7 unique
A8 tentative

B1 change
B2 interaction
B8 quantification
B12 conservation
B13 energy-matter
B15 model
B22 fundamental entities

C1 classifying
C4 working cooperatively
C8 hypothesizing
C19 consensus making
C20 defining operationally

D1 science and technology
D4 science, technology, and the environment
D10 technology controlled by society

E3 using equipment safely
E5 computer interaction
E13 using quantitative relationships

F2 questioning
F3 search for data and their meaning
F4 valuing natural environments

G1 interest
G2 confidence
G6 response preference

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

B-1 recognize that pervasive physical laws govern interactions of matter and energy;

B-2 perceive patterns which provide evidence of interactions of matter and energy;

B-3 use both qualitative and quantitative means to describe phenomena;

B-4 recognize the impact of manipulation of matter and energy on personal activities and lifestyle;

B-5 apply knowledge of numbers and their interrelationships (NUM);

B-6 develop an understanding of how knowledge is created, evaluated, refined, and changed within science (CCT); and,

B-7 develop a contemporary view of technology (TL).

Topic B-1 Chemical Change

Learning Objectives

Teacher's notes

Students should be provided with opportunities to:

B-1.1 distinguish between a physical change and a chemical change;

B-1.2 observe and describe when a chemical change takes place;

B-1.3 identify chemical reactions which are important in everyday life;

B-1.4 investigate a variety of chemical reactions;

B-1.5 recognize that matter and energy are conserved in a chemical reaction;

B-1.6 perform activities to illustrate the Law of Conservation of Mass and the Law of Constant Composition;

B-1.7 construct simple word equations to describe a chemical change;

B-1.8 use a model to illustrate how atoms become rearranged during a chemical change;

B-1.9 identify symbols used to represent elements;

B-1.10 recognize the chemical composition of common substances;

B-1.11 write simple chemical formulas;

B-1.12 construct equations for simple chemical reactions;

B-1.13 balance simple chemical equations;

B-1.14 name some chemical compounds;

B-1.15 write chemical formulas for compounds, given their names; and,

B-1.16 use atomic theory to explain chemical change.

Topic B-2 Energy Management

Learning Objectives

Students should be provided with opportunities to:

B-2.1 define energy conservation;

B-2.2 recognize the factors which are placing stress on the world's sources of energy;

B-2.3 understand the importance of conservation as a strategy for protecting and extending available energy supplies;

B-2.4 state various types of renewable and nonrenewable energy sources;

B-2.5 recognize those forms of energy on Earth that are ultimately produced from the sun's energy;

B-2.6 consider the implications of current energy use patterns for renewable and nonrenewable energy resources;

B-2.7 use extrapolation to consider the implications of maintaining current energy use patterns;

B-2.8 explain the relationship that exists between global population growth and energy demand;

B-2.9 explain how individuals can develop community awareness strategies for energy conservation;

B-2.10 suggest how political action can be taken to make various levels of government responsive to energy conservation issues;

B-2.11 give examples which illustrate how energy can be converted from one form to another;

B-2.12 recognize that, due to energy losses, energy conversions result in a net decrease in available energy;

B-2.13 analyze consumption of food as an energy input;

B-2.14 trace the various energy inputs and outputs through food production, processing, and distribution to the consumption of the food;

B-2.15 explain how science and technology can help to optimize the available energy in energy conversions;

B-2.16 identify how heat and other forms of energy are related;

B-2.17 apply an understanding of kinetic molecular theory to energy;

B-2.18 examine scientific and technological issues related to the use of fossil fuels;

B-2.19 determine some of the advantages and disadvantages of using specific sources of energy;

B-2.20 investigate the environmental consequences resulting from the use of various types of energy;

B-2.21 recognize the need for conservation and energy resource management;

B-2.22 consider how public opinion regarding energy resource development can be influenced; and,

B-2.23 examine and evaluate options for energy resource management, as a responsible citizen who is striving to attain scientific and technological literacy.

Teacher's notes

Topic B-3 Teacher Selected Physical Science Topic

Elements from topics B-1 and B-2 in the Physical Science Core Unit can be combined to prepare topic B-3, or other topics may be used. Regardless of the approach, the following should be included in the unit:

- development of the **Factors of Scientific Literacy Which Should Be Emphasized** listed under Core Unit B: Physical Science;
- **Foundational Objectives for Science and the Common Essential Learnings**;
- appropriate **Learning Objectives**;
- consideration of the Adaptive Dimension;
- a variety of student activities;
- appropriate teaching strategies; and,
- strategies for student assessment and program evaluation.

Refer to the section in this Curriculum Guide on unit planning, beginning on page 60, for some specific suggestions on how to develop a teacher-prepared unit.

Teacher's notes

Core Unit C: Life Science

Factors of Scientific Literacy Which Should Be Emphasized

A3 holistic
A4 replicable
A8 tentative

B3 orderliness
B4 organism
B11 predictability
B12 conservation
B13 energy-matter
B14 cycle
B20 theory
B26 evolution

C1 classifying
C4 working cooperatively
C6 questioning
C9 inferring
C16 designing experiments

D4 science, technology, and the environment
D8 limitations of science and technology
D9 social influence on science and technology

E2 using natural environments
E4 using audiovisual aids

F1 longing to know and understand
F4 valuing natural environments

G1 interest
G5 avocation
G6 response preference

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

C-1 appreciate the complexity of living systems;

C-2 recognize the intricate nature of the system which supports life on Earth;

C-3 realize the fragile yet robust nature of life;

C-4 understand and use the vocabulary, structures and forms of expression which characterize life science (COM);

C-5 engage in intuitive, imaginative thought and the evaluation of ideas, processes, experiences and objects in the context of understanding the place which life has in the biosphere (CCT); and,

C-6 develop a contemporary view of technology (TL).

Teacher's notes

Topic C-1 Cell Structure and Human Body Systems

Learning Objectives | **Teacher's notes**

Students should be provided with opportunities to:

C-1.1 develop proficiency in using a microscope;

C-1.2 prepare wet mount slides;

C-1.3 recognize that the cell is the fundamental entity of all life;

C-1.4 observe and describe cells using a microscope;

C-1.5 explain the function of various components of cells;

C-1.6 identify various components of cells using a microscope;

C-1.7 estimate sizes of cells;

C-1.8 investigate classification systems for cells;

C-1.9 explain the functioning of a cell;

C-1.10 identify several human body systems;

C-1.11 name the main components of several human body systems;

C-1.12 investigate how several human body systems function;

C-1.13 consider relationships between several human body systems;

C-1.14 perform laboratory activities to investigate characteristics of human body systems;

C-1.15 investigate the technology associated with donated and artificial body parts;

C-1.16 explain how technology is used to sustain a failing human body system; and,

C-1.17 investigate the diagnosis and treatment of diseases affecting several human body systems.

Topic C-2 Food Additives and Human Nutrition

Learning Objectives

Students should be provided with opportunities to:

C-2.1 define food additives;

C-2.2 classify food additives according to use;

C-2.3 examine lists of ingredients in foods to determine the presence of additives;

C-2.4 identify some of the benefits and risks of food additives;

C-2.5 consider some of the historical methods of food preservation;

C-2.6 consider some alternatives to the use of food additives;

C-2.7 perform research to determine what food additives have been banned and why they have been banned;

C-2.8 perform activities to investigate various types of food additives (e.g., using citric acid to prevent apples from oxidizing, using egg white as an emulsifying agent, etc.);

C-2.9 investigate new technology used in food processing, packaging, and preparation;

C-2.10 identify the impact of consumer demand on the agri-food industry;

C-2.11 identify the main nutrient groups (i.e., carbohydrates, fats, proteins, vitamins, minerals, water);

C-2.12 state the importance of each of the main nutrient groups;

C-2.13 recognize the importance of a well-balanced diet;

C-2.14 consider the potential risks of diets which provide excesses or deficiencies of particular nutrients;

C-2.15 explain the difference between unsaturated and saturated fats;

C-2.16 recognize the importance of fat in the diet;

C-2.17 identify sources of saturated and unsaturated fat;

C-2.18 recognize the importance of diet and exercise in controlling and maintaining weight;

C-2.19 chemically analyze foods for the presence of such things as sugar, starch, protein, fats, vitamin C, etc;

C-2.20 research the nutritional and caloric content of different foods;

C-2.21 identify changes in the nutritional value of food caused by cooking or other types of processing;

C-2.22 consider whether or not nutritional supplements are a necessary part of a balanced diet;

C-2.23 identify some diseases that may result from nutritional deficiencies or excesses;

C-2.24 examine several typical daily diets and analyze them for their nutritional value and caloric content;

C-2.25 compare the advantages and disadvantages of vegetarian and nonvegetarian diets; and,

C-2.26 compare both the historical and contemporary diets of people from different cultures.

