IMPLEMENTATION OF SENIOR 1 SCIENCE ▬▬▬

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, *Senior 1 Science: A Foundation for Implementation* acknowledges and supports cultural diversity. Included in this document are a range of instructional strategies and conceptual links to appropriate communities and their resources (e.g., Aboriginal communities, agricultural communities). 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 astronomical 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 1 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, the technological application of biological principles in areas such as genetic engineering, human reproduction, and medical technology obviously raises questions of ethics and values. The search for extra-terrestrial life has spiritual and religious implications. The environmental consequences of the industrial applications of chemistry or production of electric power 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.

The Responsible Use of Animals in the Science Classroom

The curriculum encourages science teachers to foster a respect for life and to teach about the interrelationship and interdependency of all living things. Furthermore, a stewardship approach emphasizes that humans must care for the fragile web of life that exists on this planet.

The use of live animals and the dissection of animals is a well-established place in the teaching of life sciences in particular. Well-constructed learning activities conducted by thoughtful teachers can illustrate important and enduring principles in the life sciences. However, teachers must carefully consider the educational objectives and available alternatives before using animals in the classroom. Justification on the grounds that "we have always done this" is unacceptable.

Interactive multimedia materials such as computer simulations, tutorials, videodiscs, and videotapes can substitute for the use of animals in the classroom. However, these alternatives must satisfy the objectives of teaching scientific methodology and fundamental biological concepts. If, in the judgment of the teacher, available alternatives do not meet these objectives, dissection may be used, provided that no student is forced to participate. In the event that a student chooses not to participate in a dissection, s/he is to be given assignments of comparable complexity and rigour. In outcome-based education, time is the variable.

Implementing alternative methods does not mean excluding animals from the classroom. Certain instructional strategies allow for the continued use of animals but with a modified approach, e.g., observation in behavior studies and experimentation with invertebrates. In these cases, prudent and responsible use of these animals is recommended.

Learning Resources

Traditionally, the teaching of science at Senior Years has been largely a textbook-centred exercise. The use of a single textbook as the sole resource for the teaching and learning of science severely restricts the development of knowledge, skills, and attitudes that are critical for today's students. Furthermore, it promotes the idea that all answers are enshrined in a textbook. The successful implementation of Senior 1 Science (10F) depends on a resource-based learning approach, in which textbooks are used only as one of many reference sources. Research suggests that we should provide a wide range of learning resources for structuring teaching and learning experiences. These include human resources, textbooks, magazines/periodicals, films, audio and video recordings, computer-based multimedia resources, the Internet, and other materials. While a teacher may choose to use a particular text as a primary resource, we encourage teachers to model the use of a multitude of resources for their students.

Resources referenced in this curriculum include two suggested textbooks, student learning activities outlined in a set of appendices, multimedia learning resources, and other print reference material such as the *Senior Years Science Teachers' Handbook: A Teaching Resource* (1997) and *Science Safety: A Kindergarten to Senior 4 Resource Manual for Teachers, Schools, and School Divisions* (1997). Approved learning resources for Senior 1 science are listed in the Grades 5 to Senior 1 Science Learning Resources: Annotated Bibliography available through MTBB (stock number 80382) or online at <http://www.edu.gov.mb.ca/metks4/curricul/learnres/mr-1.html>.

The choice of textbook or textbooks will depend on the local situation, reading level of the students, background of the teacher, community resources, and availability of other materials. A concerted effort should be made to utilize appropriate learning resources from a wide variety of sources. Not all curricular outcomes can be achieved by using any one text as some topics require using other references or supports.

The choice of multimedia learning resources, including video, software, CD-ROMs, microcomputer-based laboratory (MBL) probeware, calculator-based laboratory (CBL) probeware, and the Internet, will also depend on the local situation: availability of hardware, school technology budgets, teacher background and preference, community resources, and availability of other materials. The multimedia resources listed in this document in the Suggested Learning Resources column will be available for purchase through the Manitoba Text Book Bureau.

Using This Curriculum Document

This curriculum, consisting of four thematic clusters and one skills and attitudes cluster, is designed to build on what students know and are able to do as a result of their studies in Grades K-8 science.

Teachers are asked to be sensitive to the varying backgrounds of their students and to adapt instruction as necessary. Clusters do not need to be taught in the same sequence as they appear in the document. For example, it may by advantageous to make celestial observations throughout the year or perform electrostatic experiments in the winter when humidity is low. Teachers should use their own discretion. There are opportunities to achieve learning outcomes in contexts different from the way they are presented in this curriculum document. In all cases, however, the foundations, themes, and the interdisciplinary nature of science should be emphasized.

