Using the Science and Math Skills Toolkit

The Value of the Science Skills Toolkit and the Math Skills Toolkit

The strategies described on the following pages complement the Science Skills Toolkit and the Math Skills Toolkit on pages 528–560 of the student textbook. They also provide strategies for using Safety in your Science Classroom, on pages xiv–xvii of the student textbook.

The skills component of the *ON Science 9* program will be critical to you as you successfully deliver the curriculum. Thus, you will find the Science Skills Toolkit and the Math Skills Toolkit at the end of the student textbook useful in providing students with the tools they need for further skills development (and remediation). They may refer to these tools throughout the program because they are built into the textbook as an integral part of instruction.

Each unit of the *Teacher's Resource* includes many useful ideas for your implementation. The skills development that your students will gain from using the Science Skills Toolkit and Math Skills Toolkit at the end of the textbook will provide students with further background and practice for the skills they are using. They will also remind students of the importance of the processes of science, and its effect on their lives, whether they venture on into a science and/or technology career focus, or in a totally different direction. All career paths and daily lives involve science and technology in some ways. This Toolkit will help you to integrate skills throughout your course that your students will find invaluable.

Safety in your Science Classroom, page xiv

This opening section presents safety labels and symbols, and encourages students to become familiar with the safety symbols used in *ON Science 9.* Students also review all WHMIS symbols.

BACKGROUND INFORMATION

- Safety symbols are a necessary common feature of science resources and appear on containers of materials used in the science lab, the workplace, and the home. These symbols help people of differing experience, knowledge, and language skills understand the risks associated with doing certain activities and using certain materials. As students learn about scientific inquiry and methods, they should become familiar with the symbols used in this book and with the labelling system of the Workplace Hazardous Materials Information System (WHMIS). They will encounter WHMIS symbols in this book and on containers of substances they use in the science lab and at work if they have jobs.

INSTRUCTIONAL STRATEGIES

- Provide time in class for students to read the safety rules on pages xiv and xv of the student textbook. Encourage students to ask about any rule that they do not understand. Incorporate these rules into your classroom rules and routines.
- Students can play a safety symbols card game (duration about 30 min) in small co-operative learning groups to reinforce the meanings of the WHMIS symbols on page xvii. During this game, you will act as a facilitator, encouraging students to understand the group task and functional criteria, and emphasizing the group's social roles and skills. Prepare cards by making copies of the WHMIS hazard symbols and

the descriptions. Cut them into similar sizes and stack them in piles, one pile each for symbols and descriptions. You may prefer making more copies of the cards to lengthen playing time and provide opportunities for the players to see each card more frequently. There should be equal numbers of symbols and descriptions.

To play the game:

1. Have students establish a working, co-operative learning group of four students.
2. The dealer places sixteen cards facing down on the table in four rows of four cards.
3. Each player is allowed to turn over any two cards.
4. If the two cards match (symbol on one and description on the other), the player keeps them. If additional cards have been prepared, the dealer can add two more cards to the grid, face down.
5. If the two cards that were turned face up do not match, they are turned back over, and someone else attempts to make a match.
6. The game continues until all cards are picked up.

ADDITIONAL SUPPORT

- DI The card game should be involving and rewarding for kinesthetic, non-verbal, verbal, and visual learners.
- Some students may wish to draw cartoon characters who warn about various hazardous situations.

Instant Practice–Safety Symbols, p. xvii

Answers will vary. For example, Skin Protection Safety, Clothing Protection Safety, and Eye Safety are all found in Plan Your Own Investigation 1-A. The fertilizer in the investigation can stain clothing, and harm eyes and skin. Electrical Safety is found in Inquiry Investigation 7-A. Students are cautioned to unplug the projector safely.

Instant Practice–WHMIS Symbols Answers, p. xvii

1. "Flammable and combustible material" and "Compressed Gas"
2. Answers will vary but may include:
   a. Hydrogen will ignite if it comes into contact with a spark. Hydrogen is under pressure and the container may explode if heated.
   b. Anyone working with hydrogen should take precautions to keep the container cool and not drop or bang it. They must also not allow any flames or sparks close to where they are working.
   c. Store in a cool place away from any possible sources of sparks.
   d. If the gas leaks, everyone should evacuate the area. If the container explodes, treatment for cuts and burns may be necessary.
3. More detailed information may be found in the Material Safety Data Sheet for hydrogen.

