SECTION 2:
ENHANCING STUDENT LEARNING IN GRADE 11 BIOLOGY

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Science and the Learning Process

Students are 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 they are actively engaged in the learning process. Active learning involves the construction of meaning through the interaction of prior knowledge, motivation, purpose, and new experiences. The process of learning varies from one individual to another, and is shaped by many factors, including personal and social influences. Science learning is more meaningful when students

- discover the significance of science in their lives
- appreciate the interrelatedness of science, technology, society, and the environment

Science *knowledge, skills, and attitudes* are interdependent aspects of learning, and need to be integrated in the learning process. Meaningful learning in science requires both depth and breadth of understanding. To achieve the vision of scientific literacy for all, students should become more engaged in the planning, development, and assessment of their own learning experiences.

The Senior Years Student and the Science Learning Environment

Student learning is central to teachers' work. Teachers make decisions regarding course content, learning materials and resources, and instructional and assessment methods on an ongoing basis. Successful learning is more likely to occur if these decisions are informed by teachers' understanding of their students and the ways they learn.

Teachers seeking to learn about their students need to be knowledgeable in various areas, including the following:

- **How people learn:** In recent decades, cognitive psychology, brain-imaging technology, and multiple intelligences theory have transformed our understanding of learning.
- **Ways in which student populations are changing:** The students teachers encounter today are different in many respects from students a generation ago. Students are more sophisticated in their knowledge and use of information and communication technologies, and much of their understanding of the world comes from electronic media. Classrooms are more likely to be ethnically diverse. Students are more likely to be living with a single parent or stepfamily. More students have part-time jobs.
- **Developmental characteristics of students:** The characteristics of adolescent learners have many implications for teachers.

- **The unique qualities of each student:** Family relationships, academic and life experiences, personality, interests, learning styles, socio-economic status, and rate of development all influence a student's ability to learn. Teachers can gain an understanding of the unique qualities of each student through daily interactions, observations, and assessment.

Characteristics of Grade 11 Learners

For many students, Grade 11 is a stable and productive year. Many Grade 11 students have developed a degree of security within their peer group and a sense of belonging in school. They show increasing maturity in dealing with the freedoms and responsibilities of late adolescence: romantic relationships, part-time jobs, and a driver's licence. In Grade 11, most students have a great deal of energy and a growing capacity for abstract and critical thinking. Many are prepared to express themselves with confidence and to take creative and intellectual risks. The stresses and preoccupations of preparing for graduation, post-secondary education, or full-time jobs are still a year away.

For many students, Grade 11 may be the most profitable academic year of the Senior Years. Although many Grade 11 students handle their new responsibilities and the demands on their time with ease, others experience difficulty. External interests may seem more important than school. Because of their increased autonomy, students who previously had problems managing their behaviour at school may now express their difficulties through poor attendance, alcohol and drug use, or other behaviours that place them at risk.

Students struggling to control their lives and circumstances may make choices that seem to teachers to be contrary to their best interests. Communication with the home and awareness of what their students are experiencing outside school continue to be important for Grade 11 teachers. Although the developmental variance evident in previous years has narrowed, students in Grade 11 can still change a great deal in the course of one year or even one semester. Teachers need to be sensitive to the dynamic classroom atmosphere and recognize when shifts in interests, capabilities, and needs are occurring, so they can adjust learning experiences for their students.

The following chart identifies some common characteristics of late adolescence observed in educational studies (Glatthorn; Maxwell and Meiser; Probst) and by Manitoba teachers, and discusses the implications of these characteristics for teachers.

Grade 11 Learners: Implications for Teachers*

Characteristics of Grade 11 Learners	Significance for Grade 11 Teachers
Cognitive Characteristics	
• Most Grade 11 learners are capable of abstract thought and are in the process of revising their former concrete thinking into fuller understanding of principles.	• Teach to the big picture. Help students forge links between what they already know and what they are learning. Be cognizant of individual differences and build bridges for students who think concretely.
• Students are less absolute in their reasoning, more able to consider diverse points of view. They recognize that knowledge may be relative to context.	• Focus on developing problem-solving and critical thinking skills, particularly those related to STSE and decision making.
• Many basic learning processes have become automatic by Grade 11, freeing students to concentrate on complex learning.	• Identify the knowledge, skills, and strategies that students already possess, and build the course around new challenges. Through assessment, identify students who have not mastered learning processes at Grade 11 levels and provide additional assistance and support.
• Students have a clearer self-understanding and have developed specialized interests and expertise. They need to connect what they are learning to the world outside the school. Biology must be seen as valuable and necessary.	• Use strategies that enhance students' metacognition. Encourage students to develop scientific skills through exploring areas of interest. Cultivate classroom experts and invite students with individual interests to enrich the learning experience of the class.
Psychological and Emotional Characteristics	
• It is important for Grade 11 students to see that their autonomy and emerging independence are respected. They need a measure of control over what happens to them in school.	• Provide choice. Allow students to select many of the resources they will explore and the forms they will use to demonstrate their learning. Collaborate with students in assessment. Teach students to be independent learners. Gradually release responsibility to students.
• Students are preparing for senior leadership roles within the school and may be more involved with leadership in their communities.	• Provide students with leadership opportunities within the classroom and with a forum to practise skills in public speaking and group facilitation.
• Students need to understand the purpose and relevance of practices, policies, and processes. They may express their growing independence through a general cynicism about authority and institutions.	• Use students' tendency to question social mores to help them develop critical thinking. Negotiate policies and demonstrate a willingness to make compromises. Use students' questions to fuel classroom inquiry.
• Grade 11 students have a clearer sense of identity than they had previously and are capable of being more reflective and self-aware. Some students are more willing to express themselves and disclose their thoughts and ideas.	• Provide optional and gradual opportunities for self-disclosure. Invite students to explore and express themselves through their work. Celebrate student differences.

