

Introduction

Background

The ***Senior 2 Science: Manitoba Curriculum Framework of Outcomes*** (2001) (hereinafter referred to as the *Science Framework*) presents student learning outcomes for Senior 2 science. These learning outcomes are the same for students in English, French Immersion, Français, and Senior Years Technology Education programs and result from a partnership involving two divisions of Manitoba Education, Training and Youth: School Programs and Bureau de l'éducation française. Manitoba's science student learning outcomes are based on those found within the *Common Framework of Science Learning Outcomes K to 12* (Council of Ministers of Education, Canada, 1997). The latter, commonly referred to as the *Pan-Canadian Science Framework*, was initiated under the Pan-Canadian Protocol for Collaboration on School Curriculum (1995), and was developed by educators from Manitoba, Saskatchewan, Alberta, British Columbia, the Northwest Territories, the Yukon Territory, Ontario, and the Atlantic Provinces.

Student learning outcomes are concise descriptions of the knowledge and skills [and attitudes] that students are expected to learn in a course or grade level in a subject area. (*A Foundation for Excellence*, 1995)

This *Science Framework* provides the basis for teaching, learning, and assessing science, and is mandated for use in all schools (*A Foundation for Excellence*, 1995). In addition, this *Science Framework* serves as a starting point for future development of curriculum documents, support materials, learning resources, assessment tools, and professional learning for teachers. *Senior 2 Science: A Foundation for Implementation* (2001) will complement this *Science Framework*, providing support for its implementation, including suggestions for instruction and assessment.

This *Science Framework* is organized into three sections:

- **Introduction** – describes the background, vision, goals, and beliefs upon which this *Science Framework* is based.
- **Manitoba Foundations for Scientific Literacy** – describes Manitoba foundations for scientific literacy, presents the conceptual organizer for Manitoba science education, and states the general learning outcomes that are broad descriptors of what Manitoba students are expected to know and be able to do as a result of their Early, Middle, and Senior Years science education.
- **Specific Learning Outcomes** – presents specific learning outcomes that describe the knowledge, skills, and attitudes that students are expected to demonstrate with increasing competence and confidence in science by the end of Senior 2.

Vision for Scientific Literacy

Global interdependence; rapid scientific and technological innovation; the need for a sustainable environment, economy, and society; and the pervasiveness of science and technology in daily life reinforce the importance of scientific literacy. Scientifically literate individuals can more effectively interpret information, solve problems, make informed decisions, accommodate change, and create new knowledge. Science education is a key element in developing **scientific literacy** and in building a strong future for Canada's young people.

This *Science Framework* is designed to support and promote the vision for scientific literacy as articulated in the *Pan-Canadian Science Framework*.

The [Pan-Canadian Science] Framework is guided by the vision that all Canadian students, regardless of gender or cultural background, will have an opportunity to develop scientific literacy. Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them.

Diverse learning experiences based on the [Pan-Canadian Science] Framework will provide students with many opportunities to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, careers, and their future.

(Common Framework of Science Learning Outcomes K to 12, 1997)

Goals for Canadian Science Education

To promote scientific literacy, the following goals for Canadian science education were developed as part of the *Pan-Canadian Science Framework* and are addressed through Manitoba science curricula.

Science education will...

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

Beliefs about Learning, Teaching, and Assessing Science

To promote scientific literacy among future citizens, it is crucial to recognize how students learn, how science can best be taught, and how learning can be assessed. Students are curious, active learners who have individual interests, abilities, and needs. They come to school with various personal and cultural experiences and prior knowledge that generate a range of attitudes and beliefs about science and life.

Students learn most effectively when their study of science is rooted in concrete learning experiences, related to a particular context or situation, and applied to their world where appropriate. Ideas and understandings that students develop should be progressively extended and reconstructed as students grow in their experiences and in their ability to conceptualize. Learning involves the process of linking newly constructed understandings with prior knowledge and adding new contexts and experiences to current understandings.

Development of scientific literacy is supported by instructional environments that engage students in the following processes:

- **scientific inquiry:** students address questions about natural phenomena, involving broad explorations as well as focussed investigations
- **technological problem solving (design process):** students seek answers to practical problems requiring the application of their science knowledge in various ways
- **decision making:** students identify issues and pursue science knowledge that will inform the issues

It is through these processes that students discover the significance of science in their lives and come to appreciate the interrelatedness of science, technology, society, and the environment.

Each of these processes is a potential starting point for approaching science learning. These processes may encompass a variety of learning approaches for exploring new ideas, for developing specific investigations, and for applying the ideas that are learned.

To achieve the vision of scientific literacy, students must increasingly become engaged in the planning, development, and evaluation of their own learning experiences. They should have the opportunity to work cooperatively with other students, to initiate investigations, to communicate their findings, and to complete projects that demonstrate their learning. To assist teachers in planning for instruction, assessment, evaluation, and reporting, Manitoba Education, Training and Youth recommends the following:

At the beginning of a block of instruction, teachers and students identify expected student learning outcomes and establish performance criteria. It is important that these criteria correspond with provincial student learning outcomes. This communication between students and teachers helps to identify clearly what needs to be accomplished, thereby assisting in the learning process.

