INTRODUCTION ▬▬▬▬▬▬▬▬▬▬▬▬

Background

Senior 2 Science: Manitoba Curriculum Framework of Outcomes (2001) (hereinafter referred to as the *Science Framework*) and *Senior 2 Science: A Foundation for Implementation* present 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 and Youth: School Programs and Bureau de l'éducation française. Manitoba's science student learning outcomes are based on those found within *Common Framework of Science Learning Outcomes K to 12* (Council of Ministers of Education, Canada). The latter, commonly referred to as the *Pan-Canadian Science Framework (PCSF)*, 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 (Manitoba Education and Training, *A Foundation for Excellence,* 1995).

The *Science Framework* provides the basis for learning, teaching, and assessing science in Manitoba. It also 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* (2003) complements the *Science Framework*, providing support for its implementation, including suggestions for instruction and assessment.

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 achieve new understandings. Science education makes possible the development of **scientific literacy** and helps build stronger futures for Canada's young people. 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.

Senior 2 Science: A Foundation for Implementation is designed to support and promote the vision for scientific literacy as articulated in the *Pan-Canadian Science Framework* (Council of Ministers of Education, Canada) and in *Senior 2 Science: Manitoba Curriculum Framework of Outcomes* (Manitoba Education and Training, 2001).

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 (Council of Ministers of Education, Canada, *Common Framework of Science Learning Outcomes K to 12,* 1997).

Goals for Canadian Science Education

Several goals promoting scientific literacy within Canadian science education were developed as part of the *Pan-Canadian Science Framework*; these goals are addressed through Manitoba science curricula. It is hoped that 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 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; and

- 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.

Changing Emphases in Science Education Content Delivery*

The *National Science Education Standards* envision change throughout the system. The science content standards [or student learning outcomes] encompass the following changes in emphases:

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
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 ideas and information
Private communication of student ideas and conclusions to teacher	Public communication of student ideas and to classmates

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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 focused investigations;

- **technological problem solving (design process):** students seek answers to practical problems requiring the application of their science knowledge in various ways; and

- **decision making:** students identify issues and pursue science knowledge that will inform their decisions.

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 can be a starting point for science learning, and may encompass the exploration of new ideas, the development of specific investigations, and the application of ideas that are learned.

To achieve the vision of scientific literacy, students must become increasingly 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.

At the beginning of instructional design, teachers and students should 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 focused on 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.