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*Source: Manitoba Education and Training. *Senior 3 English Language Arts: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education and Training, 1999. Section 1, pp. 5–7.

Grade 11 Learners: Implications for Teachers (continued)

Characteristics of Grade 11 Learners	Significance for Grade 11 Teachers
Physical Characteristics	
• Many Grade 11 students have reached adult physical stature. Others, particularly males, are still in a stage of extremely rapid growth and experience a changing body image and self-consciousness.	• Be sensitive to the risk students may feel in public performances and increase expectations gradually. Provide students with positive information about themselves.
• By Grade 11, students are better able to sit still and concentrate on one learning task for longer periods, but they still need interaction and variety. They have a great deal of energy.	• Put physical energy to the service of active learning instead of trying to contain it. Provide variety; change the pace frequently; use kinesthetic learning experiences.
• Grade 11 students still need more sleep than adults do, and may come to school tired as a result of part-time jobs or activity overload.	• Be aware that inertia or indifference may be the result of fatigue. Work with students and families to set goals and plan activities realistically so that school work assumes a higher priority.
Moral and Ethical Characteristics	
• Grade 11 students are working at developing a personal ethic, rather than following a prescribed set of values and code of behaviour.	• Explore the ethical meaning of situations in life and in scientific contexts. Provide opportunities for students to reflect on their thoughts in discussion, writing, or representation.
• Students are sensitive to personal or systemic injustice but are increasingly realistic about the factors affecting social change.	• Explore ways in which decision-making activities can effect social change, and link to the continuum of science, technology, society, and the environment.
• Students are shifting from an egocentric view of the world to one centred in relationships and community. They are able to recognize different points of view and adapt to difficult situations.	• Provide opportunities for students to make and follow through on commitments and to refine their interactive skills.
• Students are becoming realistic about the complexities of adult responsibilities but resist arbitrary authority.	• Explain the purpose of every learning experience. Enlist student collaboration in developing classroom policies. Strive to be consistent.

(continued)

Grade 11 Learners: Implications for Teachers (continued)	
Characteristics of Grade 11 Learners	**Significance for Grade 11 Teachers**
Social Characteristics	
• By Grade 11, certain individuals will take risks in asserting an individual identity. Many students, however, continue to be intensely concerned with how peers view their appearance and behaviour. Much of their sense of self is drawn from peers, with whom they may adopt a "group consciousness," rather than from making autonomous decisions.	• Ensure that the classroom has an accepting climate. Model respect for each student. Use learning experiences that foster student self-understanding and self-reflection. Challenge students to make personal judgments about situations in life and in their natural environment.
• Adolescents frequently express identification with peer groups through slang, musical choices, clothing, body decoration, and behaviour.	• Foster a classroom identity and culture. Ensure that every student is included and valued. Structure learning so that students can interact with peers, and teach strategies for effective interaction.
• Crises of friendship and romance, and a preoccupation with relationships, can distract students from academics.	• Open doors for students to study personal relationships in science (for example, through biographies of scientists). Respect confidentiality, except where a student's safety is at risk.
• Students begin to recognize teachers as individuals and welcome a personal connection.	• Nurture and enjoy a relationship with each student. Try to find areas of common interest with each one. Respond with openness, empathy, and warmth.

Student Engagement

The concept of student engagement and its relationship to learning and achievement has become increasingly prominent in educational research and literature in recent years. While there are a number of definitions of student engagement, most contain behavioural, cognitive, and affective dimensions. The *behavioural dimension* refers to student actions related to engagement, such as participating in classroom and school activities, and accepting responsibility for their learning and assignments. The *cognitive dimension* includes student understandings about their own learning—for example, metacognition, and engaging in self-reflection and self-assessment. Student feelings about school, such as developing positive attitudes to school and school subjects, and demonstrating an interest in their learning are part of the *affective dimension*.

Research suggests that when learning activities are more student-directed than teacher-directed and the learning tasks are authentic, involving students in challenging and meaningful inquiry to solve real-life problems, students are more likely to develop positive emotions in the classroom and to become engaged in their learning (Shernoff et al). Greater engagement in classroom activities in high school is a significant predictor of continuing student motivation and commitment, increases the likelihood of successful school completion, and is critical to students' capacity to be lifelong learners (Levin; Shernoff et al).

Creating a Stimulating Learning Environment

A vital science class grows out of, and is reflected in, a stimulating and inviting learning environment. Teachers develop a positive learning environment by attending to both physical and non-physical components.