Teacher's Notes

Topic C-3 Teacher Selected Life Science Topic

Elements from topics C-1 and C-2 in the Life Science Core Unit can be combined to prepare topic C-3, or other topics may be used. Regardless of the approach, the following should be included in the unit:

- development of the **Factors of Scientific Literacy Which Should Be Emphasized** within all seven Dimensions of Scientific Literacy;
- **Foundational Objectives for Science and the Common Essential Learnings**;
- selection of appropriate **Learning Objectives**;
- consideration of the Adaptive Dimension;
- a variety of student activities;
- appropriate teaching strategies; and,
- strategies for student assessment and program evaluation.

Refer to the section in this Curriculum Guide on unit planning beginning on page 60 for some specific suggestions on how to develop a teacher-prepared unit.

Teacher's notes

Core Unit D: Science Challenge

Factors of Scientific Literacy Which Should Be Emphasized

A1 public/private
A3 holistic
A9 human/culture related

B2 interaction
B10 cause-effect
B13 energy-matter
B14 cycle
B15 model
B16 system

C2 communicating
C3 observing and describing
C4 working cooperatively
C6 questioning
C21 synthesizing

D1 science and technology
D3 impact of science and technology
D7 variable positions
D11 science, technology, and other realms

E2 using natural environments
E3 using equipment safely

F2 questioning
F3 search for data and their meaning
F5 respect for logic

G1 interest
G2 confidence
G3 continuous learner
G4 media preference
G5 avocation

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

D-1 use a variety of ways to communicate information about some area of scientific interest;

D-2 demonstrate an understanding of how scientific research is conducted;

D-3 perform investigations which demonstrate an ability to search for answers to good questions;

D-4 formulate a hypothesis, control variables, manipulate equipment and materials, record observations, and analyze the results of experimental data;

D-5 develop a positive disposition to lifelong learning (IL);

D-6 understanding the personal, moral, social, and cultural aspects of science (PSVS);

D-7 appreciate the value and limitations of technology within society (TL);

D-8 recognize the limits of individual reflection, and the need to contribute to and build upon mutual understandings (CCT); and,

D-9 use a wide range of possibilities for developing major concepts within science (COM).

Topic D-1 Extension Activities for the Previous Core Units

To extend the activities in the previous core units, teachers may use a variety of strategies. Which are used will depend on the specific learning needs and interests of students. Use of additional activities, in-depth treatment of the subject matter, and remediation, are only a few ways to do this.

Extension activities accommodate the Adaptive Dimension and facilitate the development of Critical and Creative Thinking, Independent Learning, and other Common Essential Learnings. They can also provide strong support for Gender Equity initiatives, the Indian and Métis perspectives, and Resource-Based Learning.

The "Science Challenge" aspect of the extension activities suggests that the teaching strategies for this topic be activity-based, challenging, and enjoyable for the learner. The teacher, working closely with his or her students, is in the best position to determine how this should be accomplished.

The other topics in the **Science Challenge** Core Unit also provide extension activities for the previous core units, but are directed more specifically at special projects and activities. The **Science Challenge** topics can also be blended. Several topics can be integrated in this Core Unit. For example, as a part of the extension activities, students may also be working on Science Fair projects. Or, students doing **Research Projects** may also be preparing entries for a **Science Fair**. Flexibility and a diversity of approaches have been designed into Science 10 to provide students with a motivating learning atmosphere and an opportunity to experience an authentic view of science.

Learning Objectives

Students should be provided with opportunities to:

D-1.1 engage in a more in-depth study of a topic covered in previous core units;

D-1.2 perform a variety of activities related to topics covered in previous core units;

D-1.3 experience an authentic view of science by becoming active, self-directed learners;

D-1.4 gain proficiency in performing research or in conducting experimental activities;

D-1.5 develop skills important for life-long learning; and,

D-1.6 develop a positive disposition toward science.

Teacher's notes

Topic D-2 Research Projects

Teacher's notes

Teachers should provide students with parameters for their research projects. Criteria for assessment and evaluation should be explained before students begin working on the projects. The research projects should produce some tangible, measurable outcomes, such as written reports, a multi-media presentation, an entry in a Science Fair, or data and conclusions from an investigation.

It may be preferable to distribute the 15 hours allotted to this topic throughout the course, but this is left to the discretion of the teacher.

Resources need to be available for students during their research. There are ways of making scarce resources available: interlibrary loans, telecommunications, or other distance-education resources and techniques. Teachers should show students how to search for and obtain materials in these ways.

Learning Objectives

Students should be provided with opportunities to:

D-2.1 develop a systematic approach to conducting research;

D-2.2 recognize alternative methods for obtaining, organizing, and disseminating information;

D-2.3 produce a tangible product from their research; (e.g., a report, display, oral presentation, or Science Fair exhibit, etc.)

D-2.4 utilize a wide variety of resources and techniques when conducting research;

D-2.5 recognize the role of technology in information storage, retrieval, and manipulation;

D-2.6 utilize emerging or existing technologies when conducting research;

D-2.7 communicate the results of research findings in a variety of appropriate ways;

D-2.8 recognize bias in resource materials; and,

D-2.9 develop approaches to produce balanced presentations.

Topic D-3 Science Fair Projects

Learning Objectives

Students should be provided with opportunities to:

D-3.1 produce a Level 4 or Level 5 Science Fair project involving either research or experimentation;

D-3.2 develop a proposal for a Science Fair;

D-3.3 select an appropriate category (i.e., Earth/Environmental Science, Physical Science, Life Science, Computer Science, or Applied Science and Engineering) for a Science Fair project;

D-3.4 compile a list of references and acknowledgements used in a Science Fair project;

D-3.5 keep a continuous project log of all work related to a Science Fair project;

D-3.6 identify and requisition any special equipment or materials needed in a Science Fair project;

D-3.7 conduct a self-evaluation of a completed Science Fair project;

D-3.8 become acquainted with the rules and judging criteria used at a Science Fair;

D-3.9 complete all necessary reports and documentation related to a Science Fair exhibit;

D-3.10 produce a written report summarizing all of the work done in the completion of a Science Fair project;

D-3.11 construct an exhibit for a Science Fair;

D-3.12 register for and participate in a Science Fair; and,

D-3.13 work cooperatively with others during the preparation of Science Fair projects.

A Science Fair is a collection of student projects assembled for viewing and judging. The projects may consist of original student research, demonstrations of important principles, descriptions of experimental procedures which students have performed, industrial developments or innovations, or an orderly collection of things which fall within the broad range of pure and applied science.

The suggestions provided in this Curriculum Guide are consistent (with some exceptions as noted) with the standards and criteria used for displaying and judging Science Fair projects at regional, provincial, or national levels. At the Secondary Level, projects should conform to the standards of Level 4 or Level 5 Science Fair projects to be eligible for competition beyond the local school division.

A Level 4 Science Fair project answers a question by designing experiments that control and test one or two variables. For instance, students might perform an experiment to investigate the rate of growth of a yeast culture at different temperatures. All other variables which might affect yeast growth are controlled.

Level 5 Science Fair projects are more demanding. Experiments which students conduct at this level should attempt to identify and control any variables which might have an effect on the experimental results. The work is more abstract and open-ended, often leading the student to pose further questions.

Exhibits should demonstrate artistic skills, proper construction, and academic scholarship. Self-supporting three panel backboards are used to support the exhibits. The display should be attractive and aesthetically appealing. **Display dimensions should not exceed 3.5 m high, 0.8 m deep, and 1.2 m wide in order to comply with regional, provincial, and national standards.** Judges are very strict about these dimensions. Projects exceeding the maximum dimensions are usually rejected.

Exhibits should include the title of the project, the purpose of the experiment(s) performed, a hypothesis, the procedure followed for the research or experiment, the results obtained, conclusions, potential sources of experimental error, acknowledgements, and references. Working models, if appropriate, should be included with the exhibit, as should a detailed log of all aspects of the project. There should also be a written project report which provides a synopsis of the entire project. Judges award a portion of the overall mark to each of these points. The omission of any one required item could reduce the overall score of an otherwise outstanding exhibit. All of these elements make such projects complex. For this reason, sufficient time needs to be provided for students to be able to complete Science Fair projects.

