INTRODUCTION

Background

Grades 5 to 8 Science: A Foundation for Implementation was produced by Manitoba Education and Training in collaboration with a development team composed of Manitoba educators. This resource for teachers and administrators provides support for implementing *Grades 5 to 8 Science: Manitoba Curriculum Framework of Outcomes* (2000). This framework identifies general and specific student learning outcomes for science, and integrates the four foundation skill areas of literacy and communication, problem solving, human relations, and technology.

Contents

Grades 5 to 8 Science: A Foundation for Implementation contains the following sections:

- **Introduction**—The introduction describes the background, contents, and purpose of this document.
- **Scientific Literacy**—This section presents a vision for scientific literacy and describes how the general and specific student learning outcomes help to define that vision. A chart showing the division of specific learning outcomes into clusters for each grade is provided.
- **Scientific and Technological Skills and Attitudes**—This section describes the two processes for science education, Scientific Inquiry and Design Process (Technological Problem Solving). These processes comprise the Cluster 0: Overall Skills and Attitudes included in this document.
- **Planning for Instruction and Assessment**—This section describes the importance of creating a plan for instruction and assessment to develop a balanced science program and to ensure student progress and achievement. It also provides suggested approaches for planning and assessment.
- **Suggestions for Instruction, Assessment, and Learning Resources: Grades 5 to 8**—This four-column section contains the prescribed student learning outcomes, suggestions for instruction, suggestions for assessment, and suggested learning resources. It is organized by grade and is further divided into clusters or thematic units. Each grade is accompanied by blackline masters to support and enhance learning.
- **Appendices**—The three appendices provide additional information related to general student learning outcomes, cluster titles, and pets in the classroom.
- **References**—The reference list identifies the works used in the development of this document.

Purpose

Grades 5 to 8 Science: A Foundation for Implementation provides theoretical content about science instruction. It also provides educators with practical suggestions for planning instruction and assessment to support and monitor student progress and achievement of the student learning outcomes.

Notes

SCIENTIFIC LITERACY

The Foundations for Scientific Literacy

Grades 5 to 8 Science: A Foundation for Implementation is designed in accordance with the vision for scientific literacy articulated in the *Common Framework of Science Learning Outcomes K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum* (1997) (hereafter referred to as the *Pan-Canadian Science Framework).*

The *Pan-Canadian Science Framework*

> is guided by the vision that all Canadian students, regardless of gender or cultural background, will have an opportunity to develop scientific literacy. Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them.
>
> Diverse learning experiences based on the [Pan-Canadian] framework will provide students with many opportunities to explore, analyze, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment that will affect their personal lives, their careers, and their future. (p. 4)

To develop scientific literacy, science learning experiences must incorporate the essential aspects of science and its related applications. These essential aspects, the foundations for scientific literacy, have been adapted from the *Pan-Canadian Science Framework* to address the needs of Manitoba students. Manitoba science curricula are built upon the following five foundations for scientific literacy:

A. Nature of Science and Technology

B. Science, Technology, Society, and Environment (STSE)

C. Scientific and Technological Skills and Attitudes

D. Essential Science Knowledge

E. Unifying Concepts

For more background on each of these foundation areas, consult *Grades 5 to 8 Science*: *Manitoba Curriculum Framework of Outcomes* (2000) (hereafter referred to as *5-8 Science: Manitoba Framework*).

Manitoba’s vision for scientific literacy, as reflected in the five foundation areas, represents a paradigm shift in science education also evident across North America and Western Europe. The chart on the following page highlights some areas in which there are changing emphases.

CHANGING EMPHASES*

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

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

CHANGING EMPHASES TO PROMOTE INQUIRY *

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

Achieving Scientific Literacy through Student Learning Outcomes

General student learning outcomes (GLOs) for Manitoba, based on the five foundation areas, define overall expectations for scientific literacy from Kindergarten to Senior 4. Appendix A: General Learning Outcomes includes a complete list of GLOs, excerpted from *5-8 Science: Manitoba Framework*. Specific student learning outcomes (SLOs) that further define expectations for student achievement at each grade are also included in this document.

Specific student learning outcomes for Grades 5 to 8 science are arranged in clusters. Clusters 1 to 4 are thematic groupings that generally correspond to disciplinary distinctions within science, including life science, physical science, and Earth and space science. Specific student learning outcomes included in Cluster 0 address the overall science skills and attitudes students are expected to achieve. For a full listing of Cluster 0 student learning outcomes, consult *5-8 Science: Manitoba Framework* grade-by-grade presentation, or the Overall Skills and Attitudes Chart for Grades 5 to 8 science included with that document.

Cluster Titles

Grades / Clusters	Grade 5	Grade 6	Grade 7	Grade 8
Cluster 0	Overall Skills and Attitudes (to be integrated into Clusters 1 to 4)			
Cluster 1	Maintaining a Healthy Body	Diversity of Living Things	Interactions within Ecosystems	Cells and Systems
Cluster 2	Properties of and Changes in Substances	Flight	Particle Theory of Matter	Optics
Cluster 3	Forces and Simple Machines	Electricity	Forces and Structures	Fluids
Cluster 4	Weather	Exploring the Solar System	Earth's Crust	Water Systems

See Appendix B for a Cluster Titles chart for Kindergarten to Grade 4 and Senior 1.

Notes

SCIENTIFIC AND TECHNOLOGICAL SKILLS AND ATTITUDES

Science education, with scientific literacy as its goal, must engage students in scientific inquiry, technological problem solving (design process), and decision making. These skills, behaviours, and attitudes are essential for the development of scientific understanding and the application of science and technology to new situations. Cluster 0 from *5-8 Science: Manitoba Framework* identifies student learning outcomes related to scientific inquiry and the design process (technological problem solving), as well as those that apply to both processes. For some educators, this way of conceptualizing science will be new. Yet, the increasing importance of technology in daily life and the need for critical problem-solving skills underscore the importance of integrating basic science concepts with skills and attitudes related to scientific inquiry and the design process.

The following figure, adapted from Alberta Learning, illustrates some differences and similarities between scientific inquiry and the design process in purpose, procedure, and product. As teachers plan for the integration of student learning outcomes from Cluster 0: Overall Skills and Attitudes they will become more familiar with these two distinct processes as well as the overlapping skills involved.

Processes for Science Education*

	Scientific Inquiry	**Design Process (Technological Problem Solving)**
Purpose	satisfying curiosity about events and phenomena in the natural world	coping with everyday life practices, and human needs
Procedure	What do we know? What do we want to know?	How can we do it? Will it work?
Product	knowledge about events and phenomena in the natural world	an effective and efficient way to accomplish a task or meet a need

	Scientific Question	**Technological Design Problem**
Example	Why does my coffee cool so quickly? *An answer:* Heat energy is transferred by conduction, convection, and radiation.	How can I keep my coffee hot? *An answer:* One solution is to develop a styrofoam cup that will keep liquids warm for a long time.

*__Processes for Science Education:__ Adapted with the permission of the Minister of Learning, Province of Alberta, 1999.

The specific student learning outcomes in Cluster 0 are identified as applying to scientific inquiry, the design process, or both (see example). The scientific inquiry elements are included in black type on a white box on the left. The design process elements are identified by the use of white type on a black box on the right. Learning outcomes related to both processes are located in a horizontal box below the left and right hand boxes. All specific student learning outcomes appear in a numbered and lettered sequence (e.g., 1a, 1b, 1c, 2a, 2b, etc.).