Physical components of a positive learning environment may include the following:

- seating arrangements that reflect a student-centred philosophy and that facilitate flexible student groupings
- a classroom library, including science periodicals, newspaper articles, science fiction, files of previous tests and examinations, exemplars or samples of student work (such as projects, lab reports, and posters), reference materials (including dictionaries and encyclopedias of science), and software and CD-ROM titles
- access to electronic media equipment, including overhead/LCD projector, computer with Internet access, television, DVD player/VCR, digital camera/video recorder, and microcomputer-based laboratory (MBL) probeware or calculator-based laboratory (CBL) probeware
- posters, displays, charts, diagrams, plants, animals, fossils, models, and pictures reflecting and displaying student work and stimulating student interest in the current learning focus
- posters, diagrams, and flow charts of learning processes and strategies to encourage students' independent and small-group learning
- regular access to a well-equipped and safe science laboratory to foster the development of lab skills
- student input in classroom design and displays

Non-physical components (Cotton; Marzano; Stronge; Cooper) assist teachers in building a positive learning community and may include the following:

- belief that all students are equally important in the classroom and that each student has unique qualities that contribute to the classroom learning community
- communicating interest in and attention to student interests, problems, and accomplishments
- encouragement of student efforts and development of a sense of responsibility and self-reliance
- high standards of learning for all students and provision of time, instruction, and encouragement for all learners
- development of a safe, risk-free learning environment where failure to meet expectations is not penalized but is an opportunity for improving performance
- student-centred, hands-on learning strategies where students pursue learning with the assistance of the teacher, including student collaboration and cooperation
- definition and recognition of excellence in terms of learning outcomes (criterion-referenced) rather than peer comparisons (norm-referenced)

- clear and focused instruction by providing discussion of learning outcomes and culminating assessment tasks, connections between lessons and larger concepts, and opportunities for guided and independent practice
- frequent descriptive feedback, on both in-class work and assignments, and collaboration with students in developing action plans for success

Planning with the End in Mind

Much of the educational research and literature today is focused on classroom-based assessment. Assessment has a profound impact on student motivation and self-esteem, both of which are critical influences on student learning. Wiggins and McTighe promote a backward design model in which plans for both assessment and instruction stem from a clear understanding of the learning outcomes and the criteria for success that is communicated between the teacher and students. When planning lessons and units, teachers must have a clear conception of the learning outcomes. Then, instruction, assessment, and communication are focused on the learning outcomes (Manitoba Education, Citizenship and Youth, *Communicating Student Learning*).

Wiggins and McTighe suggest the following sequence for planning:

1. Identify the desired results.
2. Determine acceptable evidence.
3. Plan learning experiences and instruction.

When planning with the end in mind, teachers first identify the learning outcomes to be addressed in a given unit or learning experience. Decisions must be made as to what students are to learn. By clarifying the learning goals, teachers are able to focus their instruction and assessment on assisting students to achieve the desired results.

Next, teachers design the culminating summative assessment tasks through which students will demonstrate evidence that they have mastered the learning outcomes. These tasks are planned and communicated to students in advance of their learning so that students have a clear understanding of the learning goals, and the products and performances by which they will demonstrate achievement of their learning. This helps students stay focused on their learning.

Once the learning outcomes are identified and the culminating tasks are designed, teachers can plan the learning experiences. Instruction and formative assessments are developed to prepare students for the culminating tasks. The learning experiences are designed to enable students to build and to practise what they need to demonstrate in the culminating tasks to provide evidence of their learning.

Major Themes in Biology

Grade 11 Biology is driven by specific learning outcomes arranged around the key themes of *wellness* and *homeostasis*. Working with "big ideas" such as these can stimulate student interest and allow for more in-depth inquiry. By organizing learning outcomes around themes, information will be presented in the context of real-world applications.

A recommended tool to help students explore the theme of wellness is the creation of a Wellness Portfolio, which is introduced in Unit 1: Wellness and Homeostasis. A number of possible assignments in a variety of formats can be found in the Suggestions for Instruction and Suggestions for Assessment sections of this document. The intent of the Wellness Portfolio is to have students learn more about their medical histories and how their own bodies work; to collect data on how their bodies are performing; to analyze how well they are taking care of themselves; and to make personal decisions about their own lifestyles to promote their wellness. By completing their portfolios, students personalize the human anatomy and physiology content in the Grade 11 Biology programming.

The theme of homeostasis is explored via an examination of individual human body systems. Learning outcomes related to homeostasis can be found throughout Grade 11 Biology. The final section of the course, Unit 6: Wellness and Homeostatic Changes, is intended to serve as a culminating look at homeostasis from a holistic perspective without being restricted to a particular body system. In this unit students are provided with the opportunity to apply what they have learned throughout Grade 11 Biology.

This curricular design empowers teachers to plan appropriate learning experiences based on the nature of their students, school, and community. Teachers are encouraged to seek their own instructional design with the new curriculum, to share approaches with colleagues, and to use the thematic focus to develop and extend student experiences and understandings in new ways.

Scaffolding and Transfer of Responsibility for Student Learning

Just as scaffolds provide support to a building under construction, scaffolding supports student learning. By providing temporary assistance or frameworks for learning (e.g., graphic organizers, group work), teachers bridge the gap between what students are able to do with the support of others and what they are able to do independently. The scaffolding helps students to advance from their current abilities to the intended goal, and is gradually removed as the students progress.

Associated with scaffolding is the gradual transfer of responsibility for learning. Initially, the teacher takes on most of the responsibility for structuring and leading the learning task, and provides a great deal of guidance to the students. As students' understanding develops, they assume more responsibility for the task by asking questions and attempting more complex applications with greater autonomy (Good and Brophy). The teacher continues to provide coaching and help to students when needed, but steadily reduces the assistance as students' expertise develops. This gradual transfer of responsibility for learning from the teacher to the students

helps students to build their confidence by permitting them to demonstrate their growing competence and increases their ability to become independent, self-regulated learners (Frey, Fisher, and Everlove).

Planning Considerations

Biology curricula in the past have focused primarily on presenting a large amount of content deemed essential. While the Grade 11 Biology curriculum continues to be concerned with students gaining the relevant knowledge, it is also concerned with fostering the development of skills (process skills, decision-making skills, problem-solving skills, laboratory skills, research skills, critical thinking skills, independent learning skills) and attitudes (respect, appreciation, reflection). A strong focus of Grade 11 Biology is to link science with students' life experiences through the themes of wellness and homeostasis.

