SECTION 3: ASSESSMENT IN SENIOR 4 PHYSICS

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Classroom assessment is an integral part of science instruction. Assessment could be described as the systematic process of gathering information about what a student knows, is able to do, and is learning to do. The primary purpose of classroom assessment is not to evaluate and classify student performance, but to inform teaching and improve learning, and to monitor student progress in achieving year-end learning outcomes.

> Rather than emphasizing the recall of specific, detailed and unrelated 'facts', [assessment in science] should give greater weight to an assessment of a holistic understanding of the major scientific ideas and a critical understanding of science and scientific reasoning (Millar and Osborne, eds., 1998).

Classroom assessment is broadly defined as any activity or experience that provides information about student learning. Teachers learn about student progress not only through formal tests, examinations, and projects, but also through moment-by-moment observation of students in action. They often conduct assessment through instructional activities.

Much of students' learning is internal. To assess students' science knowledge, skills and strategies, and attitudes, teachers require a variety of tools and approaches. They ask questions, observe students engaged in a variety of learning activities and processes, and examine student work in progress. They also engage students in peer-assessment and self-assessment activities. The information that teachers and students gain from assessment activities informs and shapes what happens in the classroom; assessment always implies that some action will follow.

To determine whether student learning outcomes have been achieved, student assessment must be an integrated part of teaching and learning. Assessment of student learning involves careful planning and systematic implementation.

Planning for Assessment

Assessment purposes, approaches, and tools should be developed with instructional approaches during the planning of the unit. In developing assessment tasks and methods, teachers determine

- what they are assessing;
- why they are assessing;
- how the assessment information will be used;
- who will receive the assessment information; and
- what assessment activities or tasks will allow students to demonstrate their learning in authentic ways.

Characteristics of Effective Assessment

Effective assessment helps focus effort on implementing strategies to facilitate learning both inside and outside the classroom, and demonstrates the following characteristics:

- congruent with instruction, and integral to it;
- ongoing and continuous;
- based on authentic tasks and meaningful science-learning processes and contexts;
- based on criteria that students know and understand, appealing to their strengths;
- a collaborative process involving students;
- multi-dimensional, and uses a wide range of tools and methods; and
- focussed on what students have learned and can do.

Effective Assessment Is Congruent with (and Integral to) Instruction

Assessment requires teachers to be aware continually of the purpose of instruction: What student learning outcomes am I targetting? What can students do to show what they have learned?

How teachers assess depends on what they are assessing—whether they are assessing declarative knowledge, procedural knowledge, or attitudes and habits of mind.

- Declarative Knowledge: If teachers wish to measure fact-based recall, declarative knowledge is the most straightforward dimension of learning to measure using traditional tools. The purpose of fostering scientific literacy, however, is not met if students simply memorize the declarative knowledge related to science; what is more important is whether students understand and are able to apply this knowledge. For example, it is more important that they understand the purposes and effects of biodiversity, that they respond to and interpret what biodiversity means for them personally and environmentally, and that they use terminology with ease to enrich their scientific communication skills, and represent—rather than reproduce—a definition of biodiversity. The challenge teachers face is to design tools that test the application of declarative knowledge.
- Procedural Knowledge: Tools that are designed to test declarative knowledge cannot effectively assess skills and processes. For example, rather than trying to infer student processes by looking at final products, teachers assess procedural knowledge by observing students in action, by discussing their strategies with them in conferences and interviews, and by gathering data from student reflections such as journals.
- Attitudes and Habits of Mind: Attitudes and habits of mind cannot be assessed directly. They are implicit in what students do and say. Assessment tools typically describe the behaviours that reflect the attitudes and habits of scientifically literate individuals. They identify the attitudes and habits of mind that enhance science-related language learning and use, and provide students with the means to reflect on their own internal processes. For example, rather than assigning global marks for class participation, teachers assess learning outcomes related to students' effective contributions to large and small groups.