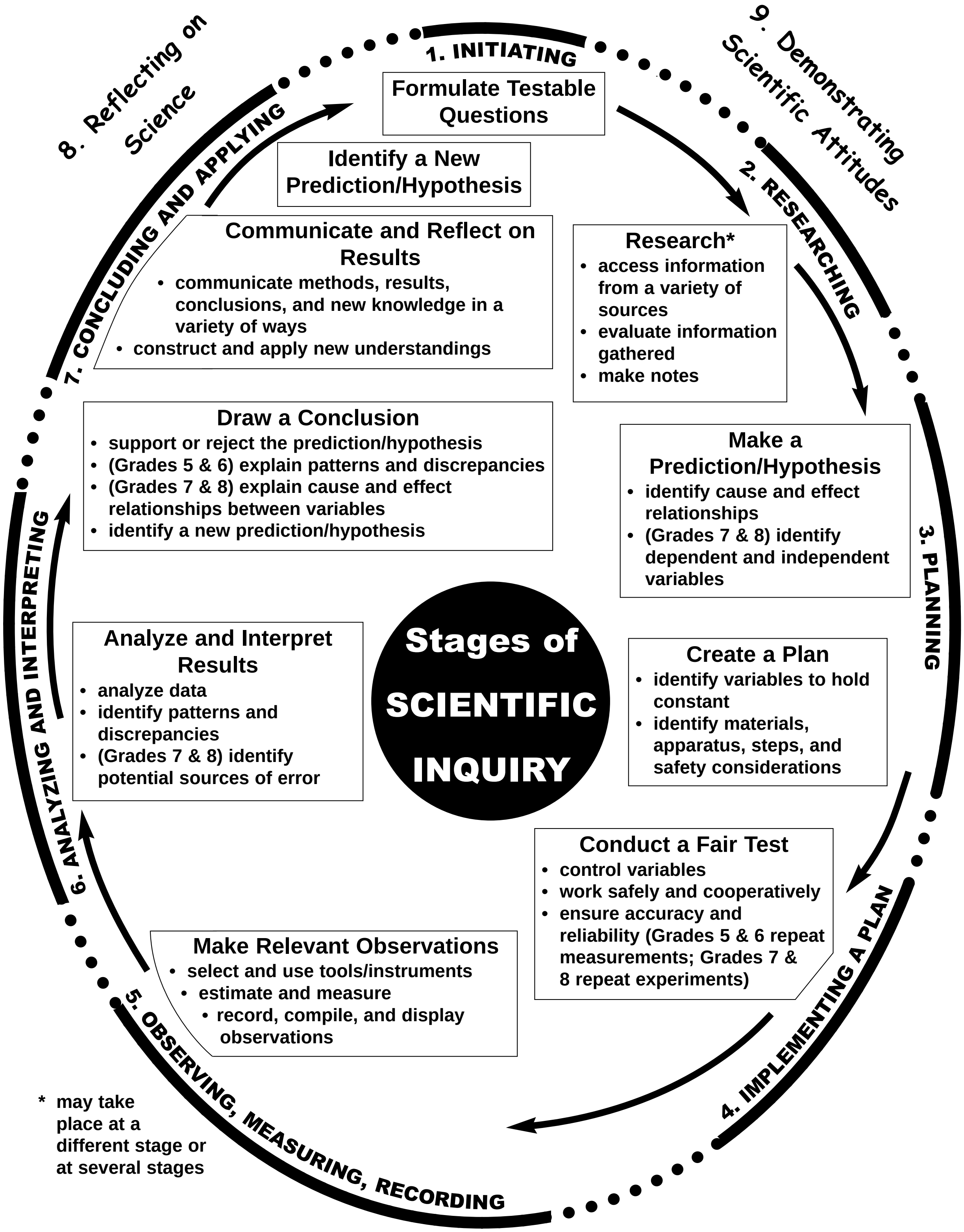
GRADE 6

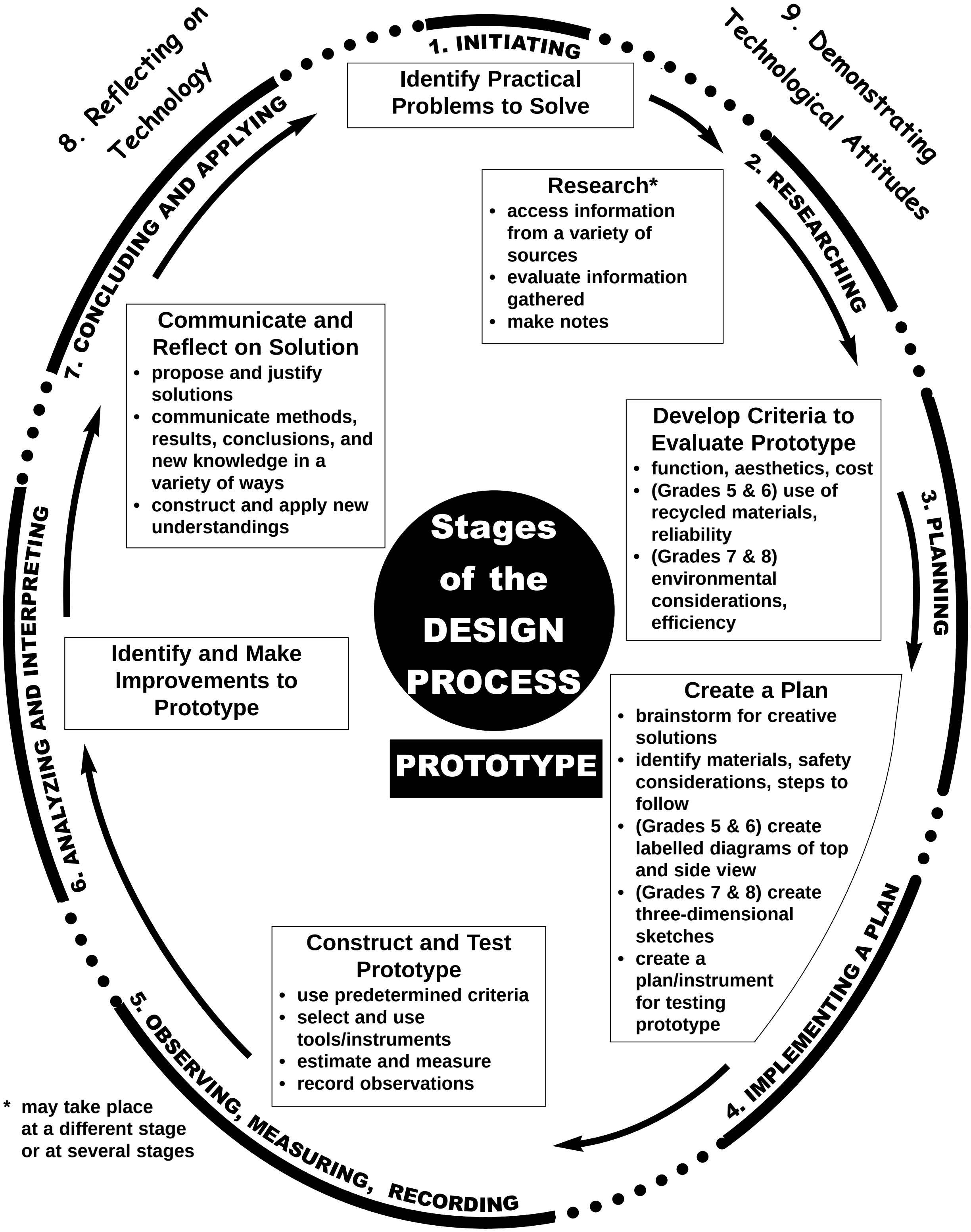
	Scientific Inquiry	Design Process
1. Initiating	**6-0-1a Formulate specific questions that lead to investigations.** Include: rephrase questions to a testable form; focus research questions. GLO: A1, C2 (ELA Grade 6, 3.1.2; Math: SP-I.1.6)	**6-0-1c Identify practical problems to solve.** *Examples: How can I make a hot-air balloon? Which type of light bulb should I buy?...* GLO: C3
	6-0-1b Identify various methods for finding the answer to a specific question and select one to implement. *Examples: generating experimental data; accessing information from a variety of sources...* GLO: C2 (ELA Grade 6, 3.2.2; Math: SP-I.2.6, SP-II.1.6)	**6-0-1d ⊂ Identify various methods to solve a practical problem, and select and justify one to implement.** *Examples: constructing and testing a prototype; evaluating consumer products; accessing information from a variety of sources...* GLO: C3 (Math: SP-I.2.6, SP-II.1.6)
2. Researching	**6-0-2a ⊂ Access information using a variety of sources.** *Examples: libraries, magazines, community resource people, outdoor experiences, videos, CD-ROMs, Internet...* GLO: C6 (ELA Grade 6, 3.2.2; Math: SP-II.1.6; TFS 2.2.1) **6-0-2b ⊂ Review information to determine its usefulness, using predetermined criteria.** GLO: C6, C8 (ELA Grade 6, 3.2.3) **6-0-2c Make notes on a topic, combining information from more than one source and referencing sources appropriately.** GLO: C6 (ELA Grade 6, 3.3.2)	

The specific student learning outcomes are further organized into the following nine categories:

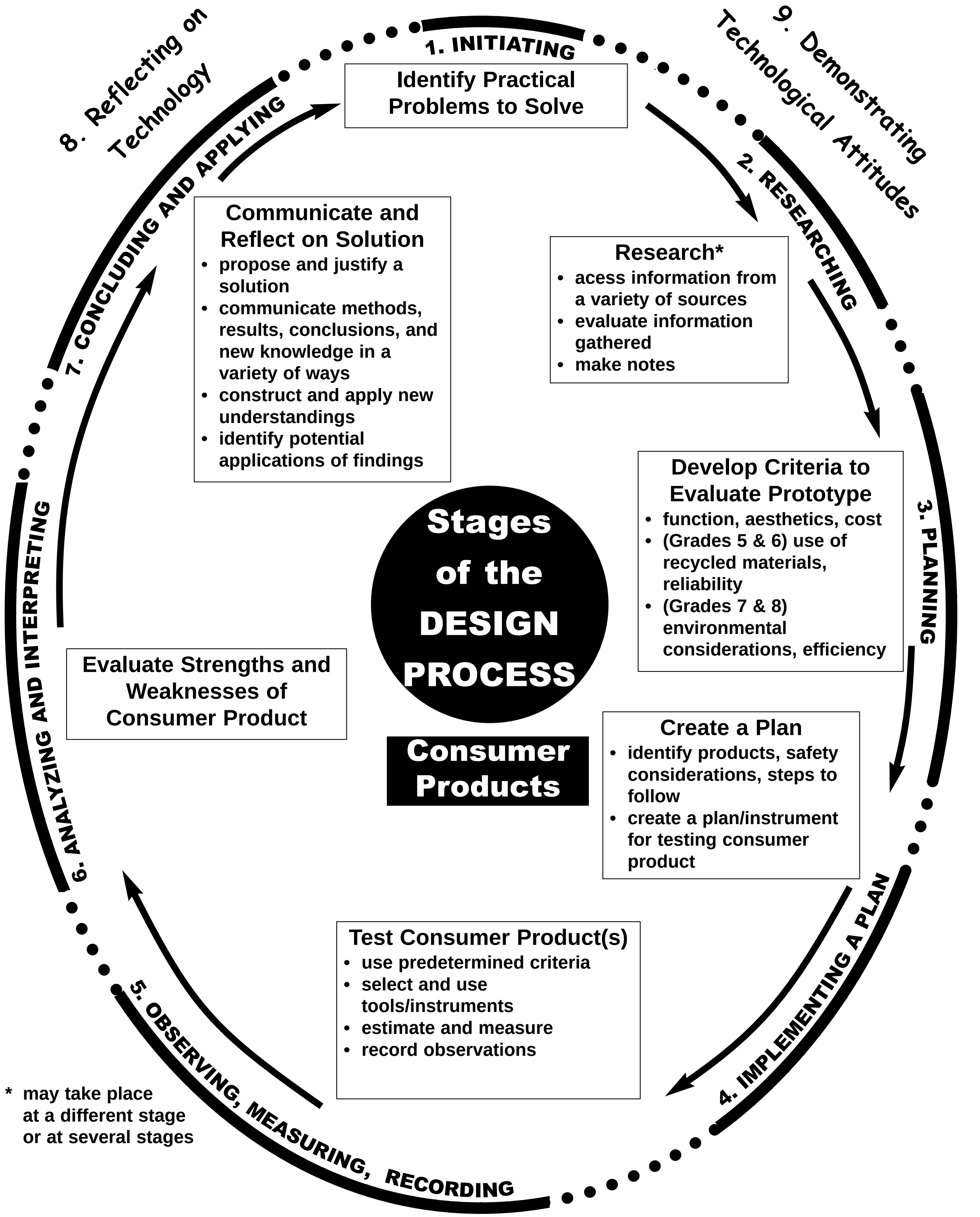
1. Initiating
2. Researching
3. Planning
4. Implementing a Plan
5. Observing, Measuring, Recording
6. Analyzing and Interpreting
7. Concluding and Applying
8. Reflecting on Science and Technology
9. Demonstrating Scientific and Technological Attitudes and Habits of Mind

The three graphics on the following pages illustrate the stages of scientific inquiry and the design process. Detailed descriptions of each process follow the graphics.