Senior 1 Science (10F) provides a solid foundation for further study in Senior 2 Science (20F) and has a multi-disciplinary focus. Accordingly, the curriculum includes only those topics that are deemed to be of relevance to students' needs and interests or are prerequisites to the further study of science at the Senior Years level.

Senior 1 Science (10F) assumes 110 hours of instructional time (see Scope, Sequence, and Time Allotments that appear with each Specific Learning Outcome or cluster of outcomes). Some time may need to be allocated to reviewing material from the appropriate sections of the grades 5–8 curricula, but formal review of previous years' work is to be avoided. Teachers need to use a variety of strategies for activating prior knowledge to determine appropriate learning strategies for their students.

Preparing a Lesson

The format of the *Senior 1 Science: A Foundation for Implementation* document allows teachers to view the four major columns, namely *Prescribed Learning Outcomes*, *Suggestions for Instruction*, *Suggestions for Assessment*, and *Suggested Learning Resources*. The learning outcomes in the first column should guide the teacher to make relevant decisions as to instruction, assessment/evaluation, and appropriate learning resources. The document also contains Cluster 0 outcomes in the *Prescribed Learning Outcomes* column. These are listed based on the suggestions made for instruction. The *Suggestions for Instruction* column provides possible avenues or actions for student learning. Teachers should use their own professional judgment regarding which strategies to use. It is NOT intended for teachers to use all of the suggested strategies. *Suggestions for Assessment* outlines a number of possible strategies beyond simple pencil and paper testing. Resources to support the prescribed outcomes are detailed in the final column, *Suggested Learning Resources*. It is hoped that this format provides a useful "map" for teachers. i.e., a clear indication of what students are to know and be able to do, as well as a resource for strategies and materials to help students achieve these outcomes.

Science curricula in the past have been primarily focussed on a wide variety of knowledge, i.e., a large amount of content material. This curriculum continues to be concerned with students acquiring relevant knowledge, but is equally concerned with the development of skills (context-based process skills, decision-making skills, problem-solving skills, laboratory experimental skills, critical thinking skills, independent learning skills), and with effecting a change of attitude. In broad terms, these learning outcomes should describe what we expect students to know and be able to do as a result of their studies.

Many of the Suggestions for Instruction columns begin by describing the probable *Entry Level Knowledge* of students based on previous studies using Manitoba's science curricula. Teachers are encouraged to determine student entry levels and select or develop approaches and materials to enable each student to achieve success. Many educators believe that time spent at this task has the greatest effect on student learning.

Senior 1 Science (10F) is driven by learning outcomes and process rather than by a text book. This design empowers teachers to plan appropriate learning experiences based on the nature of their students, school, and community. We encourage teachers to seek their own comfort level with the new curriculum, to share approaches and experiences with colleagues, and to use it to develop and extend student experiences and understandings in new ways.

Differentiating Instruction

How can Senior Years science teachers meet each student's learning requirements and still make learning experiences challenging and meaningful for all? One way to help all students achieve the prescribed student learning outcomes is to differentiate the instructional strategies. (See *Success for All Learners*: *A Handbook on Differentiating Instruction, 1996.*) Through differentiating instruction, teachers can

- activate students' prior knowledge
- accommodate multiple intelligences and the variety of learning and thinking approaches
- help students interpret, apply, and integrate information
- facilitate the transfer of knowledge, skills, and attitudes to students' daily lives
- challenge students to realize academic and personal progress and achievement

Differentiating instruction does not mean offering a different program to each student. Classroom experiences can be differentiated by offering students choices and by varying instructional and assessment strategies to provide challenging and effective learning experiences for all.

Learning Phases

Differentiated instructional strategies can be used in relation to the three learning phases:

- activating (preparing for learning)
- acquiring (integrating and processing learning)
- applying (consolidating learning)

These phases of learning are not entirely linear, nor are they discrete; rather, they provide teachers with a useful way of thinking and planning.

- The activating phase helps identify students' prior knowledge.
- The acquiring phase helps students to integrate new information with what they already know, adding or revising their previous knowledge as needed. Teachers help students make meaning of new information.
- The applying phase allows students to reflect on what they have learned, apply their learning in new situations, and extend their learning by drawing connections to other subject areas.

For a discussion of these three learning phases, see *Success for All Learners,* Chapter 6.