Further Practice

- You may wish to use BLM G-1, Safety Contract, and BLM G-2, WHMIS Symbols, with your students, depending on the needs you observe and the level of awareness and responsibility they demonstrate.

Science Skills Toolkit 1: Analyzing Issues–Science, Technology, Society, and the Environment, p. 529

This Science Skills Toolkit encourages students to think about how science and technology relate to the issues affecting society. Students learn to use science and the processes they are learning as they work through a decision-making model.

BACKGROUND INFORMATION

- Decisions about science and technology are often far reaching but are sometimes made without a clear understanding of what their effects (both positive and negative) might be. As members of society, students need to accept responsibilities for science-technology-society decisions. They need to learn to evaluate possible impacts of decisions on the world outside of the classroom. Examples of issues that may require society's decision-making skills include: deforestation, organ transplants from one species to another, cloning and genetic engineering, and the increasing use of fossil fuels.

INSTRUCTIONAL STRATEGIES

- Discuss the Science Skill scenario with the students. Have them compare the process that was followed with the steps in the model on page 529. What was the issue that was identified? How did the students go about finding their information? What alternatives did they consider?
- Suggest that students use the decision-making model to make a decision about any issue that affects their own lives by asking small groups of students to research and present the process they might take to make a decision about a societal or environmental issue. Have the students write a sentence to describe the issue and to indicate the nature of the decision. Have them write the questions they will need to answer in order to obtain the knowledge and background that will help them to suggest and evaluate alternatives. Ask them to give examples of each stage as shown in the diagram on page 529.
- Investigating an issue in their own community allows students to internalize science-technology-society-environment connections. Personal experience with such issues heightens awareness of the complexity of societal issues. Local issues enable students to appreciate the challenges that are encountered on a global scale. Whenever possible, draw in local examples with which students may have some first-hand experience.
- You may wish to distribute BLM G-6, Decision-Making Organizer, to help students develop decision-making skills.

Instant Practice–Making Societal Decisions, p. 531

Answers will vary but may include:

2.-3. Advantages of fossil fuel use

- Can be obtained from many areas of the world
- Still relatively inexpensive to obtain
- Can be used in electricity production
- Distribution network is extensive
- Helps countries improve their economies

Disadvantages of fossil fuel use

- Responsible for global warming
- Can result in pollution of land, water, and air (oil spills)
- Gases produced are thought to be responsible for increased respiratory illnesses
- Is a non-renewable resource

4.–5. Discussion will vary and can get spirited!

6. Some examples of alternatives are wind power, fuel cells, solar cells, solar power, nuclear power, biomass power, and tidal power. Advantages and disadvantages will vary for each. For example:

Advantages of nuclear power
- Technology is fairly advanced, with many built-in safeguards
- Produces large amounts of clean electrical power
- Fuel is relatively plentiful and long lasting

Disadvantages of nuclear power
- High cost of building a reactor
- Spent fuel rods take thousands of years to become less radioactive (few places to store)
- Possibility of reaction resulting in radioactive material release

Science Skills Toolkit 2: Scientific Inquiry, p. 532

Science Skills Toolkit 2 provides students with insight into the nature of science and, in particular, the methods of inquiry by which scientific knowledge is developed and validated.

BACKGROUND INFORMATION

- All scientific disciplines and specializations share one characteristic: they are based on an orderly, systematic process for asking questions and developing explanations for natural phenomena. The process is not a recipe, but it has several important features. The process is often more cyclical than linear and conclusive. For example, an experiment or investigation often stimulates new questions to explore.
- The *ON Science 9* program develops the process of science inquiry as an inherent part of the flow, sequence, and emphasis of the text and activities. Questions are stressed as the starting point for all science.
- Hands-on activities provide students with opportunities to develop inquiry skills with concrete problems and materials. Students reinforce and build upon the basic concepts covered by the text through investigation, observation, experimentation, and critical thinking about, and application of, results. Students are encouraged to evaluate not only their experimental results but also their experimental process.
- **Prediction vs. hypothesis:** A prediction is a statement of likely changes to a responding variable as a result of changes (forced or natural) in a manipulated variable. A hypothesis usually adds a possible reason for this relationship. For example, "If heat causes particles to vibrate more vigorously, then increased temperature will cause the rate of the reaction to increase."
- Scientists gain empirical support for their predictions and hypotheses through *experiments*.
  – An experiment is a test in which a manipulated variable is forced to change in order to detect a predicted result.