1. INITIATING
Formulate Testable Questions
2. RESEARCHING
Research*
• access information from a variety of sources
• evaluate information gathered
• make notes
3. PLANNING
Make a Prediction/Hypothesis
• identify cause and effect relationships
• (Grades 7 & 8) identify dependent and independent variables
Create a Plan
• identify variables to hold constant
• identify materials, apparatus, steps, and safety considerations
4. IMPLEMENTING A PLAN
Conduct a Fair Test
• control variables
• work safely and cooperatively
• ensure accuracy and reliability (Grades 5 & 6 repeat measurements; Grades 7 & 8 repeat experiments)
5. OBSERVING, MEASURING, RECORDING
Make Relevant Observations
• select and use tools/instruments
• estimate and measure
• record, compile, and display observations
6. ANALYZING AND INTERPRETING
Analyze and Interpret Results
• analyze data
• identify patterns and discrepancies
• (Grades 7 & 8) identify potential sources of error
7. CONCLUDING AND APPLYING
Draw a Conclusion
• support or reject the prediction/hypothesis
• (Grades 5 & 6) explain patterns and discrepancies
• (Grades 7 & 8) explain cause and effect relationships between variables
• identify a new prediction/hypothesis
Communicate and Reflect on Results
• communicate methods, results, conclusions, and new knowledge in a variety of ways
• construct and apply new understandings
Identify a New Prediction/Hypothesis
8. Reflecting on Science
9. Demonstrating Scientific Attitudes
Stages of SCIENTIFIC INQUIRY
* may take place at a different stage or at several stages



* may take place at a different stage or at several stages


8. Reflecting on Technology
9. Demonstrating Technological Attitudes
1. INITIATING
Identify Practical Problems to Solve
2. RESEARCHING
Research*
• acess information from a variety of sources
• evaluate information gathered
• make notes
3. PLANNING
Develop Criteria to Evaluate Prototype
• function, aesthetics, cost
• (Grades 5 & 6) use of recycled materials, reliability
• (Grades 7 & 8) environmental considerations, efficiency
Create a Plan
• identify products, safety considerations, steps to follow
• create a plan/instrument for testing consumer product
4. IMPLEMENTING A PLAN
Test Consumer Product(s)
• use predetermined criteria
• select and use tools/instruments
• estimate and measure
• record observations
5. OBSERVING, MEASURING, RECORDING
6. ANALYZING AND INTERPRETING
Evaluate Strengths and Weaknesses of Consumer Product
7. CONCLUDING AND APPLYING
Communicate and Reflect on Solution
• propose and justify a solution
• communicate methods, results, conclusions, and new knowledge in a variety of ways
• construct and apply new understandings
• identify potential applications of findings
Stages of the DESIGN PROCESS
Consumer Products
* may take place at a different stage or at several stages

Scientific Inquiry

As indicated in the graphic on page 9, scientific inquiry generally proceeds according to a sequence of stages, although there will be differences in the order and number of stages the students undertake. With repetition and experience, students will become aware of the logical underpinnings of scientific inquiry and develop familiarity and fluency with the requisite skills and attitudes.

While all grades follow the general stages of scientific inquiry, there are significant differences in expectations of students across the grades. For example, in Grades 5 and 6, students formulate a prediction/hypothesis that identifies a cause and effect relationship. In Grades 7 and 8, students begin to replace the terms *cause* and *effect* with *independent* and *dependent variables*. From Grades 5 to 8, students are also working with increasing independence to plan fair tests, including identifying variables to hold constant and identifying potential sources of error.

The Stages of Scientific Inquiry

The stages of the scientific inquiry are discussed below. Note that these stages are general guidelines only and every scientific inquiry may not address all the stages, or the stages may not be addressed in the exact order provided here. "Experiment Report" blackline masters have been provided at all grades for student use.

- **Formulate Testable Questions**

  Scientific inquiry begins with a student's ability to formulate testable questions. A general question such as "*What do plants need in order to grow?*" needs to be rephrased into a focused and testable question. Students may need to perform some background research to focus the question on one variable. A good testable question includes a cause and an effect. For example, "*Does the amount of light a geranium plant receives affect how well it grows?*" includes the "cause" (the amount of light) and the corresponding "effect" (how well the plant grows). Note: This sample question focuses on one type of plant as it is not possible to test all plant types in one experiment.

  In Grades 5 and 6, a considerable amount of teacher guidance and class discussion may be required for a class to develop a testable question. By Grades 7 and 8, students should be able to develop testable questions more independently. A good testable question will enhance students' ability to make predictions, create a plan, conduct a fair test, and make relevant observations and conclusions.

- **Research**

  The research portion of scientific inquiry may take place at various stages during scientific inquiry. It is important that students refer to a variety of sources, evaluate the information's usefulness (Grades 5 and 6), and evaluate the reliability of information gathered (Grades 7 and 8).

  English language arts, General Learning Outcome 3: *Manage Ideas and Information,* provides teachers with strategies to assist students in developing research skills and to assess those skills. This component of the scientific inquiry process provides an opportunity to integrate science and English language arts for instruction and assessment.

- **Make a Prediction/Hypothesis**

  In the Middle Years, no distinction between prediction and hypothesis is required—the two are used interchangeably. In Grades 5 and 6, prediction is more commonly used, while in Grades 7 and 8, hypothesis is used. In some cases, a distinction between the two terms is made in learning resources and it is up to the teacher to decide whether to highlight this information.

  In Grades 5 and 6, students should state the cause and effect relationship in their prediction/hypothesis. For example, students may predict that a plant that receives more light will grow more than a plant that receives less light.

  In Grades 7 and 8, students are making similar types of predictions/hypotheses. However, rather than referring to cause and effect, students identify independent (manipulated) and dependent (responding) variables. For example, the independent variable is the amount of light and the dependent variable is the recorded growth.

- **Create a Plan**

  In Grades 5 and 6, students create a written plan that includes the apparatus, materials needed, safety considerations, and steps to follow. The plan should identify variables that could affect the experiment and should be controlled to ensure a fair test. For example, the plants that are being compared should be of the same type and given the same care. Several plants should be used. A considerable amount of initial teacher guidance will be necessary. The teacher may choose to develop the plan as a class undertaking.

  In Grades 7 and 8, students create a written plan that includes the apparatus, materials needed, safety considerations, and steps to follow. The plan should identify which variables need to be controlled. Students are expected to develop the plan and identify the variables more independently than in Grades 5 and 6.

- **Conduct a Fair Test**

  In the Middle Years, students conduct fair tests in which the variables are controlled. In Grades 5 and 6, students repeat measurements to ensure accuracy. In Grades 7 and 8, students repeat measurements as well as experiments (conduct several trials) to increase accuracy and reliability. This stage of conducting a fair test presents teachers with opportunities to introduce different aspects of science safety and laboratory procedures. Students should also assume various roles in order to achieve group goals.

- **Make Relevant Observations**

  In Grades 5 and 6, students are expected to make observations that are relevant to the specific question, select and use appropriate tools (with teacher guidance), estimate and measure using SI units, and record and organize observations in a variety of formats, such as graphs, point-form notes, diagrams, sentences, charts, lists, and spreadsheets (with teacher guidance, as needed).

  In Grades 7 and 8, students are expected to make observations that are relevant to the specific question, choose and use appropriate tools, estimate and measure using SI units (making conversions when necessary), and compile and display observations and data using an appropriate format, including point-form notes, diagrams, sentences, charts, lists, spreadsheets, graphs, and frequency tallies (with teacher guidance, as needed).

- **Analyze and Interpret Results**

  In Grades 5 and 6, students analyze collected data and observations and identify patterns and discrepancies in data. Classroom data may be compiled for analysis, providing students an opportunity to identify discrepancies. For example: *"Nine out of 10 plants showed better growth in sunlight."* Discussion should take place on possible causes of this discrepancy. This provides the opportunity to discuss the nature of science and to lay the groundwork for expectations in Grades 7 and 8 related to identifying potential sources of error. However, students should come to recognize that the overall trend indicates that plants grew better in the sunlight (even though one plant did not).

  In Grades 7 and 8, students analyze collected data and observations, identify patterns and discrepancies in data, and infer and explain their relationships. Students should also be able to identify any potential sources of errors. For example, one plant that was in the sunlight may have been exposed to another factor such as spider mites or disease, resulting in poor growth.

- **Draw a Conclusion**

  In Grades 5 and 6, students are expected to draw conclusions that explain investigation results. Teachers and students should recognize the limitations of their results. For instance, in the sample plant experiment, teachers and students should note that the results from this experiment can only be applied to the one type of plant tested, although generalizations for all plants may be proposed. The conclusion should explain patterns in data and support or reject the prediction/hypothesis. For example: *"We can conclude that the amount of sunlight that a geranium plant receives affects how well it grows. In our trials, the plants that received 10 hours of sunlight grew an average of 15 cm more than the plants that only received four hours of sunlight. The plants that received the extra light also appeared more healthy (more leaves, greener, thicker stems)."*

  In Grades 7 and 8, students also draw conclusions that explain investigation results, as well as the cause and effect relationship between the independent variable and the dependent variable. For example: *"Our experiment shows that increased sunlight causes superior growth in plants. In our experiment, all variables, other than the amount of sunlight, were kept constant. In the 32 days that we ran the experiment, the plants that received 10 hours of sunlight a day grew an average of 15 cm. The plants that only received four hours of sunlight a day grew an average of 3 cm. Our results support our prediction/hypothesis."* Students are also expected to identify a new prediction/hypothesis. This should emphasize to students that even though they may have a sound conclusion, the process of scientific inquiry can continue. For example, students may predict from their findings that a plant will continue to grow at twice the rate if they double the amount of time the plant is exposed to light.