Judges qualified to evaluate the projects should be selected. They must be able to evaluate several things such as originality, accuracy, completeness, dramatic value, skill, creative ability, and the results obtained. Judges examine the written and graphic material in the exhibit. They also interview the participants. Suggestions for judging are available from the Youth Science Foundation.

Student projects compete against others exhibited in similar categories. The categories typically used in Science Fairs include: Life Science, Computer Science, and Applied Science and Engineering. Saskatchewan Education recommends using an additional category of Earth/Environmental Science, to match core unit A in the Science 10 curriculum. These categories may be further subdivided by grades, if the Science Fair has participants from other grades.

There are other considerations.

- Limit the number of students working on an exhibit to two or three at the most.
- All equipment needed for the exhibits, with the exception of such things as display tables and electrical extension cords, must be provided by the participants.
- Do not provide gas or water outlets for exhibits. Prohibit the use of open flames.
- Inspect exhibits that require electrical power carefully before allowing the participants to plug them in. Use cords in good condition which have three-pronged plugs. Do not leave them plugged in overnight.
- Arrange for adequate overnight security of the display area.
- Observe safety precautions regarding the use of electricity, sharp objects, hazardous materials, moving parts, cryogenic substances, etc. Post warning signs on or near any displays which are potentially harmful. All chemicals should be properly labelled.
- In some cases, students might be able to substitute toxic or corrosive materials with ones which are safer. For example, molasses can be used to represent crude oil in a display. Containers should be labelled with the word "simulated" if such substitutions are made.
- Inspect displays to ensure that they are sturdy and stable. Offer suggestions to students on how to transport exhibits safely to the display area. This can be a problem if exhibits are being sent to regional, provincial, or national Science Fairs. Suggest that students always take their projects with them, instead of shipping them in advance.
- Insist on safety valves on any pressurized containers.
- Glass or other fragile materials should be secured to prevent damage.
- Comply with any municipal, provincial, or federal regulations. For example, registration is required for the use of x-ray or ionizing radiation emitting equipment.
- Discourage the use of radioisotopes.
- Biological toxins, pathogenic materials, and cells or tissues infected with animal viruses should be prohibited. Ensure that all cultures on display are sealed.
- Prohibit the manipulation of recombinant DNA molecules.
- Determine if insurance coverage and fire regulations are adequate for the exhibit area. Fire extinguishers with the proper rating should be available.

Carefully scrutinize any exhibits that involve the use of living specimens. (Consult various publications from the Youth Science Foundation.) Experiments must conform to the **Animal Disease and Protection Act**, section 402 of the **Criminal Code of Canada** dealing with cruelty to animals, as well as other provincial statutes. Consult various publications from the Youth Science Foundation for more information.

If possible, limit the use of biological specimens to organisms such as bacteria, protozoa, fungi, and insects. Vertebrates should not be used in any experiments which may be harmful to the animals. Projects involving higher order vertebrates should be limited to observations of these animals in their natural state, or in protective areas such as zoos, wildlife parks, terraria, or aquaria. Observations of normal behaviour of domestic animals are also suitable. Any experiments which attempt to modify animal behaviour, or intervene externally, should be discouraged. Check with the organizers of regional, provincial, or national Science Fairs to ensure that any exhibits which advance to those levels meet with the criteria they have established regarding the use of living specimens. For example, at some Science Fairs restrictions may exist on exhibits which include developing embryos.

Sample Task Breakdown of a Science Fair Project

The following suggestions indicate some stages that might have to be followed to complete a Science Fair project. Each stage involves a variety of understandings, skills and processes. The entire process, from developing the initial question, to exhibiting the project at the Science Fair, provides students with tremendous opportunities to develop scientific literacy. These projects are also excellent for incorporating the **Foundational Objectives for Science and the Common Essential Learnings**.

The steps listed below are presented in chronological order. Adjustments may have to be made, depending on the rules of a specific Science Fair. It is recommended that the tasks be broken down in this way, giving students a suggested deadline for each stage in the completion of their projects.

- Determine the category of the project.
- State the project to be developed, in the form of a question. (Samples of questions which may spark ideas for each category start on the next page.)
- Complete a contract for the project to be developed.
- Research the topic, developing a bibliography. Submit the bibliography for evaluation.
- Keep detailed written records of correspondence and phone calls.
- Plan the experiment(s) to be performed.
- Participate in an interview with the supervising teacher to discuss the plans for the experiment(s). Attention should be paid to any safety considerations needed to perform the experiment(s) safely.
- Gather all necessary materials and perform the experiment(s).
- Analyze the experimental results and prepare a preliminary report.
- Submit the preliminary report for evaluation.
- Redo the experiment(s), making any modifications that may be necessary.
- Prepare a full write-up of the experiment(s), complete with the analysis and conclusions.
- Submit the write-up of the experiment(s) for critique. Make any suggested changes and re-submit the completed report for evaluation.
- Make preliminary decisions regarding the format of the exhibit.
- Build any working models. Complete all reports.
- Complete the exhibit.
- Examine the criteria that will be used to judge the exhibit. Make any necessary changes to improve the project.
- Complete any documentation necessary to enter the project in the Science Fair.
- Disassemble the exhibit and transport it to the Science Fair site.
- Register and complete any forms or documentation at the Science Fair site.
- Remain near your exhibit to answer questions during judging and during times when exhibits are on display to the public.
- If possible, have a photograph taken of yourself by your exhibit at the Science Fair.
- Participate in any scheduled activities taking place during the Science Fair.
- Disassemble the project once the Science Fair is over.
- Retain the entire exhibit, especially if it is selected for another Science Fair.

Some Suggested Topics for Science Fairs

One of the most difficult tasks students have is determining how to begin a Science Fair project. The task may seem overwhelming, until it is broken down into a series of more manageable steps.

The following questions and statements may help students focus on the project's starting point. These questions will give students some idea of the range of possibilities that could be explored. The questions are linked closely to many of the objectives in Science 10. Ideally, after reading through a list of suggested topics in the category they have selected, they can formulate their own question(s).

For example, to investigate Saskatchewan soils, a student might ask: "How do earthworms living in the soil affect the soil quality?" An experiment which investigates that question could be a science fair project.

Earth/Environmental Science

- What shapes do crystals have?
- Does the rate of cooling of a metal affect its crystal structure?
- How can metals be mixed to form alloys?
- What are the differences in the properties of metal alloys?
- How do the melting points of metal alloys compare to the melting points of pure metals?
- Investigate the importance to Saskatchewan of soil, potash, bentonite, oil, coal, uranium, silica sand, or some other natural resource.
- What changes in wildlife patterns result from human habitation on this planet?
- Which substances are most/least soluble in water?
- What effect does salinity have on crop yields?
- How can dissolved and suspended impurities be removed from water?
- What happens when solutions containing different ions are mixed?
- How does the hardness of water affect its ability to wash clothes?
- How do water softeners work?
- How should water be managed in your community?
- Can a model be developed to show how a large-scale water treatment facility works?
- What are some of the ways in which water can become polluted?
- How can oil spills be cleaned up?
- Can microbes be used to degrade petroleum?
- How does the temperature of water affect the solubility of different substances in it?
- How does the initial temperature of water affect the time it takes it to freeze?
- How does fresh water become oxygenated?
- Does the depth of a lake affect the amount of available oxygen in the water?
- How can the concentration of a dissolved substance in aqueous solution be determined?
- How is aquatic life affected by the amount of dissolved oxygen in the water?
- What are the interconnections between aquifers in Saskatchewan?
- How is aquatic life affected by water pollutants?
- What types of water flow fluctuations occur in rivers during spring thaw?
- How does the North American Waterfowl Management Plan operate?
- How successful have wildlife (swift fox, peregrine falcon, whooping crane) restoration projects been?
- Does the pH of water samples vary from one location to another?
- What are some of the ways in which irrigation can be used to improve crop yields?
- How can a model be developed to illustrate the Greenhouse Effect?
- How are greenhouse gases added to the atmosphere?
- How does deforestation contribute to the Greenhouse Effect?
- What is the importance of ozone in the Earth's atmosphere?
- What are some of the long-term implications of the Greenhouse Effect to agriculture in Saskatchewan?
- What legislation is currently in place to attempt to reduce the production of greenhouse gases?
- Is there a relationship between the thinning of the Earth's ozone layer and sunspot activity?
- Is uranium found in any specific geological formations?
- What industrial process is used in the mining and refining of uranium?
- What are some of the environmental concerns regarding uranium mining or the use of nuclear energy?
- What are some of the health and safety implications in the mining, processing, or use of uranium?
- What are some of the effects that radiation has on humans or other living things?
- What are some of the ways in which uranium is used?
- How is electricity produced in CANDU nuclear reactors?
- Should Saskatchewan build its own nuclear generating stations?
- What are some of the types of radiation emitted by radioactive sources?