– Although data-collection is important for establishing relationships and laws, the usefulness of particular models and theories for explanations is always debated by scientists. Constant evaluation and re-evaluation in terms of new data is important. Data that disprove theories are just as important as, or more important than, data that support current thinking.

INSTRUCTIONAL STRATEGIES

You may wish to reinforce students' understanding of the stages in the science inquiry process with further elaboration and discussion. Summarize the process by breaking it into three stages:

Developing Ideas (i.e., devising predictions and hypotheses from observations and by learning from others),

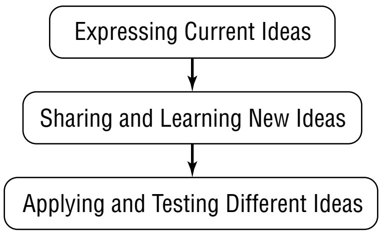
- Help students distinguish between a prediction and its hypothesis by having them consider what might happen to the drop speed of three balloons, each inflated to a different diameter (and knotted).
- Work with students to develop a prediction and hypothesis using the model sentence: As the diameter of the balloons increases, the drop speed will [class predicts a result], because [class suggests a hypothesis].

Seeking Empirical Support (i.e., conducting experiments and studies),

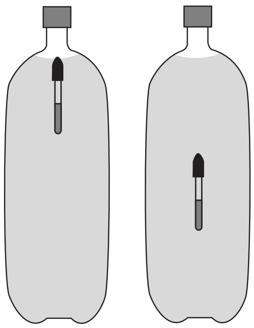
- BLM G-19, Variables in Science, can help students understand manipulated, responding, and control variables.
- Point out to students that observing—and every other stage in science inquiry—is based on or limited by some kind of theory. For example, observations cannot be made without some ideas in mind about how to interpret stimuli (i.e., sights, sounds, and so on). When we see a burner glowing red, we understand that it is hot. When we see leaves on a plant that are dry and brown, we understand that they are dead.
- Ask a few students to demonstrate the test for the class, having others record data.

Communicating (i.e., publishing articles, giving lectures, presenting findings at conferences and scientific publications).

- Help students create a graph to show their results, such as a point-and-line graph. Students can use BLM G-25, Constructing a Line Graph, for support constructing a line graph, or refer to Math Skills Toolkit 3, Organizing and Communicating Scientific Results with Graphs.
- **Practice with Science Inquiry:** A three-phase approach will help teachers and students explore the nature of science throughout this program. Generally, students will already have some preconceived notions about the nature of science, along with preconceived notions about laws and theories. These preconceived ideas should be expressed by students before they share and learn new ideas about the nature of science. Then, once they have a number of ideas available to them, they should have an opportunity to apply and test them in authentic problem-solving contexts.



- The "Cartesian Diver" demonstration will help you illustrate the science inquiry approach to questions and problems:
  - Almost fill a 2 L plastic pop bottle with water.
  - Drop in an eye dropper that is about half-filled with water, and tighten the cap on the bottle. The eye dropper should float at the top and drop down as the bottle is squeezed.



  – With one hand, hold the bottle up in front of your face and pretend to "force" the eye dropper to move down by moving a plastic pen (that you have rubbed on your clothing) along the edge of the bottle as you gently (and secretly) squeeze the bottle.
  – Ask students what they observe. Students often move directly to hypothesizing. They may say, "The pen is magnetized and is forcing the eye dropper to move." Work with the class, getting them to direct you to try different tests until they determine that pressure is the cause.
  – Point out how it is common to go through this sequence: observe, question, hypothesize, predict, test, communicate.
- Encourage students to conduct their own tests. Start by showing them an inflated balloon flying around the room when you release the untied end.
  - Ask students what they could do to get the balloon to go farther or to do more loops. Get them to brainstorm some manipulated and responding variables. Ask students to predict what might happen to the balloon if a variable is changed. Ask them to give a reason for their prediction.
  - Then, ask students to form small groups and design a test that may give them evidence to support their ideas. Ask them to record their ideas and give reasons for their decisions.
  - Once student groups have completed their tests, invite them to share their inquiry ideas and test results with the class. Encourage a discussion about the different inquiry approaches. Have students note (if appropriate) that each group had its own way of doing things and wanted to defend its methods and conclusions. This will help you stress the creative, very human aspect of science that may include "more than one right answer" when it comes to designing an approach to a problem.