- **Communicate and Reflect on Results**

  At all grades, students should be encouraged to present their results in a variety of ways, such as written reports, oral presentations, and multimedia presentations. Students should also be encouraged to apply their new understandings or look for links to daily life. For example, they may suggest, based on what they have learned in this inquiry, that greenhouse operators should increase the amount of light to which they expose their plants in order to improve yields. Further, students may want to propose an investigation into the cost-effectiveness of a tomato hothouse owner running his or her lights for extended periods of time. Would the increase in yields cover the cost of running the lights?

Additional Information

Materials/Equipment Required

In the Middle Years, the materials and equipment required for scientific inquiry become more specialized. While the specialized equipment required in Grades 5 and 6 is limited (e.g., a balance and thermometer in Grade 5), requirements for science equipment in Grades 7 and 8 increases. Grade 7 students work with equipment such as microscopes, thermometers, scientific glassware, and heating sources. Grade 8 students work with similar equipment and additional tools such as mirrors and lenses. Teachers must identify both general equipment requirements as indicated by the learning outcomes, and specific material and equipment requirements determined by the choices they make with regard to learning experiences for their students (these needs will differ from teacher to teacher). Cluster 0: Overall Skills and Attitudes provides some guidance on equipment requirements.

Safety Considerations

While the primary responsibility for safety in science belongs to teachers and other school personnel, Middle Years students must become aware of the importance of safety measures (in relation to themselves, others, and the environment) and become skilled in safety procedures. This awareness and these skills are critical components of the scientific culture of students who will become responsible citizens of the future.

Many science classes in Grades 5 and 6 (and possibly many in Grades 7 and 8) are conducted within the regular classroom setting and not a formal science lab. In this instance it is critical for practices to be in place to ensure the ongoing safety of students. Safe storage of equipment, materials, and chemicals is essential, as is effective clean-up. This is especially important if students will be eating lunch in the classroom.

In Grades 7 and 8, the complexity of experiments and the associated materials and equipment required increases substantially. There is, therefore, a heightened need for teachers and students to use safe science practices, and the new curriculum reflects a focus on student safety and a shift in expectations from previous curricula. For example, hot plates can be used as a safer source of heat that still allows students to meet the expectations set out in the learning outcomes. Similarly, while mercury thermometers may still be used in the classroom, they are not required by the curriculum and should eventually be replaced by alternative types of thermometers. Some schools and school divisions/districts have voluntarily chosen to remove mercury thermometers from classrooms because of the danger associated with breakage and the subsequent release of mercury and the challenges that are posed by clean-up. In addition, the use of bodily fluids or tissues is no longer allowed in the classroom. This means that learning activities outlined in previous curricula should be replaced with safer alternatives. For example, students should not be making wet mounts using cheek cells or taking blood samples for testing. Refer to *Science Safety: A Kindergarten to Senior 4 Resource Manual for Teachers, Schools, and School Divisions* for important safety information for teachers and students at all grades (available from the Manitoba Text Book Bureau, stock number 85293). Another valuable resource is *Be Safe! Canadian Edition: A Health and Safety Reference for Science and Technology Curriculum* (available through the Science Teachers Association of Ontario).

Assessment

Students' application of the steps of the scientific inquiry process involves the acquisition of knowledge, skills, and behaviours. Like other areas of the curriculum, scientific inquiry skills and attitudes should be assessed in relation to student learning outcomes. (See page 27 for a discussion on planning for assessment.) Teachers need to identify and become familiar with Cluster 0, grade-level learning outcomes that focus on skills specific to scientific inquiry. These skills are difficult to assess in a paper and pencil testing format. They are best assessed through observation, interviews, and tasks that involve students in actively exploring, investigating, and experimenting.

Design Process

As indicated in the graphics on pages 10-11, the design process consists of a series of sequenced stages. Through these stages, Middle Years students continue to develop the skills and attitudes of the design process that lead to a broader understanding of technological problem solving.

While all grades follow the general stages of the design process, there are significant differences in expectations of students across the grades. For example, students in Grades 5 and 6 develop criteria that include function, aesthetics, cost, reliability, and use of recycled materials, while students in Grades 7 and 8 also include efficiency and environmental considerations. Similarly, in creating a written plan, students in Grades 5 and 6 include sketches of top and side views, while students in Grades 7 and 8 include three-dimensional sketches.

At the Middle Years level the design process is separated into two approaches:

1. planning, constructing, and evaluating a prototype
2. comparing and evaluating the design of consumer products

The Stages of the Design Process for Constructing a Prototype

The stages of the design process are discussed in detail below. Note that these stages are general guidelines only and every design task may not address all the stages, or the stages may not be addressed in the exact order provided here. "Design Project Report" blackline masters have been provided at each grade for student use.

- **Identify a Practical Problem to Solve**—Identifying a practical problem initiates the design process. For example, the practical problem for learning outcome 6-4-13, *Use the design process to construct a prototype that tells the time of day or measures a time span,* could be presented in the following manner:

  "Design and construct a prototype that tells the time of day or measures a time span for a group of wilderness campers on a survival excursion. The campers will not carry any watches or clocks and need to arrive at a particular destination for pick-up at a specified time interval."

  Middle Years students should be involved in the problem identification. The problem should be framed within a context. This might involve a real-world problem or a scenario linked to another discipline, such as social studies or a literature selection. It is critical that the design challenge presented to students is problem focused as opposed to product focused. For example, "construct a boat" is a product-focused challenge, while "construct a floating device to transport a load of three blocks across a span of water one metre wide" is problem focused. The problem must also be open-ended to encourage optimum solutions.

- **Research**—Gathering information is an integral part of the design process. Information is gathered a number of ways, using a variety of resources. It occurs at various stages of the design process. The design process also draws on knowledge and skills developed through the scientific inquiry process. Effective questioning by the teacher can assist students in activating and integrating their prior knowledge and experiences. Students need to evaluate the gathered information to determine its usefulness. Researched information is organized and recorded in an appropriate format. Students need to recognize both the need to access information throughout the design process and the different resources available. Human, print, and electronic resources should be made accessible to students.

  English language arts, General Learning Outcome 3: *Manage Ideas and Information* provides teachers with strategies to assist students in developing research skills as well as assessing those skills. This component of the design process provides an opportunity to integrate English language arts and science for instruction and assessment.

- **Develop Criteria to Evaluate a Prototype**—Criteria must be specific enough to limit the scope of impractical solutions and ensure success, but also open-ended enough to allow originality and creativity. It is also important that the criteria are testable.

  Criteria should be generated with student input. They should also be framed in the context of the science learning within the cluster. The teacher may need to specify certain criteria related to the learning outcome and available materials, whereas students will often identify “real-life” type of criteria. In developing criteria, students should address function, cost, and aesthetics. In Grades 5 and 6, reliability and the use of recycled products (where appropriate) are included. Students in Grades 7 and 8 need to address environmental considerations and efficiency (where appropriate).

  To ensure that each of the specified criteria is testable, students need to provide descriptors. These might include:

  — Aesthetics: For some prototype solutions aesthetics is an important factor. The criterion of being “visually appealing” can be included, but further descriptors (e.g., colour, scale, finishing) facilitate evaluation.

  — Cost: The inclusion of cost heightens student awareness to issues of product production and cost-effectiveness. This criterion can be included by assigning a monetary value to materials or processes involved in the construction of the prototype.

  — Criteria addressing the function, reliability, and/or efficiency of the prototype must be clearly specified to ensure consistency in testing. These criteria often have a strong overlap with the scientific inquiry process as the concept of a “fair test” is applied.

  — Criteria that include the use of recycled materials or environmental considerations focus student awareness on sustainability and the potential environmental impacts of design solutions on the environment. This links with the Science, Technology, Society and Environment (STSE) component of the curriculum.

- **Create a Plan**—At this stage, the group of students generates several ideas and selects the best possible solution to the proposed problem. It is important that the teacher assists in activating students' creative thinking skills of fluency, flexibility, elaboration, and originality. This will encourage optimum solutions to the problem. The group then identifies appropriate materials, safety considerations, and a logical sequence of steps to follow. Students record their plan including labelled diagrams of the top and side views of the prototype in Grades 5 and 6, and three-dimensional sketches in Grades 7 and 8. It is important that students are aware of the value of the labelled sketch. It provides a visualization of the prototype to guide the construction and serves as a draft blueprint. The constructed prototype can be (and likely will be) altered from the initial sketch and an explanation of the need for changes is an important aspect of student learning.

  In creating a plan for the design and construction of the prototype, it is useful to have students include a plan/instrument to test the prototype according to the criteria identified and following a fair test approach.

- **Construct a Prototype**—Constructing the designed prototype gives students opportunities to apply their understanding of the properties of materials and their uses. It encourages students to identify information needs and access the required information through research. It provides the opportunity to apply the science knowledge and skills that have been acquired through that particular science cluster in a practical context.

  For example, the design problem associated with specific learning outcome 7-3-12: *Use the design process to construct a structure that will withstand the application of an external force*, requires students to apply the following knowledge and skills acquired in Cluster 3: Forces and Structures.

  — identifying internal and external forces and the stress they apply to structures

  — identifying the centre of gravity and its effect on stability

  — determining the efficiency of the structure as it relates to mass

  — investigating the effect of a force in terms of its magnitude, direction, plane, and point of application

  — determining methods to increase the strength and stability of a structure

  It is important for students to have had experience with key concepts and skills prior to the design project. The construction stage may involve the generation and revision of ideas and the identification of the need for further research. This could result in a solution that differs from the original plan.

- **Test a Prototype**—Students test the prototype against the predetermined evaluation criteria. They select and use appropriate tools and instruments in order to conduct a fair and consistent test. Students will use accurate estimates and measurements and record their observations and results. Students often needed to be reminded that their prototype needs to address *all* the criteria identified.

- **Identify and Make Improvements—**Based on the performance test of the prototype using the predetermined criteria, students analyze the performance information and identify modifications to improve the performance of their prototype and ensure that it meets all criteria. They revise the design sketch to reflect modifications and make the improvements to the prototype.