Grade 11 Biology assumes 110 hours of instructional time (including assessment).

Learning Resources

Traditionally, the approach to teaching science in the Senior Years has largely been textbook-based. Research suggests that we should move beyond a single textbook approach and provide students with a variety of information sources. These include human resources, print media, electronic media, field trips, and simulations.

Resource-based learning is a student-centred approach that adapts to student needs, interests, abilities, learning styles, and prior knowledge. An environment that is rich in resources allows students to explore and discover as they learn, and to make personal learning choices that are relevant and meaningful.

As our society continues to change, so do the roles of teachers and learners. A more flexible model of the teaching-learning process in which teachers facilitate the learning process and students make decisions and assume responsibility for their learning is becoming more prevalent in our schools. A resource-based learning approach helps students manage the information overload that typifies today's society, and teaches them how to continue their learning outside the school setting. While the development of fundamental knowledge is still essential in science, students also need the skills to locate, access, and evaluate pertinent information.

> For more information on selecting learning resources for Grades 11 and 12 Biology, see the Manitoba Education website at <www.edu.gov.mb.ca/k12/learnres/bibliographies.html>.

Diversity in the Classroom

Students come from a variety of backgrounds and have distinct learning needs, learning and thinking styles, and prior knowledge and experiences. Their depth of prior knowledge varies, reflecting their experiences inside and outside the classroom. For new learning to occur, it is important for teachers to activate students' prior knowledge, to correct misconceptions, and to encourage students to relate new information to prior experiences.

As a result of Manitoba's cultural diversity, students bring a variety of socially constructed meanings, references, and values to science learning experiences, as well as their unique learning approaches. In addition, cultural influences can affect how students think about science: reasoning by analogy or by strict linear logic; memorization of specific correct responses or generalizations; problem solving by induction or deduction; or needing to learn through hands-on experiences to gain one aspect of a skill before moving on to the next step (Kolodny). Cultural norms vary among societies; for example, values that discourage assertiveness, outspokenness, and competitiveness in some cultures can result in behaviour that may be interpreted in another culture as being indifferent, having nothing to say, or being unable to act decisively (Hoy; National Research Council). As noted in *Senior Years Science Teachers' Handbook*, "to be effective, the classroom must reflect, accommodate, and embrace the cultural diversity of its students" (Manitoba Education and Training 7.13).

Ethical Issues

A fundamental aspect of science learning and teaching (at all grades, but particularly in the Senior Years) is the consideration of controversial issues—issues that involve ethics, principles, beliefs, and values. For example, the technological application of biological principles in areas such as genetic engineering and human reproductive and medical technologies raises questions of ethics and values. Teachers should not avoid controversial issues, as discussion and debate concerning ethical questions serve to motivate students and make learning more personally meaningful.

Students should understand that science provides the background for informed personal and social decisions, and that as informed decision makers, they may have an impact on society and the world. Some students and parents may express concern because the perspectives of science conflict with personal systems of belief. These individuals have a right to expect that science and the public education system will respect those beliefs, although this does not preclude such issues from arising in the classroom. Teachers should explain that science is one way of learning about the universe and our place in it, and that other explanations have been put forth.

Dealing with Controversial Issues

The following guidelines may assist teachers in dealing with controversial issues in the classroom:

- Approach all issues with sensitivity.
- Clearly define the issues.
- Establish a clear purpose for discussions.
- Establish parameters for discussions.
- Ensure that the issues do not become personalized or directed at individual students.
- Protect the interests of individual students by finding out in advance whether any student would be personally affected by the discussion.
- Exercise flexibility by permitting students to choose alternative assignments.
- Accept the fact that there may not be a single "right answer" to a question or issue.
- Respect every student's right to voice opinions or perspectives.
- Help students clarify the distinction between informed opinion and bias.
- Help students seek sufficient and reliable information to support various perspectives.
- Allow time to present all relevant perspectives fairly and to reflect upon their validity.

The Responsible Use of Animals in the Biology Classroom

Biology teachers are encouraged to foster a respect for life and teach about the interrelationships among and interdependency of all living things. Furthermore, a stewardship approach emphasizes that humans must care for the fragile web of life that exists on our planet.

The use of live animals and the dissection of animals is a well-established practice in the teaching of life sciences. Well-constructed learning activities can illustrate important and enduring biological principles. Teachers must, however, 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.

Grade 11 Biology does not mandate that dissection (either real or virtual) take place in the classroom. Dissection is one of many instructional strategies that may be used to familiarize students with the structure and function of organs and organ systems. Interactive multimedia materials such as computer simulations, tutorials, and video clips 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 a dissection over his or her objections. In the

event that a student chooses not to participate in a dissection, he or she should be provided with an alternate activity of comparable complexity and rigour.

Implementing alternative methods does not mean excluding animals from the classroom. Classroom pets stimulate student interest in the life sciences, and their care can foster a respect for life. Certain instructional strategies allow for the continued use of animals, but with a modified approach. For example, observations of vertebrates in behaviour studies, and experimentation with invertebrates (e.g., fruit flies, planarians) can be used to illustrate important biological principles. In these cases, prudent and responsible use of these animals is essential.

Instruction

Science learning can be enhanced by using a variety of settings both in and outside the school, flexible student groupings, and numerous other instructional strategies.

Active Learning

Well-balanced science programming includes individual, collaborative, and teacher-directed learning experiences and provides students with a variety of conceptual tools and advance organizers.