When students are aware of expected outcomes, they will be more focussed on the learning and more likely to assess their own progress. Furthermore, they can participate in creating appropriate assessment and evaluation criteria. Assessment methods must be valid, reliable, and fair to students.

Changing Emphases in Science Education Content Delivery*

LESS EMPHASIS ON	MORE EMPHASIS ON
Knowing scientific facts and information	Understanding scientific concepts and developing abilities of inquiry
Studying subject matter disciplines (physical, life, earth sciences) for their own sake	Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
Separating science knowledge and science process	Integrating all aspects of science content
Covering many science topics	Studying a few fundamental science concepts
Implementing inquiry as a set of processes	Implementing inquiry as instructional strategies, abilities, and ideas to be learned

Changing Emphases to Promote Inquiry

LESS EMPHASIS ON	MORE EMPHASIS ON
Activities that demonstrate and verify science content	Activities that investigate and analyze science questions
Investigations confined to one class period	Investigations over extended periods of time
Process skills out of context	Process skills in context
Emphasis on individual process skills such as observation or inference	Using multiple process skills—manipulation, cognitive, procedural
Getting an answer	Using evidence and strategies for developing or revising an explanation
Science as exploration and experiment	Science as argument and explanation
Providing answers to questions about science content	Communicating science explanations
Individuals and groups of students analyzing and synthesizing data without defending a conclusion	Groups of students often analyzing and synthesizing data after defending conclusions
Doing few investigations in order to leave time to cover large amounts of content	Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content
Concluding inquiries with the result of the experiment	Applying the results of experiments to scientific arguments and explanations
Management of materials and equipment	Management of ideas and information
Private communication of student ideas and conclusions to teacher	Public communication of student ideas and work to classmates

* Source: *National Science Education Standards*, p. 113. © 1996 by The National Academy of Sciences. Reproduced with permission of the National Academy Press.

Diversity in the Classroom

Students come from a variety of backgrounds and have distinct learning requirements, learning and thinking approaches, and prior knowledge and experiences. Their depth of prior knowledge varies, reflecting their experiences inside and outside the classroom. Some entry-level knowledge held by students may be limited or incorrect, impeding new learning. For new learning to occur, it is important for teachers to activate prior knowledge, correct misconceptions, and encourage students to relate new information to prior experiences.

Manitoba's cultural diversity provides opportunities for embracing a wealth of culturally significant references and learning resources in the Senior Years science classroom. Students from various backgrounds bring socially constructed meanings, references, and values to science learning experiences, as well as their unique learning approaches. As noted in the *Senior Years Science Teacher's Handbook (SYSTH)*, "To be effective, the classroom must reflect, accommodate, and embrace the cultural diversity of its students" (1997, p. 7.13).

Toward this end, the *Senior 2 Science Framework* acknowledges and supports cultural diversity. Teachers are encouraged to utilize the community and the surrounding natural habitats as these relate to particular science learning outcomes, as they afford opportunities to enrich the learning experience. The careful selection of learning resources that acknowledge cultural, racial, and gender differences will allow students to affirm and strengthen their unique social, cultural, and individual identities. A meaningful learning environment for all requires that teachers be sensitive to the role that diversity plays in the Senior Years classroom.

Instructional Philosophy

The science program should employ a variety of instructional strategies that include the collection and analysis of data from both laboratory and outdoor observations (especially in the case of the ecological component), field work, the use of living organisms in a caring manner, group and individual instruction, a diversity of questioning techniques, a focus on current major issues, and a resource-based approach to learning. Senior 2 science programming should foster critical thinking skills and promote the integration of knowledge and application of facts to real-life situations.

In general, science should be taught as a way of thinking that has rules for judging the validity of answers applicable to everyday life. Science should be portrayed as intense human activity, full of trial and error, that is influenced by cultural priorities and perspectives. The myth of total objectivity that often permeates scientific dialogue also needs to be exposed. Truth should be placed in the context of something always to be sought, but we must realize that the goal can never be reached in absolute terms.

Students should be encouraged to make distinctions between what is observable and testable, as well as the abstract deductions, models, and themes that flow from evolving scientific research and thinking.

Conceptual knowledge in science must also be integrated with principles from other disciplines. Social, historical, and political implications must be included, with an opportunity for students to develop a facility to communicate ideas effectively through verbal and written expression. Finally, students should be provided with an opportunity to develop an awareness of the options

available to them for careers and vocations in the wide diversity of sciences.

Ethical Issues

For many students and teachers, the study of scientific concepts may lead to issues and questions that go beyond the traditional curriculum. For example, differing perspectives on land use raise questions about the balance between the environment and economic activities. The environmental consequences of the industrial applications of chemistry or use of fossil fuels raise issues of considerable merit. Due to the fact that these issues are derived from the study of science, they should be addressed, but it must be made clear to students that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions with sensitivity and clarity of purpose.

Concerns may be expressed by some students and parents because the evolutionary perspective of modern life science conflicts with personal beliefs. These individuals have a right to expect that science and the educational system will respect those beliefs. Teachers should explain to students that science is only one way of learning about the universe and our unique place embedded in it, and that other explanations have been put forth besides those of the traditional, western sciences.

In some cases, individual teachers may choose to discuss various alternative viewpoints on these matters with their science classes. However, because these viewpoints are not derived from the disciplines of science, they are not addressed directly in the science curriculum.