- **Communicate and Reflect on Solution**—The design process concludes with the communication and justification of a solution to the problem that has been tested with respect to the evaluation criteria and that reflects improvements based on students' analyses. "In writing, speaking, and representing, students construct meaning in order to communicate with others" (*Grades 5 to 8 English Language Arts: A Foundation for Implementation*, p. 9). Through photo essays, videos, design sketchbooks, flow charts, oral presentations, illustrated reports, demonstrations, or multimedia presentations, students communicate the products and procedures of their design process. They include the methods used, the results, and new knowledge. Students identify the strengths and weakness of their original design, and their application of new understanding is explained in the improvements made to the prototype. New problems may also be identified, leading to the need for new product development.

Additional Information

Materials/Equipment Required

Materials for a design task include recycled and everyday materials as well as tools and equipment. The use of recycled materials addresses the Science, Technology, Society and the Environment (STSE) component of the curriculum. Supplemental items such as tape, glue, scissors, etc. will need to be provided.

It is important that students become familiar with the characteristics and properties of the materials they are using. Hands-on experiences involving these materials and their structural qualities should precede a design task. For certain design tasks the types of materials can be limited. This encourages students to gain experience in the use and properties of specific materials, and be creative in their application to a task.

At times, some tools and equipment will be required for constructing a prototype. Instruction on the use of tools and equipment should precede use to ensure student safety.

Safety Considerations

The use of tools and equipment raises safety concerns. The tools and storage containers used for the technology component of the curriculum should be specifically designed to maximize user safety. Low-temperature glue guns, safety goggles, mitre boxes, and bench hooks are examples of "safer" items. If a construction part of a design task is to be done at home, parents/guardians should be alerted to provide supervision.

There are several methods to ensure safety in the classroom during the construction stage of the design process:

- Teach tool use. Demonstrate and have students practise safe use of the tools prior to beginning the task.
- Generate safety rules for the classroom, with the students developing the criteria whenever possible.
- Organize
  - — the students (groupings, supervision, responsibilities)
  - — the materials (storage, responsibilities)
  - — the tools and equipment (storage, work area, student/teacher tools, supervision)
  - — the design process display area
- Arrange the classroom for access to resources and equipment with safety in mind.

Assessment

Learning outcomes for the design process, like other areas of the curriculum, should be assessed for the acquisition of knowledge, skills, and behaviours. (See page 4 for a general discussion of assessment.) Teachers need to identify, and become familiar with, the grade-specific student learning outcomes in Cluster 0 that relate to the design process. A variety of assessment practices can be applied to the performance of a design task such as teacher observation, questioning, and student learning logs or notebooks. "Design Project Report: Assessment" and "Constructing a Prototype: Observation Checklist" blackline masters have been provided as assessment tools. It is important that the focus of assessment be on the demonstration of learning that has occurred throughout the design process. Similarly, the solution should not be evaluated on whether it worked, but rather on the degree of its effectiveness in addressing the original problem.

Because of the sequential and recursive nature of the design process, student self-assessment and peer evaluation should be ongoing. The design process also provides opportunities for formative assessment so that the teacher can plan the next stage of instruction and learning. For example, if during the design task associated with learning outcome 7-3-12, *Use the design process to construct a structure that will withstand the application of an external force*, the teacher observes that the students are encountering difficulties due to limited understanding of the structural shapes, a mini-lesson or background learning activity may be inserted into the learning experience.

In the evaluation stage of the design process, assessment should focus on the positive aspects of the solution. Through the use of probing and open-ended questions, the teacher can elicit further thinking on making improvements to enhance the solution as well as student understanding of the science knowledge connected to the design task. This will also provide indicators as to the student's level of achievement related to the learning outcomes. Design notebooks, demonstrations, oral presentation using visuals, and multimedia presentations can provide records of student learning at each stage of the design process and assist in the assessment of student learning.

The Stages of the Design Process for Evaluating Consumer Products

The stages of the design process as applied to evaluating consumer products are discussed in detail below. Note that these stages are general guidelines and every design task may not address all the stages, or the stages may not be addressed in the exact order provided here.

- **Identify a Practical Problem to Solve**—Identifying a practical problem initiates the design process. For example, the practical problem for learning outcome 5-1-05, *Evaluate prepared food products using the design process*, could be presented in the following manner:

  "In planning daily menus over a weekly period, working parents would like to include some prepared foods for supper. They want to ensure that the prepared food contributes to a balanced, nutritional meal and is reasonably priced. Which prepared foods should be considered?"

  Middle Years students should be involved in the problem identification. The problem should be framed within a context. This might involve a real-world problem or a scenario linked to another discipline such as social studies or literature. It is important that the problem is open-ended to encourage optimum solutions.

- **Research**—Gathering information is an integral part of the design process. Information is gathered in a number of ways, using a variety of resources. It occurs at various stages of the design process. The design process also draws on knowledge and skills developed through the scientific process. For example, information on consumer products may be accessed electronically through a company's website, email address, or a 1-800 number provided on the package. Students need to evaluate the information gathered to determine its accuracy and usefulness. Researched information is organized and recorded in an appropriate format. Students need to recognize both the need to access information throughout the design process and the different resources available. Human, print, and electronic resources should be made accessible to the students.

  English language arts, General Learning Outcome 3: *Manage Ideas and Information,* provides teachers with strategies to assist students in research and note-taking. This component of the design process provides an opportunity to integrate science and English language arts for instruction and assessment.

- **Develop Criteria to Evaluate a Consumer Product**—Evaluation criteria should be generated with student input. They should also be framed in the context of the science learning within the cluster. The teacher may need to specify criteria related to the learning outcome. Criteria must be testable. For consumer products some features of the design may not be readily accessible which might affect the selection of criteria. It may be important to rank the criteria in order of importance to the solution of the problem, especially when comparing consumer products.

  In developing criteria, the students should include function, cost, and aesthetics. Students in Grades 5 and 6 consider reliability and the use of recycled products (where appropriate), while in Grades 7 and 8 students address environmental considerations and efficiency (where appropriate).

  In evaluating consumer products, it is important to compare similar products. This assists students in evaluating a product using predetermined criteria, and in investigating different ways in which products are designed. The use of comparison heightens student awareness of the importance of the design component and their critical analysis of consumer products.

  To ensure that each of the specified criteria is testable, students need to provide descriptors. These might include:

  — Aesthetics: For some prototype solutions aesthetics is an important factor. The criterion of being "visually appealing" can be included, but further descriptors (e.g., colour, packaging features) facilitate evaluation.

  — Cost: The inclusion of cost assists students in analyzing the value of a consumer product.

  — Criteria addressing the function, reliability, and/or efficiency of the prototype must be clearly specified to ensure consistency in testing.

  — Criteria that include the use of recycled materials or environmental considerations focus student awareness on sustainability and the potential impacts of design solutions on the environment. This links with the Science, Technology, Society and Environment (STSE) component of the science curriculum.

- **Create a Plan—**The group identifies appropriate materials, safety considerations, and a logical sequence of steps to follow to evaluate consumer products.

  In creating a plan for the evaluation of consumer products, the teacher needs to decide whether:

  — each group will evaluate one product and then compare the effectiveness of each in solving the problem through class sharing and discussion

  or

  — each group will compare more than one product and determine the effectiveness of each in solving the problem

  It is useful to have students include a plan for testing the consumer product. This might involve developing a testing instrument with the concept of a fair test in mind.

- **Test Consumer Products**—Students test the consumer products against the predetermined evaluation criteria. They select and use appropriate tools and instruments to conduct a fair and consistent test. Students use accurate estimates and measurements and record their observations and results.

- **Evaluate Strengths and Weaknesses of Consumer Products**—From the test of the consumer product using the predetermined criteria, students identify and record its strengths and weaknesses. When comparing two or more consumer products, students may need to rank each one on each specified criterion or use a list of prioritized criteria to determine the better product. The comparison of consumer products enables students to analyze specific features that need improvements to meet the criteria.

- **Communicate and Reflect on Results**—The design process concludes with the proposal and justification of a solution to the problem that has been tested with respect to the evaluation criteria, and that reflects improvements based on students' analyses. "In writing, speaking, and representing, students construct meaning in order to communicate with others" (*Grades 5 to 8 English Language Arts: A Foundation for Implementation*, p. 9). Through oral presentations, illustrated reports, demonstrations, or multimedia presentations, students communicate the products and procedures of their design process. They include the methods used, the results, the conclusions, and new knowledge. Students identify the strengths and weakness of the consumer products. Through product comparison they apply their new understanding in recognizing the design features that best address the solution to the initial problem. New problems may also be identified, leading to the need for analysis of other products, or new product development.

Additional Information

Safety Considerations

The use of consumer products in the design process can raise different types of safety concerns. In a classroom environment health and hygiene need to be addressed, particularly if the design task involves food. To ensure safety when using consumer products, the teacher should

- select a school facility that minimizes risks, such as the gym or outdoors to test sports equipment, and the school lunchroom to test prepared food products
- address hygiene and health issues such as allergies
- check the product to be tested for defects or features that may cause injury

PLANNING FOR INSTRUCTION AND ASSESSMENT

Introduction

To implement the Manitoba science curriculum and to ensure that students successfully master the learning outcomes, teachers must have a plan for instruction and assessment. Planning needs to take place at both the school and the classroom levels. As a community of learners, the school provides opportunities for staff and students to learn together. Communication among the teachers at various grades promotes the discussion of grade level learning outcomes, student progress related to those outcomes, and strategies for the continued success of all students. Without this communication, teachers are repeatedly starting over with each new class of students. School-based planning helps teachers to see the big picture: the role of science in the whole school and in the community. Using classroom-based assessments and any other testing/assessment tools that are available, teachers are able to see general strengths and weaknesses of both individual students and the programming.

Student learning outcomes assist teachers and other educators to

- plan learning activities that support student achievement
- establish goals for learning, instruction, and assessment
- monitor student progress in achieving learning outcomes
- communicate with students, parents, and guardians about student progress
- develop a science plan for a school

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 Middle 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 Teachers' 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, *Grades 5 to 8 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 Middle Years science classroom.

Planning a Balanced Science Program

Developing a balanced, integrated science program is a dynamic process. The program is shaped by the teaching style and resources of each teacher, by the interests and abilities of the students, and by the needs of the community.