Instant Practice–Making Qualitative and Quantitative Observations Answers, p. 533

1. **a.** Qualitative
   b. Quantitative
2. **a.** Qualitative
   b. Quantitative

3. a. Qualitative
   b. Qualitative
4. a. Qualitative
   b. Qualitative
5. a. Qualitative
   b. Qualitative
6. a. Qualitative
   b. Quantitative

Instant Practice–Stating an Hypothesis Answers, p. 533

Answers will vary but may include:

1. If heat causes water to change state from solid to liquid to gas, then raising the temperature of water will cause it to change state.
2. If carbon dioxide has the greatest impact on atmospheric heating then a container filled with carbon dioxide should, heat up more when exposed to sunlight than containers filled with other atmospheric gases.
3. If the length of duration of battery life is unaffected by the device, then the same type of battery placed in different electronic equipment should all die at the same time.
4. If honey bee visits are affected by the colour of the flower, then the visit count should be different for each pot containing flowers of a different colour.

Instant Practice–Identifying Variables Answers, p. 534

1. Control: light through air from a ray box
   Manipulated variable: the material that the light is shone through such as water, plastic, glass, etc.
   Responding variable: angle that the light refracts by
2. Control: vegetable plant in potting soil
   Manipulated variable: vegetable plant potting soil with compost added to it
   Responding variable: growth of plant
3. Control: arm with no repellent
   Manipulated variable: arms covered with different types of repellent
   Responding variable: number of bites/landings

Science Skills Toolkit 3: Technological Problem Solving, p. 536

In Science Skills Toolkit 3, students learn what technology is and how it can be used to solve problems. They are given the opportunity to solve a problem, using a problem-solving process.

BACKGROUND INFORMATION

- Many people believe that technology develops from science. Indeed, scientists who do pure research often try to turn the knowledge into a usable product. This is the concept that science creates technology. Examples of such inventions are superconductors and computers, electrical impulses and virtual reality games, Teflon™ plastic and non-stick cookware, and chemistry and contact lenses.

- Yet technology can also drive science. For example, science has often been limited by technology. The discovery of the composition of Earth has parallelled the development of technology. The seismograph was invented to measure the magnitude of an earthquake.
- You might caution students about some of the problems that can result from using technology without understanding the science that informs the technology. You could argue that environmental problems have developed due to the application of technologies without fully understanding the science. The internal combustion engine has led to countless problems such as ozone depletion, smog, and the extinction of organisms due to spin-off environmental stresses.

INSTRUCTIONAL STRATEGIES

- Begin the lesson by presenting the class with a personal entertainment or communication item (e.g., hand-held electronic game, cell phone, MP3 player, portable CD player) and tell students it does not work. Have students describe what they would do to solve the problem. They could work in small groups for this exercise. Ask students to record their *approach* to solving the problem. What should they do first? Next? How do they conclude their problem-solving process? How do they evaluate their ideas?
- Conclude by referring to the diagram on page 536, Solving Technological Problems. Have students compare their process to the model to find similarities and differences. A class discussion of similarities and differences might be the most effective way to engage students in this problem-solving model.
- Ask students to compare the processes involved in science and technology by listing five steps that a scientist and an engineer might take as each worked with some objects and events such as water, buildings, or earthquakes. Ask students to then describe how the empirical tests conducted by scientists and technologists compare.
- Ask students to collect 10 newspaper or magazine articles dealing with science or technology and complete an analysis of whether the article deals with one or both fields.
- If possible, invite scientists and technicians (such as an engineer) to visit the class and talk about their work.
- Students could research a variety of technologies and try to determine the problem that resulted in the technology. Encourage them to consider how well the technology has solved each problem. If the technology has led to further problems, have them discriminate between technology as the problem and human use of it (e.g., the internal combustion engine would not be a problem if used judiciously; it becomes a problem when people base their lifestyle on it).
- Ask students to explain how their use of the computer makes them technologists.
- Have students describe how the telephone book and/or an Internet search engine are examples of information technology.

Science Skills Toolkit 4: Estimating and Measuring, p. 538

This Science Skills Toolkit provides information about the purpose of estimating and measuring (area, volume, and mass) and provides opportunities for students to practise these skills.