Assessment is intended to inform students of the programming emphases and to help them focus on important aspects of learning. If teachers assess only the elements that are easiest to measure, students may focus only on those things. For example, if science courses place a high value on collaboration, creativity, and divergent thinking, then assessment tools and processes must reflect those values. The ways teachers assess (what and how) inform students of what is considered important in learning.

Effective Assessment Is Ongoing and Continuous

Assessment that is woven into daily instruction offers students frequent opportunities to gain feedback, to modify their learning approaches and methods, and to observe their progress. Teachers provide informal assessment by questioning students and offering comments. They also conduct formal assessments at various stages of a project or unit of study.

Continuous assessment provides ongoing opportunities for teachers to review and revise instruction, content, process emphases, and learning resources.

Effective Assessment Is Based on Authentic Tasks and Meaningful Science Learning Processes and Contexts

Assessment tasks in science should be authentic and meaningful—tasks worth mastering for their own sake rather than tasks designed simply to demonstrate student proficiency for teachers and others. Through assessment, teachers discover whether students can use knowledge, processes, and resources effectively to achieve worthwhile purposes. Therefore, teachers design tasks that replicate the context in which knowledge will be applied in the world beyond the classroom.

For example, authentic science-writing tasks employ the forms used by a wide range of people (for example, scientists, journalists, filmmakers, poets, novelists, publicists, speakers, technical writers, engineers, and academics). As often as possible, students write, speak, or represent their ideas for real audiences and for real purposes. In developing assessment tasks, teachers may consider providing students with the resources people use when performing the same tasks in real-life situations related to issues in science.

Authentic assessment tasks are not only tests of the information students possess, but also of the way their understanding of a subject has deepened, and of their ability to apply learning. They demonstrate to students the relevance and importance of learning. Performance-based tests are also a way of consolidating student learning. The perennial problem teachers have with “teaching to the test” is of less concern if tests are authentic assessments of student knowledge, skills and strategies, and attitudes.

Effective Assessment Is Based on Criteria that Students Know and Understand, Appealing to Their Strengths

Assessment criteria must be clearly established and made explicit to students before an assignment or test so students can focus their efforts. In addition, whenever possible, students need to be involved in developing assessment criteria. Appendix 5 includes a process for creating assessment rubrics in collaboration with students.

Students should also understand clearly what successful accomplishment of each proposed task looks like. Models of student work from previous years and other exemplars assist students in developing personal learning goals.

Each assessment task should test only those learning outcomes that have been identified to students. This means, for example, that laboratory skills tests should be devised and marked to gather information about students' laboratory skills, not their ability to express ideas effectively when writing a laboratory report.

Effective Assessment Is a Collaborative Process Involving Students

The ultimate purpose of assessment is to enable students to assess themselves. The gradual increase of student responsibility for assessment is aimed at developing students' autonomy as lifelong learners. Assessment should decrease, rather than foster, students' dependence on teachers' comments for direction in learning and on marks for validation of their accomplishments.

Assessment enhances students' metacognition. It helps them make judgements about their own learning, and provides them with information for goal setting and self-monitoring.

Teachers increase students' responsibility for assessment by

- requiring students to select the products and performances to demonstrate their learning;
- involving students in developing assessment criteria whenever possible (This clarifies the goals of a particular assignment and provides students with the vocabulary to discuss their own work.);
- involving students in peer assessment, informally through peer conferences and formally using checklists;
- having students use tools for reflection and self-assessment at every opportunity (e.g., self-assessment checklists, journals, identification and selection of goals, and self-assessment of portfolio items); and
- establishing a protocol for students who wish to challenge a teacher-assigned mark (Formal appeals are valuable exercises in persuasive writing, and provide opportunities for students to examine their performance in light of the assessment criteria.).

Effective Assessment Is Multi-Dimensional and Uses a Wide Range of Tools and Methods

Assessment in science must recognize the complexity and holistic nature of learning for scientific literacy. To compile a complete profile of each student's progress, teachers gather data using many different means over numerous occasions. Student profiles may involve both students and teachers in data gathering and assessment.

The following chart identifies areas for assessment and some suggested assessment instruments, tools, and methods.