Planning a balanced science program needs to take into account

- that specific learning outcomes stated are end-of-year learning outcomes. Students may achieve the learning outcomes at any time during the year.
- that learning is recursive and cumulative; many of the learning outcomes need to be addressed in different ways throughout the school year. Students need practice in many meaningful contexts to consolidate new knowledge, skills, and strategies.
- that planning is continuous, informed by ongoing classroom assessment
- that a variety of instructional approaches, classroom management techniques, assessment practices, tools, strategies, and problem-solving activities are essential
- that student grouping patterns should be varied: individual, pairs, small groups, large groups, whole class, heterogeneous, homogeneous, student-directed, teacher-directed
- that students have various learning approaches and multiple intelligences
- that students learn at various rates, necessitating pre-teaching, review, additional practice for some students, and/or challenging extension activities for others

Teachers strive for balance in their classrooms. The following diagram illustrates options to consider in planning instructional and assessment activities.

Planning to Ensure Balance*

explicit instruction	and	indirect instruction
interactive learning	and	independent learning
vicarious experiences	and	concrete experiences
teacher choices	and	student choices
teacher assessment	and	self/peer assessment
teacher talk	and	student talk

* **Planning to Ensure Balance:** Adapted from Manitoba Education and Training, *Kindergarten to Grade 4 English Language Arts: A Foundation for Implementation*. Winnipeg, MB: Manitoba Education and Training, 1997, p. 29.

Questions to Guide Results-Based Planning

1. *What do we want students to know and be able to do?*
   This question can be answered by reading the student learning outcome to determine the knowledge, skills, and strategies that it includes.

2. *What do students already know?*
   This question can be answered by having students work through learning activities that demonstrate their prior knowledge related to particular learning outcomes. Using strategies such as KWL Charts, word cycles, and concept maps would also help to provide information on prior knowledge.

3. *What instructional methods, materials, and strategies will help students develop these competencies?*
   These will be drawn from teachers' experiences, professional resources, or instructional suggestions provided in this document.

4. *What is the purpose for assessment? How will the assessment be used?*
   Various assessment audiences and purposes are suggested on page 29 and in the "Principles of Assessment" chart on page 29.

5. *What assessment tasks will allow students to demonstrate their understanding in authentic ways?*
   Assessment tasks will be drawn from teachers' experiences, professional resources, or suggestions provided in this document.

Phases of Learning

When preparing instructional plans and goals, teachers should consider three learning phases:

1. activating (preparing for learning)
2. acquiring (integrating and processing learning)
3. applying (consolidating learning)

These phases are not entirely linear, but are a useful way of thinking and planning. A variety of activating, acquiring, and applying strategies are discussed in *Success for All Learners: A Handbook on Differentiating Instruction* (Manitoba Education and Training, 1996). Many of these strategies have been incorporated into the suggestions for instruction and assessment provided in this document.

- **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 student learning occurs during the activating phase than at any other time. In planning instruction and assessment, teachers develop learning activities and select strategies for activating students' prior knowledge. These learning activities provide information about the extent of students' prior knowledge of the topic to be studied, and about their knowledge of and proficiency in applying skills and strategies needed for learning in this topic area.

  Prior knowledge activities include the following:

  — helping students relate new information, skills, and strategies to what they already know and can do

  — allowing teachers to correct misconceptions that might otherwise persist and make learning difficult for students

— allowing teachers to augment and strengthen students' knowledge bases in cases where students do not possess adequate prior knowledge and experience to engage with new information and ideas

— helping students recognize gaps in their knowledge

— stimulating curiosity, and initiating the inquiry process that will direct learning

- **Acquiring (Integrating and Processing Learning)**

  In the second phase of learning, students absorb 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 other sources.

  Because learning is an internal process, facilitating learning requires more of teachers than the simple presentation of 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, interviews, and examination of student work.

- **Applying (Consolidating Learning)**

  New learning that is not reinforced is soon forgotten. Teachers need to move students beyond guided practice and into independent practice. 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 or integrating what they have learned in one strand with other strands or subject areas, students strengthen and extend learning.

Planning for Instruction

The use of essential questions (Jacobs, 1997, Wiggins and McTighe, 1998) can be an important planning tool for teachers. Essential questions help to organize instruction and focus the science learning related to a specific cluster or combination of clusters. They allow teachers to group related learning outcomes and target key ideas. They lead to the selection of learning activities that will aid students in the pursuit of answers to the essential questions. This pursuit involves the skills and processes of Cluster 0: Scientific and Technological Skills and Attitudes and balances the knowledge component of the answer to the essential question with the skills and thinking involved in acquiring that knowledge. The benefits of planning based on essential questions are summarized as follows:

How Do Essential Questions Enhance Student Learning?

1. They motivate students and allow them to activate their thinking related to a cluster.
2. They focus student learning.
3. They allow students to have a variety of learning experiences that develop and reinforce key concepts/answers to a limited number of big questions.
4. They clarify what is expected of students (students must know the answer to the questions and be able to explain how they gained that understanding).

How Do Essential Questions Help Organize Instruction?

1. They focus instruction and create links among learning outcomes.
2. They highlight conceptual priorities related to the cluster.
3. They guide the design of learning experiences.
4. They can be sequenced so that they lead naturally from one to another.
5. They engage students in uncovering the important ideas at the heart of a subject.
6. They guide the design of assessment tasks that allow students to demonstrate their understanding of the cluster-related knowledge and skills.

Generally, two to five essential questions are required to address the learning outcomes related to a particular cluster. Teachers first must become familiar with the content of the clusters in order to group related learning outcomes and identify an essential question that would encompass them. There is no one set of "ideal" essential questions for any cluster. The questions must be shaped according to an individual teacher's way of thinking and relate to his or her students. Essential questions may also change and evolve over the course of study, or from one year to the next.

What Makes a Question an Essential Question?

1. It can and should be asked over and over.
2. It cannot be answered satisfactorily in one sentence.
3. It is provocative and multi-layered to reveal the richness and complexity of the subject.
4. It points to the key inquiries and core ideas.
5. It brings together the content from several learning outcomes.
6. It is understood by each student.

Teachers may choose to post the essential questions on their classroom bulletin board and construct the "answers" with students as they progress through a series of learning experiences. Sample essential questions from Grade 5, Cluster 4: Weather include:

- What is weather?
- How can we predict weather?
- How does weather affect humans and other animals?

These questions encompass the learning outcomes for this cluster on weather. Using these questions, a teacher can identify what student answers would look like upon completion of a unit of study (and confirm that the required learning outcomes would in fact be addressed) and identify what learning experiences the students would need to undertake in order to generate the needed answers. The essential questions would also guide the selection of assessment tasks that would allow students to demonstrate what they have learned and explain how they know what they know.

Planning based on essential questions represents only one possible approach to planning that teachers may use. It is important for teachers to develop a way of planning that suits their needs and results in the development of balanced, meaningful science programs.

Planning for Assessment

Assessment is a "systematic process of gathering information about what a student knows, is able to do, and is learning to do" (Manitoba Education and Training, *Reporting on Student Progress and Achievement*, p. 5). Assessment is an integral part of instruction that enhances, empowers, and celebrates student learning.

Meaningful Assessment

One purpose of meaningful assessment is to inform instruction by providing information about student learning. This information can then be used to provide direction for planning further instruction. Assessment should occur in authentic contexts that allow students to demonstrate learning by performing meaningful tasks.

Meaningful content and contexts for assessment help students by engaging their attention and encouraging them to share their work and talk about their progress. Students need to take an active part in assessment. When students understand assessment criteria and procedures, and take ownership for assessing the quality, quantity, and processes of their own work, they develop self-assessment skills. The ultimate goal of assessment is to develop independent, lifelong learners who regularly monitor and assess their own progress.

This evolving definition of meaningful assessment reflects changes in thinking that have taken place nationally and internationally. The following chart summarizes the changing emphases in assessment.

CHANGING EMPHASES*

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

The Teacher's Role in Assessment

In the classroom, teachers are the primary assessors of students. Teachers design assessment tools with two broad purposes: to collect information that will inform classroom instruction, and to monitor students' progress toward achieving year-end science learning outcomes. Teachers also assist students in developing self-monitoring and self-assessment skills and strategies. To do this effectively, teachers must ensure that students are involved in setting learning goals, developing action plans, and using assessment processes to monitor their achievement of goals. Teachers also create opportunities to celebrate their progress and successes.

Teachers learn about student learning and progress by regularly and systematically observing students in action, and by interacting with students during instruction. Because students' knowledge and many of their skills, strategies, and attitudes are internal processes, teachers gather data and make judgments based on observing and assessing students' interactions, performances, and products or work samples. Teachers demonstrate that assessment is an essential part of learning. They model effective assessment strategies and include students in the development of assessment procedures, such as creating rubrics or checklists.

Assessment Purposes and Audiences

The quality of assessment largely determines the quality of evaluation. Evaluation is "the process of making judgments and decisions based on the interpretation of evidence gathered through assessment" (Manitoba Education and Training, *Reporting on Student Progress and Achievement*, p. 39). Valid judgments can be made only if accurate and complete assessment data are collected in a variety of contexts over time. Managing assessment that serves a multitude of purposes and audiences is a challenging task. Teachers must continually balance the assessment of their students' progress in the development of knowledge, skills, strategies, and attitudes with the purposes and audiences for the information collected.

Principles of Assessment*
1. An Integral Part of Instruction and Learning Assessment . . . • is meaningful to students • leads to goal setting • fosters transfer/integration with other curricular areas and application to daily life • reflects instructional strategies used • uses a wide variety of strategies and tools • reflects a definite purpose
2. Continuous and Ongoing Assessment . . . • occurs through all instructional activities • occurs systematically over a period of time • demonstrates progress towards achievement of learning outcomes *(continued)*

Note: These principles of assessment apply to all subject areas.

*__Principles of Assessment:__ Adapted from Manitoba Education and Training, *Kindergarten to Grade 4 Mathematics: Classroom-Based Assessment*. Winnipeg, MB: Manitoba Education and Training, 2000, p. 3.

Principles of Assessment *(continued)*

3. Authentic and Meaningful Learning and Contexts

Assessment . . .