- What precautions can be taken to minimize the risk of exposure to different types of radiation?
- What are some of the technical difficulties arising out of nuclear waste disposal?
- What are the risks and benefits of the use of nuclear energy for peaceful purposes?
- How biodegradable is newspaper in a waste disposal site?

Physical Science

- Can fibres examined under a microscope be used to identify different types of clothing?
- Which brand of batteries really lasts longer?
- What types of batteries work the best in cold weather?
- How are the viscosities of different grades of motor oil affected by temperature?
- What are some ways in which soil erosion can be minimized?
- What differences can be observed between physical and chemical changes?
- What are some observable changes that would indicate that a chemical change has taken place?
- What are some of the different kinds of chemical reactions that can take place?
- What experiment(s) can be performed to investigate the conservation of matter and energy in chemical reactions?
- What experiment(s) can be performed to illustrate the Law of Conservation of Mass or the Law of Constant Composition?
- Research the system of nomenclature used for chemicals.
- How can models be used to illustrate the changes that take place during chemical reactions?
- Research modern atomic theory. How has atomic theory changed over the past hundred years as new experimental evidence became available?
- What are some of the factors which are placing stress on the world's resources?
- How can conservation be used as a strategy for protecting and extending available energy supplies?
- How do chemicals used in crop protection work?
- What are the standards and procedures for identifying carcinogens?
- How are acceptable standards for levels of toxins in water or air established?
- What are some of the long-term implications if current energy use patterns are extrapolated into the future?
- What implications does global population increase have on long-term energy demands?
- What implications does third-world development have on long-term energy demands?
- How can communities work together to help protect the environment?
- Develop a working model to show how energy can be converted from one form to another.
- Illustrate ways in which science and technology can utilize energy efficiently.
- Research attempts being made to promote the concept of sustainable development.
- Illustrate the relationship between kinetic molecular theory and energy.
- Investigate the long-term implications of the continued use of fossil fuels.
- Develop a device which uses solar energy instead of conventional fossil fuels.
- Evaluate different options regarding energy use management.

Life Science

- Observe and describe cells using a microscope.
- Develop a portfolio of photographs using photomicroscopy.
- Compare the resolving power of different types of microscopes.
- What effect do electric fields have on plant growth or cell development?
- How does soil composition affect the yield of a particular cash crop?
- How do different types of cells compare in size and other physical characteristics?
- What are some of the different parts of cells?
- How do specialized groups of cells work together?
- What is cell differentiation? What mechanisms might be responsible for causing this?
- How does diffusion occur through cell membranes?
- Can aromatic substances found in plants be produced artificially in the laboratory?
- What are some different human body systems?
- How does a particular human body system operate?
- What are some of the relationships that exist between different human body systems?
- What laboratory investigations could be developed to investigate the characteristics of human body systems?
- Is strength related to lung capacity?
- Is maximum lung pressure related to lung capacity?
- What is the minimum concentration of a "taste" chemical that can be detected?
- What is integrated pest management?
- How can technological developments be used to sustain a failing body system?
- How are diseases affecting human body systems diagnosed and treated?
- What reasons are there for using food additives?

- Identify and classify a variety of food additives.
- What tests can be performed to chemically analyze the ingredients of food?
- What are some of the possible dangers of food additives?
- What are some of the benefits of food additives?
- What scientific tests must be performed before a food additive is licensed for human consumption?
- What are some of the historical and new technologies of food processing, packaging, and preparation?
- What types of food wrap work the best?
- How are new food products developed, certified and marketed?
- What is the best way to prevent freezer burn?
- How effective are different types of detergents and antiseptics in controlling bacteria?
- What is the importance of each of the main food nutrient groups? How does the body utilize each?
- What is fibre? Why is it important in the diet?
- What are the potential risks of diets involving high or low amounts of substances such as sugar, fat, cholesterol, sodium, caffeine, or alcohol?
- What are saturated and unsaturated fats?
- Can people tell the difference between the taste of butter and margarine?
- What chemical processes can be used to alter the structure of fat molecules?
- What is the nutritional and caloric content of different foods or diets?
- How is the nutritional value of food changed by preparing, processing, or cooking it?
- What types of diseases may result from nutritional deficiencies?
- What are some of the advantages and disadvantages of vegetarian diets?
- How do the historical and contemporary diets of people from different cultures compare in nutritional value?
- Why are the recommended diets of males and females, children and adults, and pregnant women different?
- How and when were crops such as corn (maize), pumpkins, canola and wheat developed?
- How effective is preserving meats by drying and by making pemmican?

Computer Science

- How accurate are calculators?
- Can an interface device be designed to monitor weather conditions continuously?
- How is data transfer handled between different I/O devices?
- How can microwaves be used to transmit computer data?
- Can random numbers be used to simulate the random collisions in an ideal gas?
- Program the computer to simulate an industrial process which may be impractical to illustrate in another way in the classroom.
- Program the computer to simulate a change in the land over time.
- How can a computer be used to control a robot?
- Develop a video game which illustrates an important concept in science
- How can a computer be programmed to facilitate data gathering and analysis for a specific experiment?

Applied Science and Engineering

- What are some of the design considerations required in constructing a solar heated home?
- What type of propeller design is the most efficient for a wind generator?
- How do landforms and tall buildings affect wind flow patterns?
- What is the optimum design for a shelter belt?
- How do different types of home insulation compare in R-values?
- How can landscaping be used to improve the energy efficiency of a home?
- Why do transformers sometimes fail in hot weather?
- How can various consumer products be tested to determine how well they perform?
- How can a weir be constructed to provide oxygenation in a river without blocking the migration of aquatic species?
- How can a recovery plant be designed to recycle plastics?
- What are the design considerations for an intensive agricultural operation?
- Can a device be designed to commercially convert animal manure into methane gas?
- What types of biodegradable inks can be used for newsprint?
- How can an enclosure be designed to keep a particular type of animal safe and comfortable in the classroom?
- How can an enclosure be designed to keep a particular type of animal safe and comfortable outdoors at -40°C?
- How could a greenhouse be developed to exploit waste heat in an industrial facility?
- How can a water wheel be designed most efficiently to convert potential energy into mechanical energy?
- How could a detector be designed to analyze automobile exhaust emissions?

- Is it possible to develop a device to test for the amount of alcohol present in a person's saliva?

Student Project Checklist

Make sure that the Science Fair project you are working on conforms to the following guidelines. These are general guidelines that apply to many Science Fairs. Check the rules for the Science Fair you will be entering. There may be some special rules which apply.

____ The exhibit is no more than 3.5 m high, 1.2 m wide, and 0.8 m deep.

____ Hazardous materials are not being used. If hazardous materials are used, which supervising teacher approved their use?

____
(name)

____ If applicable, hazardous substances are replaced by safer ones.

____ Pressurized containers with safety valves are used.

____ There are no open flames in the exhibit.

____ Electrical conductors have three-prong grounded connectors.

____ Electrical conductors are properly insulated.

____ Voltages above 10 kV are not generated.

____ Lasers are not operated during public display.

____ High energy radiation sources are registered and approved for use, if allowed.

____ Radioisotopes above the level of background radiation are not used.

____ If vertebrates are used in the project, which supervising teacher approved their use?

____
(name)

____ Procedures which could harm or distress animals are not used.

____ All microbial cultures are sealed.

____ Pathogenic organisms are not used.

____ Experimental manipulation with recombinant DNA is not done.

____ Biological toxins are not on display.

Teacher's notes

Topic D-4 Science Olympics

Science Olympics are structured activities engaging students in some kind of Science Challenge. They can involve an entire class, broken down into teams, working on the same problem, or a number of stations which groups work through in rotation. The activities offer enrichment to the science program. Further details regarding these topics are provided in Science Program Overview and Connections K-12.

Many resource materials are becoming available which offer suggested Science Olympics activities. Such activities may be used as is, or modified depending on the needs and interests of the class, and the types of equipment and materials available. For a listing of resources which might offer some suggested activities for **Science Olympics**, refer to *Science 10: A Bibliography for the Secondary Level.*

One idea which is gaining popularity is the **Super Science Saturday**. It provides students with an opportunity to become involved in Science Olympics on a voluntary basis. Interest in such programs is usually high, attracting those students who are highly motivated and keen on exploring a science challenge. These programs are also useful during Education Week, or during the school's open house. Parent and community interest can be quite high. These activities serve to make science enjoyable, and may lead some students to consider registering for other Secondary Level science courses.