Effective science instruction includes the use of strategies that promote student inquiry and interaction. These strategies include cooperative and peer learning, laboratory activities, project-based learning, teacher- and student-initiated inquiry, and research.

It is through guided inquiry and interaction that students construct meaning from their individual experiences. Students require opportunities to engage in authentic and relevant scientific issues and events. It is important that these experiences be integral to science learning.

Active learning is encouraged through resource-based and experiential learning. These include laboratory activities, field studies, and the use of information and communication technologies. Effective practices in science actively engage students in scientific inquiry processes such as research, problem solving, and decision making.

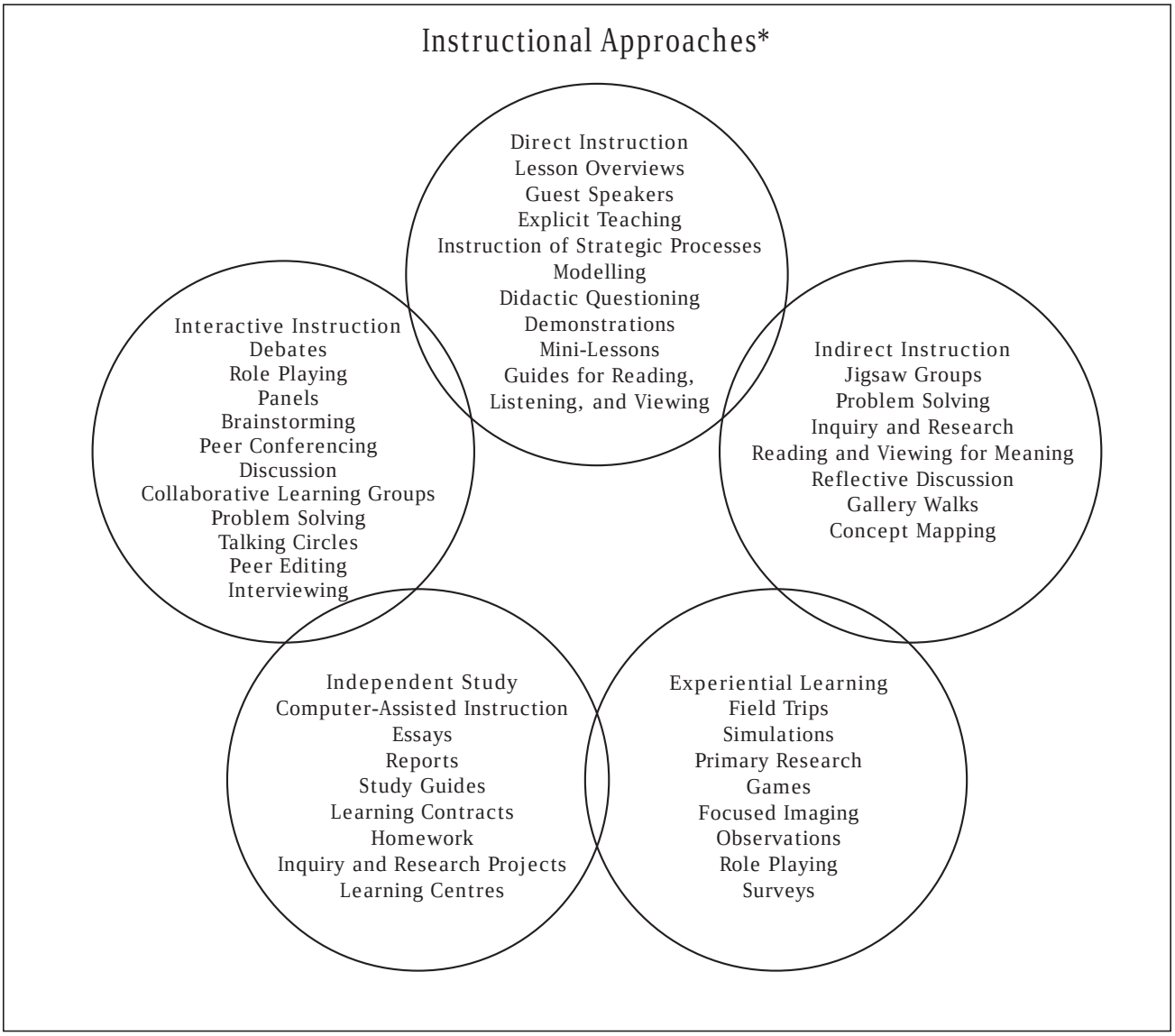
Instructional Approaches

In planning learning experiences, teachers can chose from a variety of instructional approaches and methods and use these in various combinations.

Instructional approaches may be categorized as

- direct instruction
- indirect instruction
- experiential learning
- independent study
- interactive instruction

The following diagram displays these instructional approaches and suggests some examples of methods within each approach. Note that the approaches overlap.



*Source: Saskatchewan Education. *Instructional Approaches: A Framework for Professional Practice.* Regina, SK: Saskatchewan Education, 1991. 20. Adapted by permission.

Teachers consider a number of factors as they select and adapt instructional approaches and methods:

- Will the approach meet the unique learning styles of students?
- Will it assist students in achieving the targeted learning outcomes?
- Will it engage them?
- Do student have the prerequisite knowledge of the content and/or skills to enable them to learn with this approach?
- What are the advantages and disadvantages of this approach?

Some of these considerations are included in the following chart.