- focuses on connecting prior knowledge and new knowledge (integration of information)
- focuses on authentic problem-solving contexts and tasks
- focuses on application of strategies for constructing meaning in new contexts

4. Collaborative and Reflective Process

Assessment . . .

- encourages meaningful student involvement and reflection
- involves parents as partners
- reaches out to the community
- focuses on collaborative review of products and processes to draw conclusions
- involves a team approach

5. Multidimensional—Incorporating a Variety of Tasks

Assessment . . .

- uses a variety of authentic strategies, tasks, and tools
- is completed for a variety of purposes and audiences
- reflects instructional tasks

6. Developmentally and Culturally Appropriate

Assessment . . .

- is suited to students' developmental levels
- is sensitive to diverse social, cultural, and linguistic backgrounds
- is unbiased

7. Focused on Students' Strengths

Assessment . . .

- identifies what students can do and are learning to do
- identifies competencies in the development of knowledge, skills and strategies, and attitudes
- considers preferred learning approaches
- focuses on celebrations of progress and success
- provides for differentiation
- provides information to compare a student's performance with his or her other performances

8. Based on How Students Learn

Assessment . . .

- uses sound educational practice based on current learning theory and brain research
- fosters development of metacognition
- considers multiple intelligences and learning approaches
- uses collaborative and cooperative strategies
- considers research on the role of memory in learning
- reflects current models of learning

9. Offer Clear Performance Targets

Assessment . . .

- encourages student involvement (setting criteria, measuring progress, working towards learning outcomes and standards)
- encourages application beyond the classroom
- provides a basis for goal setting
- provides students with a sense of achievement
- provides information that compares a student's performance to predetermined criteria or standards

Purposes of Ongoing Assessment

Ongoing assessment helps teachers decide

- whether students have mastered certain learning outcomes
- whether they are making progress in attaining other learning outcomes
- which learning outcomes need to be the focus of further instruction and assessment
- whether instructional resources, activities, and strategies need to be adapted
- which tools would be most appropriate for assessment
- whether individual students need alternative learning experiences or further support

Formative Assessment

Formative assessment is data collected about the individual students and/or the whole group during classroom instruction.

Formative assessment is designed to guide instruction and to improve student learning. This is done by

- identifying specific learning needs
- providing feedback describing students' performance

The instruments used in formative assessment provide information or data that teachers, parents/guardians, and students may use to identify factors that facilitate or hinder student learning.

Possible assessment strategies/tools that can be used for formative assessment include:

- observations recorded on checklists or in teacher notes
- performance tasks with scoring rubrics
- diagnostic interviews
- group/peer assessments
- self-assessment
- paper-and-pencil tasks
- science notebooks

Note: "The thrust of formative assessment is toward improving learning and instruction. Therefore, the information should not be used for assigning marks as the assessment often occurs before students have had full opportunities to learn content or develop skills" (Manitoba Education and Training, *Reporting on Student Progress and Achievement*, p. 9).

Summative Assessment

Summative assessment (evaluation) is based on an interpretation of the assessment information collected. It helps determine the extent of each student's achievement of identified 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

Suggestions for Assessment

In *Grades 5 to 8 Science: A Foundation for Implementation*, a variety of assessment types and tools have been suggested. The intent is to reflect a variety of assessment practices and emphasize the need for frequent and varied assessment to gain information for formative and summative assessments. Teachers must be aware that the same tool may be used with different types of assessment, and to collect either formative or summative data.

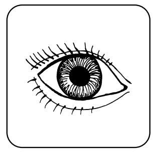
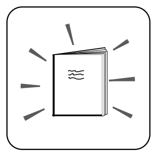
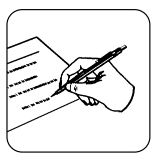
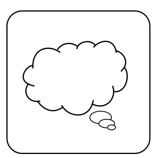
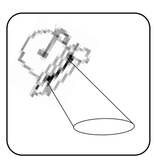
Assessment can take place during a learning experience through *observation*. Tools such as rating scales, checklists, and anecdotal records can help gather and record information. This type of assessment addresses the activating and acquiring stages of learning where group work or teacher-guided practice takes place. A teacher is looking for students to demonstrate a particular behaviour/skill and record its presence. A particular emphasis and/or group of students are usually identified as a focus for a particular observation period. Observational assessments are mainly used to assess process skills (scientific inquiry, design process, or group skills). A number of observations would need to be compiled in order to obtain a clear and accurate picture of student knowledge and skills.

Assessment tools that follow learning experiences allow students to apply knowledge gained or to reflect on the learning process. A *product or work sample* can be assessed through the use of tools such as rating scales, checklists, rubrics, and anecdotal comments. This assessment can be carried out by the student, by peers, or by the teacher. *Quizes and tests* (restricted response/extended response) can be used, accompanied by answer keys (for restricted response questions) or checklists and rating scales (for extended response questions). Short quizes are often used as Admit Slips or Exit Slips, to be given out at the beginning or the end of a class as a quick check of student understanding of concepts that have recently been introduced. *Reflection*, through the use of peer- or self-assessments, can allow students to reflect on the process and/or product. Reflective comments can also allow students to reflection on their own learning. Rating scales, checklists, and dialogues or interviews are useful tools in this area.

Performance tasks allow students to synthesize and apply a broad range of knowledge and skills gained through previous learning activities. They represent realistic tasks and result in a wide range of complex performances. The focus may be on a performance and/or a product. Rating scales or rubrics are used to assess the richness of the performance.

The following table summarizes the assessment types and tools used in the Suggestions for Assessment column.

Summary of Assessment Types and Tools

Formative or Summative Assessment (depending on stage of learning and purpose for assessment)		Learning Stage	Icon	Types of Assessment	Tools
	During the Learning Experience	**Activating** **Acquiring** **(group work or teacher-guided practice)**		**Observation** • to assess scientific inquiry skills, design process skills, group skills	rating scales, checklists, anecdotal records
	Following the Learning Experience	**Applying** **Reflecting** **(group, individual)**		**Product/Work Sample** • may be assessed by self, peers, and/or teacher	rating scales, checklists, rubrics, anecdotal comments
				**Quizzes/Tests** • may be restricted or extended response	restricted response: answer keys; extended response: checklists, rating scales
				**Reflection** • includes peer or self-assessment of the process and/or product, and general reflection on learning	rating scales, checklists, dialogue/interview
				**Performance Tasks** • synthesize a broad range of knowledge and skills from previous learning activities • focus may be on the performance and/or a product • result in a wide range of complex performances	rating scales, rubrics

Notes

Suggestions for Instruction, Assessment, and Learning Resources: Grades 5 to 8

Manitoba Education and Training
2000

SUGGESTIONS FOR INSTRUCTION, ASSESSMENT, AND LEARNING RESOURCES: GRADES 5 TO 8

Section Organization

The suggestions for instruction, assessment, and learning resources contained in this section of the document provide teachers with a foundation for implementing the student learning outcomes identified in *Grades 5 to 8 Science: Manitoba Curriculum Framework of Outcomes* (2000). This section of the Grades 5 to 8 document is organized by grade, each containing four clusters or thematic units, accompanied by blackline masters (BLMs) that are intended to support and enhance learning and assessment.

Guide to Reading the Four Columns

A two-page, four-column format is used for each grade:

- Column one cites the student learning outcome statements that define what students are expected to achieve at the end of each grade. They include the learning outcomes related to thematic clusters as well as learning outcomes related to Cluster 0: Overall Skills and Attitudes, selected to correspond to the suggestions for instruction.
- Column two contains suggestions for instruction directly related to the attainment of specific learning outcomes.
- Column three contains suggestions for assessing specific student learning outcomes.
- Column four cites suggested learning resources to support instruction and assessment.

Teacher notes providing background information and/or planning hints are incorporated in either column two or three.

The following pages provide further clarification on reading the four-column format and the specific learning outcomes.

Links to Supporting Resources

Suggested Learning Resources

The suggested learning resources contained within column four include student and teacher resources (print and multimedia) that were identified through a Manitoba Learning Resource Review, as well as additional items for teacher reference. A complete list and description of the recommended learning resources appear in *Grades 5 to Senior 1 Science Learning Resources: Annotated Bibliography: A Reference for Selecting Learning Resources*, published online at: <http://www.edu.gov.mb.ca/metks4/curricul/learnres/mr-1.html>. Learning resources selected in subsequent reviews will be posted at the same website. The learning resources may be ordered from the Manitoba Text Book Bureau (MTBB) online catalogue at: <http://edu.gov.mb.ca/metks4/curricul/learnres/mtbb>.

The suggested learning resources are intended to be a starting point for teachers in the selection of learning resources for their students and should be supplemented by locally selected items to support a resource-based learning approach.