Individual or team projects may be used. A great deal of creativity can go into these projects.

Science Olympics can be highly organized and structured like a Science Fair. Unlike a Science Fair, which displays projects that students have created and developed on their own, a **Science Olympics** provides students with a given number of challenging science problems to solve within a fixed amount of time. The problems are usually open-ended, yielding a variety of creative solutions. Students must draw on a wide range of scientific knowledge and skills in order to attempt a solution to the problems. Coordinating projects with other schools could be worth pursuing.

Competition should not be emphasized. Participation and working cooperatively with others are much more important. Everyone who participates in a **Science Olympics** wins in one way or another. If prizes are awarded, consider distributing certificates of participation and consolation prizes to everyone.

Learning Objectives

Students should be provided with opportunities to:

D-4.1 participate in a **Science Olympics** program;

D-4.2 recognize the need to work cooperatively when developing a solution to a **Science Olympics** problem;

D-4.3 utilize a wide range of knowledge and skills during a **Science Olympics**;

D-4.4 demonstrate that problem solving in science often involves imagination and creativity;

D-4.5 recognize that many problems are holistic in nature, offering a wide variety of possible approaches and solutions;

D-4.6 conduct a self-evaluation or group-evaluation of a **Science Olympics** activity;

D-4.7 become acquainted with the rules and judging criteria used during **Science Olympics**;

D-4.8 complete all necessary written reports and documentation related to a **Science Olympics** activity; and,

D-4.9 exhibit a keen interest in science.

Teacher's notes

Topic D-5 Science Outreach

This topic provides an opportunity for teachers and students to experience various aspects of science within and beyond the confines of the classroom. A **Science Safari** refers to a variety of field trip activities to outdoor or non-school indoor sites. Activities could include an interpretive hike along a nature trail, a visit to a municipal water treatment or waste disposal facility, or a visit to some important nearby industrial site.

Crucial to a successful experience is the preliminary preparation for the **Science Safari**, and the follow-up activities. The time required to do this must be considered. Further information is available in *Science Program Overview and Connections K-12*. Refer as well to the section in this Curriculum Guide on field trips, beginning on page 24, and to *Teaching Science Through A Science-Technology-Society-Environment Approach: An Instruction Guide*.

While the **Science Safari** extends the science classroom into the community, the community can also be brought into the classroom as science guests. Speakers, science careers seminars, and cross-cultural experiences bring the science which is done in the community to the students in the school.

Science Outreach is encouraged in all science courses from kindergarten to grade 12. The **Science Challenge** Core Unit provides an opportunity for teachers to integrate outreach activities with other core units of the course, as well as with other disciplines.

This unit presents an opportunity to produce reports, videos, slide-tape presentations or posters which can convey the discoveries of the **Science Outreach** to others. Cooperation with elementary school teachers may result in the production of a package for teachers or may allow the Science 10 students to give presentations to elementary level students.

Learning Objectives

Students should be provided with opportunities to:

D-5.1 participate in **Science Outreach** activities;

D-5.2 recognize the need to work cooperatively with others during a **Science Safari**;

D-5.3 utilize a wide range of knowledge, skills, and processes during a **Science Safari**;

D-5.4 recognize that understandings in science extend across the entire curriculum;

D-5.5 complete a written report (or some other tangible product such as a bulletin board display, an oral presentation, or a **Science Fair** project) based on **Science Outreach** activities;

D-5.6 exhibit a keen interest in science;

D-5.7 demonstrate a willingness to learn;

D-5.8 recognize the interrelatedness of all things; and,

D-5.9 conduct a self-evaluation or group evaluation of a **Science Outreach** activity.

Teacher's notes

Science 10

An Information Bulletin for Administrators

Saskatchewan Education, Training and Employment

1993 Revision

Table of Contents

Introduction

Effective implementation of a new course of study necessitates administrative commitment and support. To enable administrators to play an active role in curriculum implementation, information and assistance must be provided.

This *Science 10 Information Bulletin* has been designed to enable school-based administrators and others to support teachers in implementing a quality science program. This document aims to provide you with an overview of Science 10 and its connections.

Purposes of this Information Bulletin

This bulletin will:

- set the Science 10 curriculum into the context of Core Curriculum and the foundation study of science for Saskatchewan schools;
- outline the new curriculum;
- describe what is new about the curriculum;
- describe the resources recommended for use with the curriculum; and,
- describe the plans for maintenance.

Rationale for the Curriculum

The science curriculum in Saskatchewan is moving away from a traditional curriculum oriented toward the memorization of facts and concepts, to one that stresses the scientific literacy of the student. Scientific literacy is defined by the factors of the Dimensions of Scientific Literacy (Hart, 1987).

Science is both a body of knowledge and a process of discovery. It is a tool to help describe and explain the natural world. A key to the achievement of scientific literacy is the presentation of science information in context, so that the facts, concepts, and processes of science are closely linked to natural phenomena. Values, attitudes, and interests associated with science must also be considered.

Aim and Goals

The major aim of the K-12 Science program is to develop scientific literacy in students. For Saskatchewan schools, scientific literacy has been defined by seven goals called Dimensions. These Dimensions of Scientific Literacy are the foundation for the renewed curriculum. By actively participating in K-12 science, a student will be enabled to do a number of things.

- Understand the **nature of science** and scientific knowledge. Science is a unique way of knowing about the world.
- Understand and accurately apply appropriate **science concepts**, principles, laws and theories in interacting with society and the environment.
- Use the **processes of science** in solving problems, making decisions, and furthering understanding of society and the environment.
- Understand and appreciate the joint enterprises of **science and technology** and the **interrelationships** of these to each other in the context of **society and the environment**.
- Develop numerous manipulative **skills** associated with science and technology. Many of these deal with measurement.
- Interact with the various aspects of society and the environment in ways that are consistent with the **values that underlie science**.
- Develop a unique view of technology, society and the environment as a result of science education, and continue to extend this **interest and attitude** throughout life.

Each of the above goals has been defined further as a series of factors. (See Appendix A.) This collection of factors of scientific literacy specifies the science curriculum.

Overview of the Science Curriculum

There are three important aspects to the science program. The first is the underlying foundation of the Common Essential Learnings. The science program is structured in such a way that each of these are incorporated to the greatest degree possible during the teaching of science.

The second aspect is the Dimensions of Scientific Literacy. These Dimensions, delineated by the factors within each Dimension, are the target outcomes for students finishing their science education in Saskatchewan schools. (See Appendix A.)

No one can maintain that there is a particular body of knowledge that all graduates should attain. **However, research into science education indicates that acquiring an understanding of, and an ability in, the factors that underlie the Dimensions of Scientific Literacy, will give students the ability to function in society as scientifically literate people.**

The third aspect is that of scientific knowledge. There is an expectation that students should acquire that knowledge through an activity-oriented science program. The Common Essential Learnings and the factors within the Dimensions of Scientific Literacy are taught through the content of the disciplines of science. The science program seeks to use the broad fields of earth science, life science and physical science as sources of activities and information in order that the first two aspects can be accomplished.

Foundational Objectives

The Foundational Objectives represent those objectives that all students in Science 10 should be able to achieve. They are the common core experiences that link all Saskatchewan Science 10 classrooms. In each classroom, these objectives must form the focus of the study of science.

The topics are the science content areas under which each individual teacher organizes activities and information to motivate the student. The learning objectives listed for each topic in the Guide are suggestions of how that topic may be used to achieve the Foundational Objectives for the unit. In a typical classroom, the teacher will select some from those provided, and develop others in response to the identified needs of the class. **The learning objectives for the topics do not define what must be covered. That guidance comes from the Foundational Objectives.**

Science 10 is intended as a student-directed course. Rather than being recipients of information, the students should take an active role in pursuing and refining their thoughts about science and issues in science. Instructional approaches must vary from the traditional lecture and demonstration in order that this approach is valid; the same applies to assessment and evaluation.

Core Unit A: Earth/Environmental Science

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

- appreciate the complexity within natural systems
- examine the impact of historical and contemporary human activity on the biosphere
- examine the impact of human activity ... traditional lifestyles
- identify ways that the impact of human activity can be reduced
- analyze the effect of the environment on personal activities and lifestyles
- analyze the environmental impact of personal activities and lifestyles;
- use a wide range of resources and activities to develop knowledge of natural systems (COM)
- engage in intuitive, imaginative thought and the evaluation of ideas, processes, experiences and objects in the context of understanding the effect which humans have on the biosphere (CCT)
- develop an understanding that technology both shapes, and is shaped by, society (TL)
- meet personal learning needs (IL).