Senior 1 Science: A Foundation for Implementation includes cross-references to *Success for All Learners: A Handbook on Differentiating Instruction* (1996) and *Senior Years Science Teachers' Handbook* (1997). Teachers can refer to these documents for further information. Strategies that can be used effectively in the Senior Years science classroom include graphic organizers (such as mind maps), knowledge charts that utilize students' prior knowledge, collaborative activities in brainstorming for solutions to design problems, information-processing strategies, science learning logs, and many others. A detailed listing of the instructional strategies recommended throughout *Senior 1 Science: A Foundation for Implementation* follows:

Instruction

- **Entry-Level Knowledge —** Entry-level knowledge summarizes prior content knowledge that students may have obtained in earlier grades, other courses, or through personal experiences. Activating this knowledge can be a powerful tool, as students organize and make meaning of new ideas, experiences, and information in connection with their prior knowledge.

- **Notes for Instruction** — Notes for instruction outlines the depth and breadth to which learning outcomes are to be addressed. Definitions, safety concerns, and teaching/learning suggestions may also be included.

- **Student Learning Activities —** A number of instructional strategies involving student engagement with learning materials are available for each learning outcome. Deciding which learning activities to use is an important part of a teacher's initial planning. Teachers need to make deliberate, informed decisions about the best tools to use for each learning task to successfully reach each learning outcome of the curriculum, given the particular needs and characteristics of their students.

- **Journal Writing —** Science journal writing allows students to explore and record all aspects of their science class experiences. By sorting out their thoughts on paper or thinking about their learning (metacognition), students process more deeply what they are learning.

- **Class Discussion —** Discussions can be used in a variety of ways. They can spark interest in a topic or learning outcome, activate prior knowledge by inviting speculation on why certain events occur, or generate ideas for solutions to problems.

- **Prior Knowledge Activities —** Students learn best when they can relate new knowledge to what they already know. Brainstorming, KWL charts, and Listen-Think-Pair-Share are just a few of the strategies that can be used to activate and assess students' prior knowledge.

- **Student Research/Reports —** Learning projects that involve student research are one of the most effective ways to individualize instruction in a diverse classroom. These learning activities provide students with the opportunity to develop their research skills as they gather, process, and evaluate information.

- **Teacher Demonstration —** Demonstrations can arouse student interest and allow for visualization of phenomena. For instance, discrepant events can be a powerful tool. Demonstrations can activate prior knowledge and generate discussion around learning outcomes.

- **Visual Displays —** When students create visual displays, they make their thinking visible. Generating diagrams, posters, or models provides students with the opportunity to represent abstract information in a more concrete form.

- **Collaborative Teamwork —** Instructional strategies, such as the Jigsaw or Roundtable, encourage students to learn from one another and develop teamwork skills. The use of cooperative learning activities can lead to increased understanding of content and improved thinking skills.

- **Laboratory Activities —** Laboratory activities, whether student- or teacher- designed, provide students with the opportunity to apply their scientific knowledge and skills related to a group of learning outcomes. Students appreciate the hands-on experience of doing science.

- **Debates —** Debates draw upon students' own positions on STSE issues. When carefully structured, debates can be used to encourage students' consideration of societal concerns and the opinions of others, and improve their communication and research skills.

Assessment

Assessment is "the systemic process of gathering information about what a student knows, is able to do, and is learning to do" (*Reporting on Student Progress and Achievement,* 1997, p. 38). Assessment involves collecting, interpreting, and communicating results related to students' progress and achievement.

In Senior Years science, as in other subject areas, effective assessment is

- an integral part of instruction and learning

- continuous and ongoing

- authentic and reflective of meaningful science-learning processes and contexts

- a collaborative and reflective process

- multi-dimensional, incorporating a variety of tasks

- developmentally and culturally appropriate

- focussed on students' strengths

- based on how students learn

- supportive of learning by offering clear performance targets to students

(Adapted from *Senior 1 English Language Arts: Manitoba Curriculum Framework of Outcomes* and *Senior 1 Standards*, 1996, p. 53.)

This view of effective assessment in science for Manitoba is reflective of changes in emphases in science education at the national level and is congruent with international changes in science education. The following chart summarizes, at a glance, some of the changes in the area of assessment.

Changing Emphases in Assessment of Student Learning*

The *National Science Education Standards* envision change throughout the system. The assessment standards encompass the following changes in emphases:

LESS EMPHASIS ON	MORE EMPHASIS ON
Assessing what is easily measured	Assessing what is most highly valued
Assessing discrete knowledge	Assessing rich, well-structured knowledge
Assessing scientific knowledge	Assessing scientific understanding and reasoning
Assessing to learn what students do not know	Assessing to learn what students do understand
Assessing only achievement	Assessing achievement and opportunity to learn
End of term assessments by teachers	Students engaged in ongoing assessment of their work and that of others
Development of external assessments by measurement experts alone	Teachers involved in the development of external assessments

Formative and Summative Assessment

Assessment can be formative or summative.