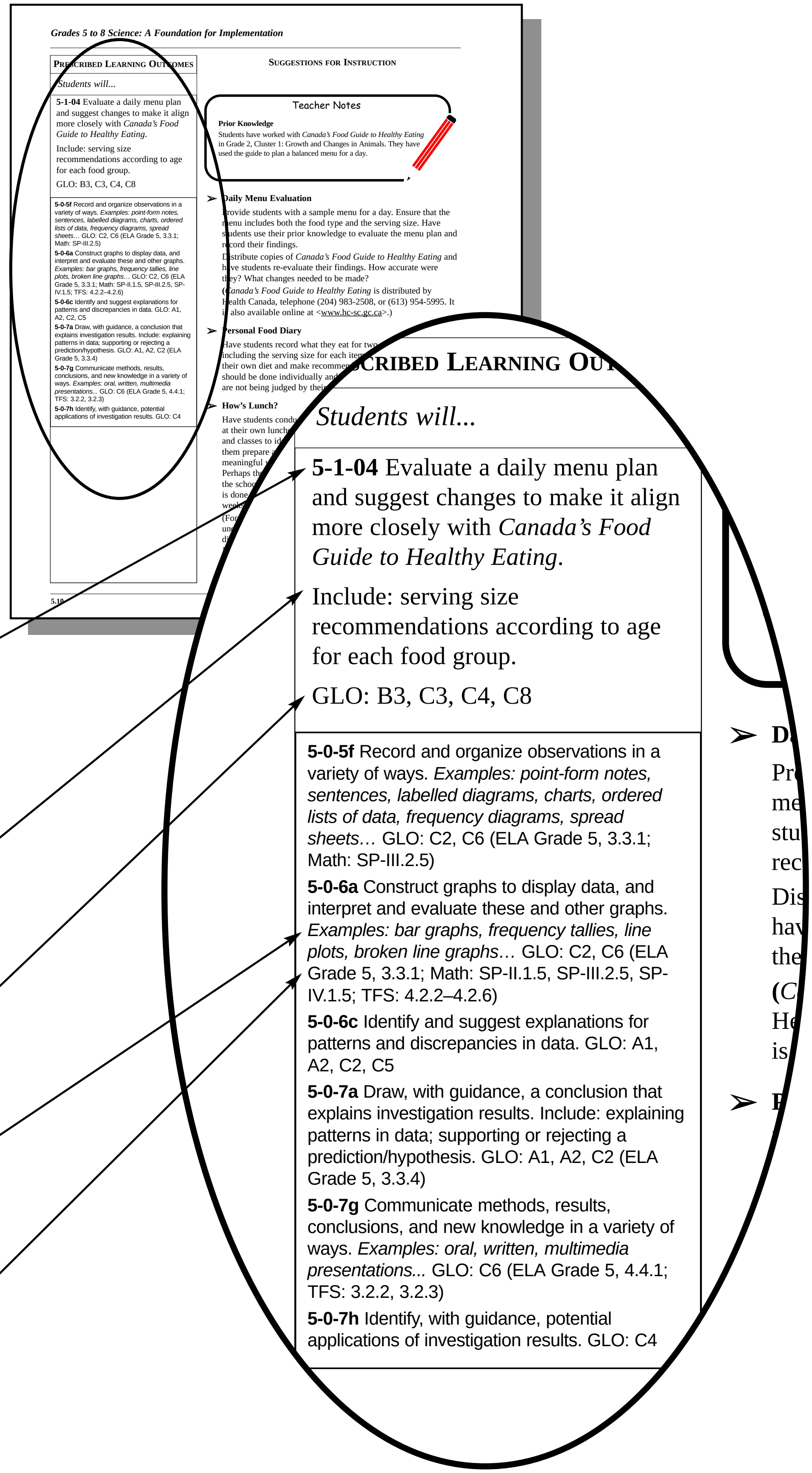
Other Links

Grades 5 to 8 Science: A Foundation for Implementation includes links to a number of related documents (see summary table below). Within Cluster 0: Overall Skills and Attitudes, cross-references are made to specific student learning outcomes identified in Manitoba's mathematics and English language arts curricula to facilitate curricular integration and the application of numeracy and literacy skills within a science context. Cross-references are also made to *Technology As a Foundation Skill Area: A Journey Toward Information Technology Literacy* (1998) to facilitate the development of skills related to information technology.

Within the suggestions for instruction and the suggestions for assessment (columns two and three), references are made to several other Manitoba Education and Training documents that provide strategies for learning, teaching, and assessment, and/or background information related to the suggested learning experiences or specific student learning outcomes. A summary of these documents and the abbreviations used (if any) is provided below:

Document Titles	Abbreviations
• *Education for a Sustainable Future: A Resource for Curriculum Developers, Teachers, and Administrators* (2000)	
• *Grades 5 to 8 English Language Arts: A Foundation for Implementation* (1998)	• *5-8 ELA*
• *Grades 5 to 8 Mathematics: A Foundation for Implementation* (1997)	• *5-8 Math*
• *Kindergarten to Senior 4 Physical Education/Health Education: Manitoba Curriculum Framework of Outcomes for Active Healthy Lifestyles* (2000)	
• *Native Studies: Middle Years (Grades 5 to 8): A Teacher's Resource Book* (1997)	
• *Native Studies: Middle Years (Grades 5 to 8): A Teacher's Resource Book Framework* (1997)	
• *Science Safety: A Kindergarten to Senior 4 Resource Manual for Teachers, Schools, and School Divisions* (1997)	
• *Senior 3 Agriculture: A Full Course for Distance Education Delivery, Field Validation Version* (1999)	
• *Senior Years Science Teachers' Handbook: A Teaching Resource* (1997)	• *SYSTH*
• *Success for All Learners: A Handbook on Differentiating Instruction: A Resource for Kindergarten to Senior 4 Schools* (1996)	• *Success*
• *Technology As a Foundation Skill Area: A Journey Toward Information Technology Literacy* (1998)	• *TFS*

Guide to Reading Specific Learning Outcomes



First digit indicates grade; second digit indicates cluster number; third digit(s) indicates specific learning outcome number

Include: Indicates a mandatory component of the specific learning outcome

Cross-reference to general learning outcomes (see Appendix A)

Example: Provides ideas of what could be included (non-mandatory)

Cross-reference to other areas: Math, ELA (English language arts), TFS (Technology As a Foundation Skill Area)

The Four-Column Format

Prescribed learning outcome statements that define what students are expected to achieve at the end of each grade

Suggestions for student learning experiences directly related to the attainment of specific learning outcome(s)

Teacher planning hints and/or background information on science concepts

Learning outcome(s) related to thematic clusters

Learning outcomes related to Cluster O: Overall Skills and Attitudes, selected to correspond to Suggestions for Instruction

Reference to other curricula/support documents to facilitate integration

Grades 5 to 8 Science: A Foundation for Implementation

PRESCRIBED LEARNING OUTCOMES

Students will...

5-1-04 Evaluate a daily menu plan and suggest changes to make it align more closely with *Canada's Food Guide to Healthy Eating.*

Include: serving size recommendations according to age for each food group.

GLO: B3, C3, C4, C8

5-0-5f Record and organize observations in a variety of ways. *Examples: point-form notes, sentences, labelled diagrams, charts, ordered lists of data, frequency diagrams, spread sheets…* GLO: C2, C6 (ELA Grade 5, 3.3.1; Math: SP-III.2.5)

5-0-6a Construct graphs to display data, and interpret and evaluate these and other graphs. *Examples: bar graphs, frequency tallies, line plots, broken line graphs…* GLO: C2, C6 (ELA Grade 5, 3.3.1; Math: SP-II.1.5, SP-III.2.5, SP-IV.1.5; TFS: 4.2.2–4.2.6)

5-0-6c Identify and suggest explanations for patterns and discrepancies in data. GLO: A1, A2, C2, C5

5-0-7a Draw, with guidance, a conclusion that explains investigation results. Include: explaining patterns in data; supporting or rejecting a prediction/hypothesis. GLO: A1, A2, C2 (ELA Grade 5, 3.3.4)

5-0-7g Communicate methods, results, conclusions, and new knowledge in a variety of ways. *Examples: oral, written, multimedia presentations...* GLO: C6 (ELA Grade 5, 4.4.1; TFS: 3.2.2, 3.2.3)

5-0-7h Identify, with guidance, potential applications of investigation results. GLO: C4

SUGGESTIONS FOR INSTRUCTION

Teacher Notes

Prior Knowledge

Students have worked with *Canada's Food Guide to Healthy Eating* in Grade 2, Cluster 1: Growth and Changes in Animals. They have used the guide to plan a balanced menu for a day.

➢ **Daily Menu Evaluation**

Provide students with a sample menu for a day. Ensure that the menu includes both the food type and the serving size. Have students use their prior knowledge to evaluate the menu plan and record their findings.

Distribute copies of *Canada's Food Guide to Healthy Eating* and have students re-evaluate their findings. How accurate were they? What changes needed to be made?

(*Canada's Food Guide to Healthy Eating* is distributed by Health Canada, telephone (204) 983-2508, or (613) 954-5995. It is also available online at <www.hc-sc.gc.ca>.)

➢ **Personal Food Diary**

Have students record what they eat for two or three days, including the serving size for each item. Have them evaluate their own diet and make recommendations for change. (This should be done individually and privately so that students' diets are not being judged by their peers.)

➢ **How's Lunch?**

Have students conduct a lunch-bag study that involves looking at their own lunches or the lunches of students from other grades and classes to identify what food groups are represented. Have them prepare a report with the data organized and displayed in a meaningful way, along with conclusions and recommendations. Perhaps the findings of the investigation could be published in the school newsletter and sent home to parents/guardians. If this is done, students could undertake another investigation a few weeks later to determine whether changes were made.

(For strategies and assessment suggestions to aid students in understanding the data collection process, grouping data, displaying data, and drawing conclusions from data, refer to *5-8 Math*, Statistics and Probability, pp. C-3 to C-15.)

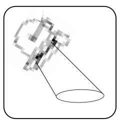
5.10

Suggestions for assessing specific learning outcome(s)

Suggested student learning resources and teacher support materials (print and multimedia)

Grade 5, Cluster 1: Maintaining a Healthy Body

SUGGESTIONS FOR ASSESSMENT



Menu Evaluation

Provide students with the following:

Menu Evaluation: Sam's Daily Menu

Breakfast:
- Frosted cereal
- Milk

Lunch:
- Soda pop
- French fries
- Chicken fingers
- Chocolate brownie

Supper:
- Potatoes
- Steak
- Mixed vegetables
- Pudding

Snack:
- Potato chips
- Soda pop

Look at Sam's menu for the day.

a. Is this a healthy diet?

b. If not, what changes would you recommend? Explain your thinking.

Look for:

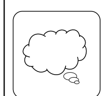
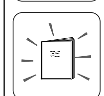
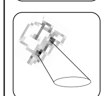
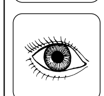
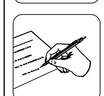
- Sam's breakfast is not balanced. He needs to have something from each food group.
- Sam's lunch has too many high-fat foods. He needs to add vegetables and dairy products.
- Sam's supper is balanced.
- Sam's snack is not nutritional. He needs to substitute fruit and milk or something comparable.

SUGGESTED LEARNING RESOURCES

Pan Canadian Science Place 5: *Body Works* (Lesson 3)

5.11

Icon indicating type of assessment:

Icon	Type
	**Reflection**
	**Product/ Work Sample**
	**Performance Task**
	**Observation**
	**Quiz/Test**

Icon (spiral coil) indicating assessment task, presented in a format suitable for student use

Notes