BACKGROUND INFORMATION

- Estimating, as defined here, is essentially simple sampling. Sampling involves techniques that are used to obtain a statistically significant (accurate) estimate of a total population size (total number of individual items) when counting the entire population is impractical or impossible. **Note:** Multiple samples should be used in any estimation and the results averaged so as to increase the reliability of the sampling.
- The skill of estimating is useful in social sciences when surveys are conducted on percentages of the human population and the results are extrapolated to the rest of the population. The technique is also very important in the physical sciences. Populations of organisms (and objects) can be estimated fairly accurately.

INSTRUCTIONAL STRATEGIES

- Encourage students to express their understanding of how to estimate and measure. If time allows, having the students demonstrate their own methods would set up a comparison to the methods described here. Let the students draw their own conclusions as to the efficiency and accuracy of any method.
- You may wish to distribute BLM G-27, Estimating, to help students practise estimating measurements for science.
- When students measure the size of angles in situations involving light rays, it is preferable that the apparatus be set up on a sheet of paper. While the light is still on, the students should mark the position of the incident ray and reflected (or refracted) ray(s) using a pencil directly on the paper. Two marks should be drawn for each ray and the position of all apparatus noted as well. After the apparatus is removed, the students should be able to use the marks to complete the drawing (using a ruler) and measure the needed angles from the drawing.
- While it is tempting to set up a number of stations for students to rotate through while practising the methods described here, it is more appropriate to refer to them when each technique is needed for the particular investigation that is to be carried out. In this way, the relevance of the methodology is immediately apparent. Whether you decide to provide work stations or refer to estimating and measuring techniques only when students actually need them, provide opportunites for students to attempt the estimation or various measurements a number of times using different samples and materials.

ADDITIONAL SUPPORT

- Most students will have little difficulty with the skills outlined here. Break up the skill set for those who cannot acquire the skills easily, and supplement it with additional opportunities to practise the acquired skills when appropriate to the investigations planned.
- Provide challenges for students who have no difficulties with the concepts and skills taught in this section. Ask them to devise methods to estimate or measure in increasingly difficult situations, such as gas production of water plants or yeast cells, moose populations in aerial photographs of central Ontario or fish populations in fast-flowing streams that have been sampled by nets strung in certain places.
- Provide an opportunity for students to complete the Instant Practice on page 480. This will give you an opportunity to observe where individual students run into difficulty so that you can give them help and extra practice.

INSTRUCTIONAL STRATEGIES

- Go over the examples given on page 538 of *ON Science 9,* to ensure that students understand how to measure length and how to calculate the area of a square and a rectangle. Provide further examples for any students who have difficulty.
- Have students complete the Instant Practice on page 538. Identify any students who are unable to complete the questions, and provide support, such as carrying out the practice with a classmate who has strengths in this area.

Instant Practice–Estimating and Measuring

Answers, p. 480

1. Estimates will vary. For example, 3.5 × 4.0 toothpick units.
2. Answers will vary. For example, 5.0 × 3.5 toothpick units. This is the same width as my estimate, but 1 toothpick longer.
3. Answers will vary. For example, hockey sticks, length of a leg, or a piece of stiff wire
4. Answers will vary and are dependent on what students choose in question 3.

INSTRUCTIONAL STRATEGIES (Measuring Volume)

- Go over the material presented on pages 539–540 of *ON Science 9,* making sure that students understand the terms and that they understand the importance of measuring from the lowest level of the meniscus.
- Through discussion, elicit from students the reason for using the liquid displacement method for finding the volume of an irregularly shaped object. Have them complete the Instant Practice on page 540. In small groups, have students measure several irregularly shaped objects. Each student should have an opportunity to measure the object and then share his or her findings.

Instant Practice–Measuring Volume Answers, p. 540

A. 73 mL

B. 18.0 mL

C. 650 mL

INSTRUCTIONAL STRATEGIES (Measuring Mass)

- Students are probably familiar with using balances to measure mass, so it is simply a matter of ensuring that they are familiar with the type of balance used in your school and that they learn how to handle it carefully.
- Ask students if they are familiar with the question "Which is heavier, a kilogram of lead or a kilogram of feathers?" Although it is tempting for students to say that the lead is heavier, if the measure is the same the mass of the two substances is the same. Have students complete the Instant Practice on page 540.

Instant Practice–Measuring Mass Answers, p. 540

The mass of the table salt is 70 g.