Data-Gathering Profile			
Observation of Processes		**Observation of Products and Performances**	
Teacher • checklists • conferences and interviews • anecdotal comments and records • reviews of drafts and revisions • oral presentations • rubrics and marking scales	Students: • journals • self-assessment instruments and tools (e.g., checklists, rating scales, progress charts) • peer-assessment instruments and tools (e.g., peer conference records, rating scales)	Teacher: • written assignments • demonstrations • presentations • seminars • projects • portfolios • student journals and notebooks • checklists • rubrics and marking scales	Students: • journals • self-assessment instruments and tools • peer-assessment instruments and tools • portfolio analysis
Classroom Tests		**Divisional and Provincial Standard Tests**	
Teacher • paper-and-pencil tests (e.g., teacher-made tests, unit tests, essay-style tests) • performance tests and simulations • rubrics and marking scales	Students: • journals • self-assessment instruments and tools	Teacher marker: • rubrics and marking scales	

Effective Assessment Focusses on What Students Have Learned and Can Do—Not on What They Have Not Learned or Cannot Do

Assessment must be equitable; it must offer opportunities for success to every student. Effective assessment demonstrates the knowledge, skills and attitudes, and strategies of each student and the progress the student is making, rather than simply identifying deficits in learning.

To assess what students have learned and can do, teachers should use a variety of strategies and approaches.

- Use a wide range of instruments to assess the multi-dimensional expressions of each student's learning, avoiding reliance upon rote memorization.
- Provide students with opportunities to learn from feedback and to refine their work, recognizing that not every assignment will be successful nor will it become part of a summative evaluation.
- Examine several pieces of student work in assessing any particular learning outcome to ensure that data collected are valid bases for making generalizations about student learning.
- Develop complete student profiles by using information from both learning outcome-referenced assessment, which compares a student's performance to predetermined criteria, and self-referenced assessment, which compares a student's performance to her or his prior performance.
- Avoid using assessment for purposes of discipline or classroom control. Ryan, Connell, and Deci (1985) found that assessment that is perceived as a tool for controlling student behaviour, meting out rewards and punishments rather than providing feedback on student learning, reduces student motivation.

Students are sometimes assigned a mark of zero for incomplete work. Averaging a zero into the student's mark, however, means the mark no longer communicates accurate information about the student's achievement of science learning outcomes. Unfinished assignments signal personal or motivational problems that should be addressed in appropriate and alternative ways.

- Allow students, when appropriate and possible, to choose how they will demonstrate their competence.
- Use assessment tools appropriate for assessing individual and unique products, processes, and performances.

Managing Classroom Assessment

Assessment is one of the greatest challenges science teachers face. The practices that make science classrooms vital and effective (promoting student choice, assessing processes, and assessing the subjective aspect of learning) make assessment a complex matter.

Systems and supports that may assist teachers in managing assessment include:

- dispensing with ineffectual means of assessment;
- using time savers;
- sharing the load;
- taking advantage of technology; and
- establishing systems of recording assessment information.

Dispensing with Ineffectual Means of Assessment

Teachers should question the efficacy, for example, of writing lengthy commentaries on summative assessment of student projects. Detailed comments are best provided as formative assessment, when students can make immediate use of the feedback, and shared orally in conferences, which provide opportunities for student-teacher discussion.

The time spent in assessment should be learning time, both for teacher and student.

Using Time Savers

Many effective assessment tools are time savers. Developing checklists and rubrics is time-consuming; however, well-written rubrics may eliminate the need to write extensive comments, and may mean that student performances can be assessed largely during class time.

Sharing the Load

While the ultimate responsibility for assessment rests with the teacher, student self-assessment also provides a wealth of information. Collaborating with students to generate assessment criteria is part of effective instruction. Senior 4 students may develop checklists and keep copies of their own goals in an assessment binder for periodic conferences. Students may be willing to contribute work samples to be used as models with other classes.

Collaborating with other teachers in creating assessment tools saves time and provides opportunities to discuss assessment criteria.