Topics:
- Water Quality*
- The Greenhouse Effect
- Uranium

*suggested topic

Core Unit B: Physical Science

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

- recognize that pervasive physical laws govern interactions of matter and energy
- perceive patterns which provide evidence of interactions of matter and energy
- use both qualitative and quantitative means to describe phenomena
- recognize the impact of manipulation of matter and energy on personal activities and lifestyle
- apply knowledge of numbers and their interrelationships (NUM)
- develop an understanding of how knowledge is created, evaluated, refined and changed within science (CCT)
- develop a contemporary view of technology (TL).

Topics:
- Chemical Change* *suggested topic
- Energy Management
- Teacher Selected Physical Science Topic

Core Unit C: Life Science

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

- appreciate the complexity of living systems
- recognize the intricate nature of the external system which supports life on Earth
- realize the fragile yet robust nature of life
- understand and use the vocabulary, structures and forms of expression which characterize life science (COM)
- engage in intuitive, imaginative thought and the evaluation of ideas, processes, experiences and objects in the context of understanding the place which life has in the biosphere (CCT)
- develop a contemporary view of technology (TL).

Topics:
- Cell Structure and Human Body Systems* *suggested topic
- Food Additives and Human Nutrition
- Teacher Selected Life Science Topic

Core Unit D: Science Challenge

Foundational Objectives for Science and the Common Essential Learnings

In this unit students will increase their abilities to:

- use a variety of ways to communicate information about some area of scientific interest
- demonstrate an understanding of how scientific research is conducted
- perform investigations which demonstrate an ability to search for answers to good questions
- formulate a hypothesis, control variables, manipulate equipment and materials, record observations, and analyze the results of experimental data
- develop a positive disposition to life-long learning (IL)
- understand the personal, moral, social, and cultural aspects of science (PSVS)
- appreciate the value and limitations of technology within society (TL)
- recognize the limits of individual reflection, and the need to contribute to and build upon mutual understandings (CCT)
- use a wide range of possibilities for developing major concepts within science (COM).

Topics:
- Extension Activities to Previous Units
- Research Projects
- Science Fair Projects
- Science Olympics
- Science Outreach

What's New About this Curriculum?

- Science 10 calls for a balanced approach to scientific literacy: content; processes and skills; interests, attitudes, and values.
- Science 10 is still an activity-based course, but the definition of activity is broadened to encourage a wider range of instructional and evaluation approaches than have previously been emphasized in many Science 10 classrooms. This has been done in order to strengthen the emphasis on all of the Common Essential Learnings.
- Science 10 takes into account special initiatives of the Core Curriculum, such as the Adaptive Dimension, Gender Equity, Indian and Métis

perspectives, and Resource-Based Learning.

- Science 10 is a flexible course, offering a strong earth/environmental-physical-life science core presented through topics which the teacher can select to best fit the needs within the classroom.
- Science 10 has been designed as a transitional course, a bridge from the integrated approach of the Middle Level (grades 6 to 9) curriculum to the disciplines of biology, chemistry and physics in grades 11 and 12.
- Science 10 provides the opportunity to challenge each student to take responsibility for learning through project work, independent study and small group cooperative study.
- The curriculum guide for Science 10 defines the curriculum. Numerous resources have been identified and referenced to the Curriculum Guide by means of the Information Bulletin-Key Resources. **Science 10 can not be delivered using one textbook as the only resource.**

Recommended Resources for Implementation

- Saskatchewan Education documents are provided.

  - *Science Program Overview and Connections K-12 (Draft)* — for teachers and administrators. (At least one per school.)
  - *Science 10: A Curriculum Guide for the Secondary Level* (one per teacher)
  - *Science 10: An Information Bulletin for the Secondary Level — Key Resources* (one per teacher)
  - *Science 10: A Bibliography for the Secondary Level* (at least one per school)
  - *Understanding the Common Essential Learnings - A Handbook for Teachers*
  - *Student Evaluation: A Teacher Handbook*
  - *Instructional Approaches: A Framework for Professional Practice*
  - *The Adaptive Dimension in Core Curriculum*

- Key classroom print materials (See Appendix B).

  NOTE: Teachers should see these resources before ordering decisions are made.

The Science Curriculum Advisory Committee recommends that, in order to implement Science 10 with a resource-based learning focus, students have access to a variety of the recommended key resources in a ratio of at least one key resource per student.

- Possible variations:
  - 1 text per student. (Some additional resource-based learning support is possible.)
  - 1 text per 2 students. (Additional support for resource-based learning is possible.)
  - 1 text A per student in one classroom plus one text B per student in another classroom. (Additional support for the resource centre is possible.) Devise strategies to swap texts periodically.
  - 1 text per 3 or 4 students plus copies of other items, to create resource packages useable in groups for activities where there is a designated reader, investigator/manipulator, and recorder/reporter.

- Teacher resource materials.

  All teacher editions plus certain key supports from resource packages may be procured.

- Additional resource centre support.

  See the comments above. Consult the Bibliography for suggestions.

Questions to ask about resources

- What kind of materials, print and nonprint, are necessary to meet the objectives of the program? How can these materials best be selected and used by educators and students alike?
- What resources do we already have in the school division?
- Are the learning resources readily available?
- Are sufficient resources available to teach the program as intended?

Equipment and Supplies

Teachers should use the Curriculum Guide and resources to determine which activities are likely to be performed. See the equipment and supplies listed in the resources chosen. Set up a school/division inventory of equipment and obtain the necessary equipment to teach the activity-based program that has been designed.

- Here are some suggestions for sources of supplies.
  - Reuse/use materials from home.
  - Procure unused equipment from other schools.
  - obtain community and industry support.

- Classroom/labs may need to be upgraded. See the Guide for additional information.

- Classroom facilities for doing activity-based Science 10 should include most or all of the following features:
  - flat, movable desks or tables appropriate to the size of the students (for group work);
  - perimeter counter space;
  - as much storage as possible;
  - sinks with hot and cold running water;
  - electrical outlets;
  - AV equipment and accessories;
  - reading materials display area;
  - bulletin/display area;
  - adjacent or centralized preparation/storage area; and,
  - natural window lighting for plants or artificial plant-growing lights.

Questions to ask about facilities

- Are equipment and facilities adequate to facilitate the achievement of program objectives?
- What areas need improvement?

Role of Administrators

- Considering the needs, interests and resources of the school community and school division, assist teachers to determine the order in which the core and optional units will be presented.
- Support the development of a large and varied collection of resources to support Resource-Based Learning.
- Support and encourage teachers to cooperate to plan instructional strategies and methods, as well as evaluation strategies.
- Inform parents, boards and community about the philosophy and rationale of the new courses. This is especially critical when each student does not have a personal copy of a textbook.
- Encourage teachers to make the maximum use of community resources.
- Monitor the programs and provide support and assistance where necessary.

Questions to consider

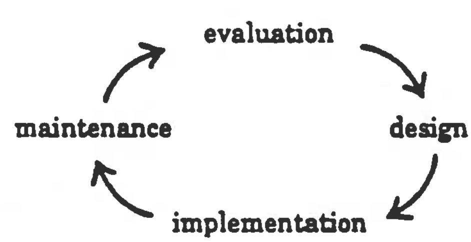
- Are teachers supported in attending the implementation workshops?
- What other provisions can be made for staff development?
- Is inservice and teacher education adequate? In what specific areas is more help needed?
- What provisions are in place to free up time for teacher planning?
- Is teacher planning time sufficient to support the achievement of program objectives?
- Do administrators and trustees understand and support the program?
- Have steps been taken to make parents aware of the program and its objectives?

Maintenance

"(The) teacher has a key role as classroom manager; managing time, people, resources and the classroom environment including collaboration with other teachers and students."

- *Science for Saskatchewan Schools: Summary of Framework for Science Curriculum Development*. Saskatchewan Education, 1987.

In part, Saskatchewan Education plans to maintain the curriculum for Science 10 through information provided in *Update Bulletins*. Other support will come through Core Curriculum initiatives involving school divisions. This plan is part of the curriculum development model which has been adopted by Saskatchewan Education, as outlined below:



Maintenance Needs (5-7 year cycle):

- Documents for new teachers must be ordered
- Update classroom and teacher resource materials on a continuing basis
- Resource centre support
- Equipment and supplies
- Inservice on instructional approaches should be provided.
- Program evaluation should be done.