- **Formative assessment** is based on data collected before an instructional sequence is completed. Its purpose is to improve instruction and learning by

  — providing students and teachers with information about students' progress in accomplishing prescribed learning outcomes

  — evaluating the effectiveness of instructional programming content, methods, sequence, and pace

- **Summative assessment** (evaluation) is based on an interpretation of the assessment information collected. It helps determine the extent of each student's achievement of prescribed learning outcomes. Evaluation should be based on a variety of assessment information. Summative assessment is used primarily to

  — measure student achievement

  — report to parent(s)/guardian(s), students, and other stakeholders

  — measure the effectiveness of instructional programming

Senior 1 Science: A Foundation for Implementation suggests a range of assessment strategies. The same strategy can be used for both formative and summative assessment, depending on the purpose of the assessment.

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* Source: *National Science Education Standards*, p. 100. © 1996 by The National Academy of Sciences. Reproduced with permission of the National Academy Press.

A detailed discussion of the suggested assessment strategies included in this document follows:

- **Observation —** Observation of students is an integral part of the assessment process. It is most effective when focussed on skills, concepts, and attitudes. Without record keeping, however, observations and conversations can easily be forgotten. Making brief notes on index cards, self-stick notes, or grids, as well as keeping checklists, helps teachers maintain records of continuous progress and achievement.

- **Interviews —** Interviews allow teachers to assess an individual's understanding and achievement of the prescribed student learning outcome(s). Interviews provide students with opportunities to model and explain their understandings.

  Interviews may be both formal and informal. Posing science-related questions during planned interviews enables teachers to focus on individual student skills and attitudes. Questioning students about how they solved problems or answered science questions reveals their thinking processes and their use of skills. Using a prepared set of questions ensures that all interviews follow a similar structure. It is important to keep a record of student responses and/or understandings.

- **Group/Peer Assessment —** Group assessment gives students opportunities to assess how well they work within a group. Peer assessment gives them opportunities to reflect on one another's work, according to clearly established criteria. During the peer assessment process, students must reflect on their own understanding in order to evaluate the performance of another student.

- **Self-Assessment —** Self-assessment is vital to all learning and, therefore, integral to the assessment process. Each student should be encouraged to assess her/his own work. Students apply known criteria and expectations to their work and reflect on results to determine their progress toward the mastery of a prescribed learning outcome. Participation in setting self-assessment criteria and expectations helps students to see themselves as scientists and problem solvers. It is important that the teacher model the self-assessment process before expecting students to assess themselves.

- **Performance Assessment/Student Demonstration —** Performance tasks provide students with opportunities to demonstrate their knowledge, thinking processes, and skill development. The tasks require the application of knowledge and skills related to a group of student learning outcomes. Performance-based tests do not test the information that students possess, but the way their understanding of a subject has been deepened, and their ability to apply their learning in a simulated performance. A scoring rubric that includes a scale for the performance of the task helps organize and interpret evidence. Rubrics allow for a continuum of performance levels associated with the task being assessed.

- **Science Journal/Learning Log Entries —** Science journal writing and learning log entries provide opportunities for students to reflect on their learning and to demonstrate their understanding using pictures, labelled drawings, and words. They can be powerful tools of formative assessment, allowing teachers to gauge a student's depth of understanding. In this document, direct questions/scenarios frame the science journal suggestions.

- **Rubrics/Checklists** — Rubrics and checklists are tools that identify the criteria upon which student processes, performances, or products will be assessed. They also describe the qualities of work at various levels of proficiency for each criterion. Rubrics and checklists may be developed in collaboration with students.

- **Visual Displays** — When students or groups of students prepare visual displays, they are involved in processing information and producing a knowledge framework. The completed poster, concept map, diagram, etc., is the product with which teachers can determine what their students are thinking.

- **Laboratory Report** — Laboratory reports allow teachers to gauge the ability of students to observe, record, and interpret experimental results. These tools can aid teachers in determining how well students understand the content.

- **Written Quiz/Test** — Quizzes can be used as discrete assessment tools, and tests can be larger assessment experiences. These written tasks may include items such as multiple choice questions, completion of a drawing or labelled diagram, problem solving, or long answer questions.

- **Research Report/Presentation** — Research projects allow students to reach the learning outcomes in individual ways. Assessment should be built into the project at every stage, from planning, to researching, to presenting the finished product.

The foregoing assessment suggestions are not meant to be limiting. Teachers are strongly encouraged to develop their own assessment for Senior Years science based on their students' learning requirements and the prescribed student learning outcomes. *Reporting on Student Progress and Achievement: A Policy Handbook for Teachers, Administrators, and Parents* (1997) contains further information related to reporting on student progress.