Instructional Approaches: Roles, Purposes, and Methods*

Instructional Approaches	Roles	Purposes/Uses	Methods	Advantages/ Limitations
Direct Instruction	• Highly teacher-directed • Teacher uses didactic questioning to elicit student involvement	• Providing information • Developing step-by-step skills and strategies • Introducing other approaches and methods • Teaching active listening and note making	Teachers: • Explicit teaching • Lesson overviews • Guest speakers • Instruction of strategic processes • Lecturing • Didactic questioning • Demonstrating and modelling prior to guided practice • Mini-lessons • Guides for reading, listening, and viewing	• Effective in providing students with knowledge of steps of highly sequenced skills and strategies • Limited use in developing abilities, processes, and attitudes for critical thinking and interpersonal learning • May encourage passive, not active learning
Indirect Instruction	• Mainly student-centred • Teacher's role shifts to facilitator, supporter, resource person • Teacher monitors progress to determine when intervention or another approach is required	• Activating student interest and curiosity • Developing creativity and interpersonal skills and strategies • Exploring diverse possibilities • Forming hypotheses and developing concepts • Solving problems • Drawing inferences	Students: • Observing • Investigating • Inquiring and researching • Jigsaw groups • Problem solving • Reading and viewing for meaning • Reflective discussion • Concept mapping	• Active involvement an effective way for students to learn • High degree of differentiation and pursuit of individual interests possible • Excellent facilitation and organizational skills required of teachers • Some difficulty integrating focused instruction and concepts of content

(continued)

*Source: Manitoba Education and Training. *Senior 3 English Language Arts: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education and Training, 1999. Section 2, pp. 5–6.

Instructional Approaches: Roles, Purposes, and Methods (continued)

Instructional Approaches	Roles	Purposes/Uses	Methods	Advantages/ Limitations
Interactive Instruction	• Student-centred • Teacher forms groups, teaches and guides small-group skills and strategies	• Activating student interest and curiosity • Developing creativity and interpersonal skills and strategies • Exploring diverse possibilities • Forming hypotheses and developing concepts • Solving problems • Drawing inferences	Students participating in: • Discussions • Sharing • Generating alternative ways of thinking and feeling • Decision making • Debates • Role-playing • Panels • Brainstorming • Peer conferencing • Collaborative learning groups • Problem solving • Talking circles • Interviewing • Peer editing	• Increase of student motivation and learning through active involvement in groups • Key to success is teacher's knowledge and skill in forming groups, instructing, and guiding group dynamics • Effective in assisting students' development of life skills in cooperation and collaboration
Experiential Instruction	• Student-centred • Teacher's role may be to design the order and steps of the process	• Focusing on processes of learning rather than on products • Developing students' knowledge and experience • Preparing students for direct instruction	Students participating in: • Learning activities • Field trips • Simulations • Primary research • Games • Focused imaging • Role-playing • Surveys • Sharing observations and reflections • Reflecting critically on experiences • Developing hypotheses and generalizations in new situations	• Increase in student understanding and retention • Additional resources and time required for hands-on learning
Independent Study	• Student-centred • Teacher's role to guide or supervise students' independent study, teach knowledge, skills, and strategies that students require for independent learning, and provide adequate practice	• Accessing and developing student initiative • Developing student responsibility • Developing self-reliance and independence	Students participating in: • Inquiry and research projects • Using a variety of approaches and methods • Computer-assisted instruction • Essays and reports • Study guides • Learning contracts • Homework • Learning centres	• Students grow as independent, lifelong learners • Student maturity, knowledge, skills, and strategies important to success • Student access to resources essential • Approach flexible (may be used with individual students while other students use other approaches)

Phases of Learning*

Teachers find the following three phases of learning helpful when planning learning experiences:

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

The instructional strategies suggested in this document are organized into activating and acquiring/applying strategies. While these phases are not entirely linear, they are useful for thinking about and planning learning experiences. A variety of activating, acquiring, and applying strategies are discussed in *Senior Years Science Teachers' Handbook* and *Success for All Learners: A Handbook on Differentiating Instruction* (Manitoba Education and Training).

Activating (Preparing for Learning)

One of the strongest indications of how well students will comprehend new information is their prior knowledge of the subject. Some educators observe that more learning occurs during this activating phase than at any other time. In planning instruction and assessment, teachers develop student learning experiences and select strategies for activating their students' prior knowledge. Using these activating strategies, the learning experiences then provide information about the extent of students' prior knowledge of the topic to be studied, their knowledge of and familiarity with the context in which that knowledge was acquired, and their knowledge of and proficiency in applying skills for learning.

Learning experiences that draw on students' prior knowledge

- help students relate new information, skills, and strategies to what they already know and can do (e.g., if a text includes unfamiliar vocabulary, students may not recognize the connection between what they know and the new material being presented)
- allow teachers to recognize misconceptions that might make learning difficult for students
- allow teachers to augment and strengthen students' knowledge base when students do not possess adequate prior knowledge and experience to engage with new information and ideas
- help students recognize gaps in their knowledge
- stimulate curiosity and initiate the inquiry process that will direct learning

This document contains numerous strategies for activating students' prior knowledge, such as brainstorming, KWL (Know, Want to Know, Learned) guides, demonstrations, and questions to stimulate class discussions.

*Source: Manitoba Education and Training. *Senior 3 English Language Arts: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education and Training, 1999. Section 2, pp. 6–8.

Acquiring (Integrating and Processing Learning)

In the second phase of learning, students engage with new information and integrate it with what they already know, adding to and revising their previous knowledge. Part of the teacher's role in this phase is to present this new information or to help students access it from various resources.