Questions to ask about maintenance

- To what extent are teachers familiar with the actual curriculum guide, its philosophy, Foundational Objectives, activities and methods? (This is what is meant by the **intended** curriculum.)
- To what extent do the actual experiences which teachers provide (the **taught** curriculum) match the intended curriculum?
- How are teachers structuring their observations of students to ensure that Foundational Objectives are being met?
- Do teachers have a system for providing information to students and parents?
- Are all students progressing as a result of the experiences teachers provide?
- Are teachers adapting materials, methods or setting when necessary to meet individual student needs?
- Are teachers regularly incorporating opportunities for independent exploratio. .d learning?
- To what extent do teachers understand the relationships between the Common Essential Learnings and the Science program?
- Are teachers attending to the incorporation of the Common Essential Learnings in their lesson (and unit) planning process?
- To what extent do teachers appear to be enthusiastic about the Science program and their lessons?
- To what extent do the activities and teacher questions involve students in creating and reflecting upon content and processes of the program?
- What teaching methods are used? Are they appropriate? Are they varied? Are they consistent with what the curriculum recommends?
- What human and material resources are used? To what extent are community resources and programs used to enrich the program?
- Are sufficient resources available to teach the program as intended?
- Has an in-school or school division(s) network been established to support delivery of this program through idea exchanges and peer coaching?
- What other provisions are made for staff development? Are they appropriate and sufficient?
- Are equipment and facilities adequate to facilitate the achievement of program objectives?
- What areas need further improvement?
- Is equipment well utilized?
- Are the financial resources allotted sufficient to support the achievement of program objectives?

Dimensions; Factors	Levels: Elementary						Middle				Secondary		
	K	1	2	3	4	5	6	7	8	9	10	11	12
A Nature of Science													
1. public/private	—	—	—	—	—	—	—	—	—	—	—	—	—
2. historic	—	—	—	—	—	—	—	—	—	—	—	—	—
3. holistic	—	—	—	—	—	—	—	—	—	—	—	—	—
4. replicable	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
5. empirical	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
6. probabilistic			- -	- -	- -	- -	- -	- -	- -	—	—	—	—
7. unique				- -	- -	- -	- -	- -	—	—	—	—	—
8. tentative							- -	—	—	—	—	—	—
9. human/culture related							- -	- -	- -	- -	—	—	—
B Key Science Concepts													
1. change	—	—	—	—	—	—	—	—	—	—	—	—	—
2. interaction	—	—	—	—	—	—	—	—	—	—	—	—	—
3. orderliness	—	—	—	—	—	—	—	—	—	—	—	—	—
4. organism	—	—	—	—	—	—	—	—	—	—	—	—	—
5. perception	—	—	—	—	—	—	—	—	—	—	—	—	—
6. symmetry	—	—	—	—	—	—	—	—	—	—	—	—	—
7. force	- -	- -	—	—	—	—	—	—	—	—	—	—	—
8. quantification	- -	- -	—	—	—	—	—	—	—	—	—	—	—
9. reproducibility of results	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
10. cause-effect	- -	- -	- -	—	—	—	—	—	—	—	—	—	—
11. predictability	- -	- -	- -	- -	—	—	—	—	—	—	—	—	—
12. conservation	- -	- -	- -	- -	- -	—	—	—	—	—	—	—	—
13. energy-matter		- -	- -	—	—	—	—	—	—	—	—	—	—
14. cycle		- -	- -	—	—	—	—	—	—	—	—	—	—
15. model		- -	- -	—	—	—	—	—	—	—	—	—	—
16. system		- -	- -	—	—	—	—	—	—	—	—	—	—
17. field		- -	- -	—	—	—	—	—	—	—	—	—	—
18. population				- -	—	—	—	—	—	—	—	—	—
19. probability				- -	- -	- -	- -	- -	- -	—	—	—	—
20. theory				- -	- -	- -	- -	- -	- -	- -	—	—	—
21. accuracy						- -	- -	- -	- -	—	—	—	—
22. fundamental entities							- -	—	—	—	—	—	—
23. invariance							- -	—	—	—	—	—	—
24. scale							- -	—	—	—	—	—	—
25. time-space							- -	- -	—	—	—	—	—
26. evolution							- -	- -	- -	—	—	—	—
27. amplification									- -	—	—	—	—
28. equilibrium										- -	—	—	—
29. gradient										- -	—	—	—
30. resonance										- -	—	—	—
31. significance										- -	—	—	—
32. validation										- -	—	—	—
33. entropy										- -	- -	—	—
C Processes of Science													
1. classifying	—	—	—	—	—	—	—	—	—	—	—	—	—
2. communicating	—	—	—	—	—	—	—	—	—	—	—	—	—
3. observing and describing	—	—	—	—	—	—	—	—	—	—	—	—	—
4. working cooperatively	—	—	—	—	—	—	—	—	—	—	—	—	—
5. measuring	—	—	—	—	—	—	—	—	—	—	—	—	—
6. questioning	- -	- -	—	—	—	—	—	—	—	—	—	—	—
7. using numbers	- -	- -	—	—	—	—	—	—	—	—	—	—	—
8. hypothesizing		- -	- -	—	—	—	—	—	—	—	—	—	—
9. inferring		- -	- -	—	—	—	—	—	—	—	—	—	—
10. predicting		- -	- -	—	—	—	—	—	—	—	—	—	—
11. controlling variables		- -	- -	—	—	—	—	—	—	—	—	—	—
12. interpreting data			- -	—	—	—	—	—	—	—	—	—	—
13. formulating models			- -	- -	- -	- -	- -	—	—	—	—	—	—
14. problem solving			- -	- -	- -	- -	- -	- -	- -	—	—	—	—
15. analyzing				- -	- -	- -	—	—	—	—	—	—	—
16. designing experiments				- -	- -	- -	- -	- -	- -	—	—	—	—
17. using mathematics							- -	—	—	—	—	—	—
18. using time-space relationships							- -	- -	—	—	—	—	—
19. consensus making							- -	- -	- -	—	—	—	—
20. defining operationally								- -	- -	- -	—	—	—
21. synthesizing										- -	- -	—	—

[1]Adapted from: Hart, E.P. (1987). *Science for Saskatchewan Schools: Proposed Directions. Field Study. Part B. A Framework for Curriculum Development.* A Saskatchewan Instructional Development Research Unit project funded by Saskatchewan Education.

Levels

Elementary: K, 1, 2, 3, 4, 5 · Middle: 6, 7, 8, 9 · Secondary: 10, 11, 12

Dimensions; Factors	----	——
D Science-Technology-Society-Environment Interrelationships		
1. science and technology	K–2	3–12
2. scientists and technologists are human	1–6	7–12
3. impact of science and technology	3–5	6–12
4. science, technology, and the environment	3–5	6–12
5. public understanding gap	3–8	9–12
6. resources for science and technology	3–8	9–12
7. variable positions	3–9	10–12
8. limitations of science and technology	6–8	9–12
9. social influence on science and technology	7–9	10–12
10. technology controlled by society	9	10–12
11. science, technology, and other realms	9	10–12
E Scientific and Technical Skills		
1. using magnifying instruments		K–12
2. using natural environments		K–12
3. using equipment safely		K–12
4. using audio-visual aids		K–12
5. computer interaction		K–12
6. measuring distance	K–1	2–12
7. manipulative ability	K–2	3–12
8. measuring time	1	2–12
9. measuring volume	1	2–12
10. measuring temperature	1	2–12
11. measuring mass	2	3–12
12. using electronic instruments	5–8	9–12
13. using quantitative relationships	5–9	10–12
F Values That Underlie Science		
1. longing to know and understand		K–12
2. questioning		K–12
3. search for data and their meaning		K–12
4. valuing natural environments		K–12
5. respect for logic	K–2	3–12
6. consideration of consequences	K–5	6–12
7. demand for verification	3–5	6–12
8. consideration of premises	9	10–12
G Science-Related Interests and Attitudes		
1. interest		K–12
2. confidence		K–12
3. continuous learner		K–12
4. media preference	K–2	3–12
5. avocation	3–5	6–12
6. response preference	3–5	6–12
7. vocation	3–8	9–12
8. explanation preference	6–9	10–12
9. valuing contributors	6–9	10–12

KEY: ---- Preparation. Emerging in these grades. Limited focus.
—— Development. Addressed in full, and appropriate to the grade level. Emphasized.

Appendix B. Key Resources

Note: Most items are available through the Book Bureau (BB). Item 4 must be ordered from the U.S.A. Items 5, 9, 10, and 11 may be obtained free or for a nominal fee. Prices listed for any of the materials may change. **Teachers should inspect these resources before final ordering decisions are made.**

Student Textbooks

1. *Heath Science Connections 10* (Print-Non-Fiction). Jack L. Candido, et al. D.C. Heath Canada Ltd., Toronto, ON (BB), 1988. 774 p. BB Order No. 6174 ($39.80 hdc.)