Taking Advantage of Technology

Electronic tools (e.g., audio tapes, videotapes, and computer files) can assist teachers in making and recording observations. Word processors allow teachers to save, modify, and reuse task-specific checklists and rubrics.

Establishing Systems for Recording Assessment Information

Collecting data from student observations is especially challenging for Senior Years teachers, who may teach several classes of students in a given semester or term. Teachers may want to identify a group of students in each class for observation each week. Binders, card files, and electronic databases are useful for record keeping, as are self-stick notes recording brief observations on student files, which can later be transformed into anecdotal reports.

Teachers may also want to develop comprehensive forms for listing the prescribed learning outcomes, and for recording data.

This view of effective assessment in science for Manitoba reflects changes in emphases in science education at the national level and is congruent with international changes in science education. The following chart summarizes 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 assessment by measurements experts alone	Teachers involved in the development of external assessments

Types of Assessment

Assessment can be formative, summative, or diagnostic.

- **Formative assessment** is given during the instructional unit and provides students and teachers with information about students' progress in accomplishing prescribed learning outcomes. Formative assessment also evaluates the effectiveness of instructional programming content, methods, sequence, and pace.
- **Summative assessment** (evaluation) is based on an interpretation of the assessment information collected and is given at the end of an instructional unit. 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, to report to parent(s) or guardian(s), students, and other stakeholders, or to measure the effectiveness of instructional programming.
- **Diagnostic assessment** is given before instruction and determines student understanding of topics before learning takes place.

Assessment Strategies

Senior 4 Physics suggests a range of assessment strategies. The same strategy can be used both for formative and summative assessment, depending on the purpose of the assessment. Suggested assessment strategies that can be used in the science classroom are discussed in detail in the following section. Teachers are encouraged to develop their own assessment for Senior Years science based on their students' learning requirements and the prescribed student learning outcomes.

- **Observation**

  Observation of students is an integral part of the assessment process. It is most effective when focussed on skills, concepts, and attitudes. 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. Students reveal their thinking processes and use of skills when they are questioned about how they solved problems or answered science questions. 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 or 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 teachers 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 Entries**

  Science journal writing provides opportunities for students to reflect on their learning and to demonstrate their understanding using pictures, labelled drawings, and words. These journal entries can be powerful tools of formative assessment, allowing teachers to gauge a student's depth of understanding.

- **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 student groups prepare visual displays, they are involved in processing information and producing a knowledge framework. The completed poster, concept map, diagram, model, et cetera, is the product with which teachers can determine what their students are thinking.

- **Laboratory Reports**

  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.

- **Pencil-and-Paper Tasks**

  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. Ensure that both restricted and extended expository responses are included in these assessment devices.

- **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.

- **Interpretation of Media Reports of Science**

  Short pieces extracted from newspapers could be used to assess the following: whether students understand the scientific content of the piece; whether they can identify and evaluate the possible risks and quality of the evidence presented; whether they can offer well-thought-out reactions to the claims; and, finally, whether they can give their opinion about future action that could be taken by individuals, government, or other bodies (Millar and Osborne, 1998, p. 26).

- **Demonstration of an Understanding of the Major Explanatory Stories of Science**

  Questions should seek to examine observable results such as the following: whether students have understood what the particle model of matter is; whether they can give a short account of it; whether they can use it to explain everyday phenomena; and whether they can explain why it is an important idea in science (Millar and Osborne, 1998, p. 26).

- **Asking and Answering Questions Based on Data**

  Such questions should assess students' abilities to represent data in a variety of ways; to formulate and interpret the messages that can be extracted from data; and to detect errors and dishonesty in the way data are presented or selected. The ability to manipulate and interpret data is a core skill that is of value, not only in science, but also in a wide range of other professions and contexts (Millar and Osborne, 1998, p. 26).

- **Recognizing the Role of Evidence**

  At the heart of scientific rationality is a commitment to evidence. Contemporary science confronts the modern citizen with claims that are contested and uncertain. Questions based on historical or contemporary examples can be used to investigate students' understanding of the role of evidence in resolving competing arguments between differing theoretical accounts (Millar and Osborne, 1998, p. 26).

NOTES