Since learning is an internal process, facilitating learning requires more of teachers than simply presenting information. In the acquiring phase, teachers instruct students in strategies that help them make meaning of information, integrate it with what they already know, and express their new understanding. In addition, teachers monitor these processes to ensure that learning is taking place, using a variety of instruments, tools, and strategies such as observations, conferences, and examination of student work.

In practice, within an actual lesson or unit, the acquiring phase of learning may include a series of steps and strategies, such as

- setting the purpose (e.g., discrepant events, lesson overviews, learning logs, Admit Slips)
- presenting information (e.g., demonstrations, guest speakers, mini-lessons, active reading)
- processing information (e.g., note making, group discussions, journals, visual representations)
- modelling (e.g., role-playing, demonstrations)
- checking for understanding (e.g., quizzes, informal conferences)
- practising (e.g., guided practice, rehearsals)

Applying (Consolidating Learning)

New learning that is not reinforced is soon forgotten. The products and performances by which students demonstrate new learning are not simply required for assessment; they have an essential instructional purpose in providing students with opportunities to demonstrate and consolidate their new knowledge, skills and strategies, and attitudes. Students also need opportunities to reflect on what they have learned and to consider how new learning applies to new situations. By restructuring information, expressing new ideas in another form, or integrating what they have learned in science with concepts from other subject areas, students strengthen and extend their learning.

To ensure that students consolidate new learning, teachers plan various learning experiences involving

- reflection (e.g., journals, Exit Slips)
- closure (e.g., sharing of products, debriefing on processes)
- application (e.g., inquiry, design process, decision making)

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 identified learning outcomes is to differentiate the instructional strategies.

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 strategies, and attitudes to students' daily lives
- challenge students to realize academic and personal progress and achievement

Differentiating instruction does not mean offering different programming 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. Ideas for differentiating instruction are provided in *Senior Years Science Teachers' Handbook* and in *Success for All Learners: A Handbook on Differentiating Instruction* (Manitoba Education and Training).

Assessment

Assessment is integral to instruction and learning. It plays a major role in how students learn, their motivation to learn, and how teachers teach.

Purposes of Assessment

Research indicates that ongoing formative assessment contributes more significantly to learning than the traditional focus on summative assessment (Black and Wiliam). Manitoba Education refers to formative assessment as assessment *for* learning and assessment *as* learning.

Each type of assessment serves a purpose and contributes to student success:

- **Assessment *for* learning** helps teachers to gain insight into what students understand so that they can appropriately plan and differentiate teaching strategies and learning opportunities to help students progress. Students need frequent opportunities to obtain meaningful and relevant feedback. Descriptive feedback that includes analytical questions and constructive comments provides information to students that they may use to adjust their learning processes, and is more helpful to students than a numeric or alphabetic grade.
- **Assessment *as* learning** helps students to develop an awareness of how they learn and to use that awareness to adjust and advance their learning, taking an increased responsibility for their learning. When students have the opportunity to become reflective learners they can synthesize their learning, solve problems, apply their learning in authentic situations, and better understand their learning processes.

- **Assessment *of* learning** serves to confirm whether or not students have met curricular outcomes, and provides evidence of achievement to students, teachers, and parents, as well as to the broader educational community. Assessment *of* learning supports learning when it is used to celebrate success, adjust future instruction, and provide feedback to the learner.

Assessment must be planned with its purpose in mind. Assessment *for*, *as*, and *of* learning all have a role to play in supporting and improving student learning, and must be appropriately balanced. The most important part of assessment is the interpretation and use of the information that is gleaned for its intended purpose.

For more information on assessment, consult *Rethinking Classroom Assessment with Purpose in Mind: Assessment for Learning, Assessment as Learning, Assessment of Learning* (Manitoba Education, Citizenship and Youth).

Assessment in the Phases of Learning

Assessment takes place in each of the three phases of learning (activating, acquiring, and applying) and benefits both students and teachers at each phase.

Assessment at Different Phases of Learning*

	Students	Teachers
Activating Phase	Assessment in the activation stage helps **students** • "set the stage" and mentally plan and prepare for new learning • identify the focus of new learning • identify what they already know about a topic • gain interest in a new topic	Assessment in the activation stage helps **teachers** • identify gaps, strengths, misconceptions, and faulty information in students' prior knowledge • identify student interests • provide a focus for planning instructional strategies and the selection of student learning resources • determine which instructional approaches or resources need to be implemented or adapted
Acquiring Phase	Assessment during the acquisition stage helps **students** • become aware of the progress and the degree of understanding they are achieving • experience and adapt different approaches and strategies that facilitate their learning • identify what further learning they need to undertake • improve as they practise	Assessment during the acquisition stage helps **teachers** • revise learning strategies to meet evolving student needs • monitor student growth and progress, and determine whether students are achieving specific learning outcomes (SLOs) • determine if individual students need additional support or further learning opportunities to achieve SLOs • identify which learning outcomes need to be the focus of subsequent instruction and assessment • gather evidence of student growth, which may be used for reporting
Applying Phase	Assessment during the application stage helps **students** • become aware of their growth and achievement, and celebrate their successes • identify their strengths, as well as areas needing further growth • deepen their understandings as they make connections and reflect on their learning, and apply new ideas in meaningful and authentic ways	Assessment during the application stage helps **teachers** • be fully aware of student understanding and achievement of learning outcomes • identify student strengths and areas needing further learning • provide evidence of student growth and achievement for reporting to parents and administrators • reflect on their teaching practices in order to identify changes and revisions to learning strategies

*Source: Manitoba Education, Citizenship and Youth. *Grade 9 Social Studies: Canada in the Contemporary World: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education, Citizenship and Youth, 2007. Overview, p. 43.