   Heath Science Connections 10 is a traditional-style science text. It presents information about a wide variety of topics from the life, earth and physical sciences. Special sections -- "Science in Action", "Science in Society" and "Science-Related Career" -- help tie the science concepts to the lives of the students.

   Laboratory activities are incorporated into the text and are used to reinforce or to verify the principles which have been introduced. At the end of each chapter, problems dealing with application of principles, problem solving and project ideas offer opportunities for developing the Common Essential Learnings and the Dimensions of Scientific Literacy.

2. *Logical Reasoning in Science and Technology* (Print-Non-Fiction). Glen S. Aikenhead. John Wiley and Sons Canada Ltd., Toronto, ON (BB), 1991. 400 p. BB Order No. 6202 (in press; to be published in April, 1991. ($29.15 hdc.) Teacher Guide. BB Order No. 6218.

   Logical Reasoning in Science and Technology is a text which presents scientific concepts in a technological and social context. The context is the development of the Borkenstein breathalyser, and its use to estimate the level of alcohol in the blood by analysis of a person's breath. The scientific concepts include the chemistry and physics necessary to understand the mechanics of the breathalyser, and the biology of the human digestive and respiratory systems.

   A wide range of activities, from traditional science labs to simulations and small group discussion, are integrated into the text. Many of these activities shift the active role in the classroom to the student and the student's working group. The text strongly supports developing the Common Essential Learnings and the Dimensions of Scientific Literacy.

3. *Visions 1* (Print nonfiction). Braaten, Audrey, et al. Gage (BB), 1992. Text - Order # BB 864 ($52.45 hdc). Teacher's Guide - Order # BB 865 ($52.45) Blackline masters - Order # BB 866.

   This resource integrates issues related to society, technology and the environment with the science of matter and energy in physical, chemical, and biological systems.

   The book, developed in Alberta for the new Alberta Science 10 curriculum, incorporates a variety of innovative laboratory and classroom activites. The Teacher's Guide provides good support for teachers without a strong science background.

Student and Teacher References

4. *American Indian Ecology* (Print-Non-Fiction). J. Donald Hughes. Texas Western Press, El Paso, TX (UTEP), 1983. 174 p. ISBN 0-87404-070-1 ($20.00 U.S. hdc.)

   American Indian Ecology has a two-fold purpose for the Science 10 teacher. It is an orientation to the world view which is shared by most of the Indian peoples of North America. The book helps teachers to be able to incorporate Indian and Métis perspectives into the teaching of science by aiding them in understanding what that perspective is. Secondly, it provides some information which students may use when they consider the issue of water quality. The need for water of good quality knows no cultural boundaries. This book is recommended as a teacher resource.

5. *Energy Technologies*

(Print-Non-Fiction). Richard Wray, et al. S.E.E.D.S. Foundation, Edmonton, AB (BB), 1983. 64 p. BB Order No. 6175 ($2.35 pbk.); BB Order No. 6176 ($11.65 pbk. Teacher's Guide)

Energy Technologies, a SEEDS module, is a key resource for classes which select the energy management option in the physical science unit. A description of energy in its various forms, how energy is produced and used, and the effect of energy production and use on the environment is the focus of this activity-based unit. A teacher's guide to the module plus a classroom set of the student booklets are still free to teachers who attend a SEEDS workshop. (Contact Peter Stroh in Saskatoon at 374-3543.)

6. *Investigating Aquatic Ecosystems 2nd ed.* (Print-Non-Fiction). William A. Andrews and Sandra J. McEwan. (Contours: Studies of the Environment). Prentice-Hall Canada Inc., Scarborough, ON (BB), 1987. 342 p. BB Order No. 6179 ($28.70 pbk.)

Investigating Aquatic Ecosystems is a 1987 revision of one of the volumes in the **Contours: Studies of the Environment** series. Chapters 4 through 6 will be valuable for classes studying the topic of water quality. The book combines information, activities and suggestions for investigations into a very useful package. The book is also an excellent resource for the units on ecosystems and on the diversity of life in Biology 20.

7. *Issues for Today: Acid Rain, Genetic Engineering, Herbicides and Pesticides, The Greenhouse Effect.* (Print-Non-Fiction). William Smallwood. GLC Silver Burdett, Scarborough, ON (BB), 1985. 105 p. BB Order No. 6180 ($11.50 Pbk.)

Four major environmental issues are discussed. Of these, the greenhouse effect section will be useful for the grade 10 curriculum. The other topics are useful in Biology 30 and Chemistry 30. Rather than being definitive presentations of each issue, these readings serve to initiate student interest and research on the topic.

8. *Science, Process and Discovery* (Print-Non-Fiction). Dennis Field. Addison Wesley Publishers Ltd., Don Mills, ON (BB), 1985. 187 p. BB Order No. 6177 ($14.95 pbk.) BB Order No. 6178 ($20.05 pbk. Teacher's Guide, 1989).

This resource is an inquiry into the nature of science and scientific inquiry. Part One of the book introduces the principles by which all science operates. Parts Two through Five offer 24 case studies which illustrate the principles described in Part One and give a behind-the-scenes look into how scientists work and think. The case studies are classified as from general science, physics, chemistry and biology.

This book is a good resource for developing the Dimensions of Scientific Literacy, especially Dimension A (nature of science) and Dimension C (processes of science). A teacher's guide gives valuable suggestions on how to use this book in class. The book is also listed in the Information Bulletin for Biology 20/30, Chemistry 20/30 and Physics 20/30. Part One and selected case studies could be used in Science 10, followed by use of other case studies in each of the three senior sciences.

9. *Project WILD (1990) Activity Guide* (Print-Non-Fiction). Canadian Wildlife Federation, Ottawa, Ontario, 1990. 462 p. ISBN 1-55029-036-3

The 1990 version of the *Project WILD Activity Guide* contains both aquatic activities and "aquatic extensions" to many of the activities from the previous editions. This revision makes the Project WILD guide an especially useful resource for the water quality topic in the Earth/Environmental Science Core Unit. Project WILD guides are free to teachers attending a Project WILD workshop. The guide can not be purchased. (Contact the Project WILD Coordinator at 787-5242, Regina.)

10. *A Fine Science 1985* (Videotape). Saskatchewan Education/Canadian Broadcasting Corporation (MHP), 1985. Order No. V02309-V02321 (Programs 1-13) BB Order No. 5908 ($3.35 pbk. Teacher's Guide)

A Fine Science 2 1986 (Videotape). Saskatchewan Education/Canadian Broadcasting Corporation (MHP), 1986. Order No. V02417 - V02429 (Programs 1-13). BB Order No. 5909 ($3.35 pbk. Teacher's Guide).

The series, produced in 1985 and 1986, looks at the state of science and technology in Saskatchewan. A variety of areas is examined -- medicine, communications, natural resources, agriculture, power systems, water management, and pure science research. It is useful for career awareness, and as a link between what the students are learning and their lives in this province. It provides excellent support for developing the Common Essential Learnings and the Dimensions of Scientific Literacy.

Programs are available from Media House Productions for the cost of the videotape plus a nominal dubbing charges. Blank tapes may be purchased from Media House for this service or clients may supply their own tapes. Copies of the teacher's guides were sent to each school in 1985 and 1986.

11. *Uranium* (kit). (Saskatchewan Resource Series). Saskatchewan Education, Regina, 1990. Kit. BB Order No. 609 ($29.15). Print package only. BB Order No. 6092 ($7.62).

This kit provides teacher background information and suggestions for student activities about the uranium mining industry in Saskatchewan. It can help acquaint students with what uranium is, how it is mined, what it is used for, and with some of the issues concerning its production and use.

One copy of this kit was sent to all schools that enrol grade 10 students. Additional copies of the kit or the print material alone are available in the Book Bureau. The videotape may be acquired through Media House Productions.

12. E.D.I.T. series (Print nonfiction) Tooke, Moyra and The Common Heritage Foundation. distributed by Teachers' Press.

The modules in this series are comprised of case studies, fact sheets and simulations dealing with various environmental and social issues. They are excellent for promoting discussion, research, critical thinking and social values in the classroom. Modules in the series appropriate for grade ten are:

#8 *Energy and Development: Planning for Growth and Conservation*

#14 *Freshwater: Issues of Concern and Conservation*

#16 *The Question of Climate Change*

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