Congruence of Assessment with Learning

There are three types of learning outcomes in science—knowledge, skills, and attitudes—and assessment needs to be congruent with each type of learning.

- **Knowledge:** Science places significant emphasis on the acquisition of knowledge. Students do not gain true understanding of science or meet the goal of scientific literacy if they simply memorize and recall facts. Students must be encouraged to use the knowledge they acquire to synthesize and apply new understandings and to demonstrate evidence of their learning.
- **Skills:** The assessment of science skills and processes requires different tools and strategies than the assessment of knowledge. Because skill development is ongoing, students should practise skills throughout the course. Skills are best assessed by observing students in action, by discussing their learning strategies in conferences and interviews, and by gathering data from student reflections and self-assessments.
- **Attitudes:** Attitudes are implicit in what students do and say, and are not always measurable in the way that knowledge outcomes are measurable. Similar to skills, attitudes are best assessed by observing students in action, looking for behavioural indicators as expressions of student attitudes, and engaging students in critical dialogue.

> 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 science reasoning (Millar and Osborne 25).

Assessment Modes, Strategies, and Tools

Assessment is embedded in the learning process. It is deeply interconnected with curriculum and instruction and must be balanced in order to improve learning and achievement for all students. Cooper suggests teachers consider modes, strategies, and tools when developing assessment tasks:

- **Modes** are the ways in which students demonstrate their learning. They include writing, doing, and speaking, and may be used in combination in an assessment task.
- **Strategies** are the tasks in which the students engage. These include tests and quizzes, journals, inquiry projects, laboratory activities, debates, mind maps, multimedia presentations, and diagrams. The type of strategy selected should match the learning being assessed.
- **Tools** are the instruments used to record the assessment data. Examples of assessment tools are marking schemes, rubrics, checklists, and rating scales. The tool must correspond to the strategy that has been chosen. For example, a rubric is used to assess an open-response essay question or an inquiry project, while a marking scheme is used to assess a multiple choice test.

Assessment Tools and Strategies*	
Observations of Skills and Processes	**Tests, Products, and Performances**
Teacher assessment: • checklists and rating scales • anecdotal records • conferences and interviews • review of work in progress Student peer assessment and self-assessment • checklists and rating scales • logs and journals	Teacher assessment: • rubrics and marking scales • conferences • portfolios Student peer assessment and self-assessment • checklists • reflective journals • portfolios

* Source: Manitoba Education, Citizenship and Youth. *Grade 9 Social Studies: Canada in the Contemporary World: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education, Citizenship and Youth, 2007. Adapted from Overview, p. 45.

Characteristics of Effective Assessment**

Effective assessment helps focus effort on implementing strategies to facilitate learning both inside and outside the classroom. Effective assessment is

- congruent with instruction
- ongoing and continuous
- based on authentic tasks
- based on criteria that students know and understand
- a collaborative process involving students
- focused on what students have learned and can do

Effective Assessment Is Congruent with Instruction

Assessment requires teachers and students to be aware continually of the purpose of instruction. How teachers assess depends on what they are assessing—whether it is knowledge, skills, or attitudes. Assessment is intended to inform students of the programming emphases and to help them to focus on important aspects of learning. If teachers assess only the elements that are easiest to measure, students may focus only on those things.

** Source: Manitoba Education and Training. *Senior 3 English Language Arts: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education and Training, 1999. Adapted from Section 2, pp. 10–14.

Effective Assessment Is Ongoing and Continuous

Assessment that is woven into daily instruction offers students frequent opportunities to gain descriptive feedback, to modify their learning approaches and methods, and to observe their progress. Teachers provide assessment for learning by questioning students and offering comments throughout a project or unit of study. They also conduct assessments of learning at the completion 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, and for students to assess their own knowledge, skills, and learning strategies in order to develop their understanding and to refine their learning strategies.

Effective Assessment Is Based on Authentic Tasks

Assessment tasks in science should be authentic and meaningful—tasks worth doing for their own sake. 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.

Authentic assessment tasks are tests not only 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 tasks are also a way of consolidating student learning.

Effective Assessment Is Based on Criteria That Students Know and Understand

Assessment criteria must be clearly established and made explicit to students prior to an assignment or test so that students can focus their efforts. Each assessment task should test only those learning outcomes that have been identified to students. This means, for example, that laboratory skills tests need to be devised and marked to gather information about students' laboratory skills, not their ability to express ideas effectively when writing a laboratory report.

Wherever possible, students need to be involved in co-constructing the assessment criteria. Students should also understand clearly what successful accomplishment of each proposed task looks like. Samples of student work from previous years and other exemplars assist students in developing personal learning goals.

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 judgments 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
- 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, self-assessment of portfolio items)
- 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 Focused on What Students Have Learned and Can Do

Assessment must be equitable; it must offer opportunities for success to every student. Effective assessment demonstrates the knowledge, skills and strategies, and attitudes 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 need to use a variety of strategies and approaches, such as the following:

- Use a wide range of instruments to assess the multi-dimensional expressions of each student's learning, avoiding reliance upon rote recall or 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 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.

At times, a common practice was to assign a mark of zero for incomplete student work. However, averaging a zero into the student's mark 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 need to 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.

For more information regarding assessment, consult *Rethinking Classroom Assessment with Purpose in Mind: Assessment for Learning, Assessment as Learning, Assessment of Learning* and *Communicating Student Learning: Guidelines for Schools* (Manitoba Education, Citizenship and Youth).

NOTES