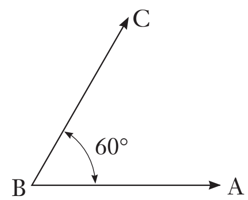
INSTRUCTIONAL STRATEGIES (Measuring Angles)

- Students may have little or no experience with protractors but will probably enjoy using them. If any students have difficulty using their protractors, a few extra practice examples should solve the problem. If you see students who seem unsure of what they are doing, provide more examples of angles to give them more practice in identifying existing angles before they go on to draw angles of their own.
- Provide an opportunity for students to do the Instant Practice on page 484.

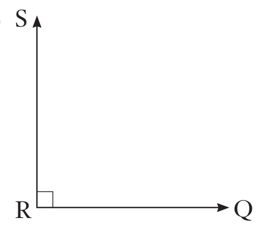
Instant Practice–Measuring Angles Answers, p. 484

1. **a.** 70°
b. 160°
c. 70°
d. 95°
e. 120°
f. 180°
g. 80°
h. 150°

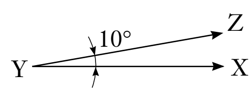
2. **a.**



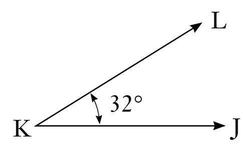
b.



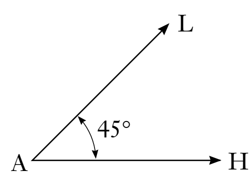
c.



d.



e.



INSTRUCTIONAL STRATEGIES (Measuring Temperature)

- Go over the material on page 541 of the textbook, ensuring that students understand how to properly use and read a thermometer.
- Since students should be very familiar with thermometers, no Instant Practice exercises have been provided. Draw students' attention to the tips on page 541, and provide time to discuss the reasons for tips second and third (the thermometer is too delicate to use as a stirring rod; a false reading could be obtained if the thermometer bulb touches the walls of a container).

ASSESSMENT

- Performance tasks involving the estimating and measuring of similar materials can be used to assess how well students have learned these skills. The performance tasks should parallel the type of work done by the students during the formative learning of this material.

Science Skills Toolkit 5: Precision and Accuracy, p. 542

This Science Skills Toolkit will help students to identify and understand two of the causes of experimental errors.

BACKGROUND INFORMATION

Some errors in experiments are caused by making incorrect assumptions, by forgetting a step in a procedure or a calculation, or by other errors of judgement. These can be prevented by careful planning and careful execution. There are two causes of error, however, that are inherent in any experiment. These are caused by the precision and accuracy that the measuring tools we use allow us to have.

- Precision refers to the exactness of a measure. A bathroom scale allows us to see our mass to the nearest kilogram, or perhaps to estimate to the nearest half of a kilogram. A sensitive electronic laboratory scale, however, allows students to measure chemicals to the nearest 0.1 g, or the nearest 0.0001 kg. This scale allows for more precise measurements. Similarly, a metre stick calibrated in centimetres does not allow for measurements as precise as those obtained from a metre stick that is calibrated in millimetres.
- Accuracy refers to the consistency of measurements. If you placed a reactant for an experiment on a laboratory scale five times and obtained measurements of 12.4 g, 12.3g, 12.5 g, 12.7 g, and 11.9 g, you would not think the scale was very accurate. No matter how precise the measurement, the lack of accuracy would impede your experimental results.
- Both precision and accuracy are important considerations in analyzing the results of an experiment. It is advantageous for students to use tools that allow for as much precision and accuracy as possible, but it is often more important for them to be aware of the precision and accuracy they are working with, when it comes time to analyze their results.

INSTRUCTIONAL STRATEGIES

- To help students understand the role that precision plays in determining scientific results, give pairs of students a metre stick (or a strip of paper 1 m long) that is calibrated only in decimetres. Ask them to use it to find the length, width and area of their desk, or of a table in the classroom. Once they have done that, give them a metre stick calibrated in millimetres and ask them to use that to find the length, width, and area once more. Then discuss their experience with them. Ask:
  - What were the challenges in using the first measurement tool?
  - What were the advantages of using the second tool?
  - When might the first tool be precise enough?
  - In what situations might you need a tool even more precise than the metre stick calibrated in millimetres?
  - What difference do you think a more or less precise tool could have made to an experiment you conducted recently?

- To help students understand the role that accuracy can play in determining scientific results, give pairs of students a strip of elastic that is 1 m long. Ask them to use the metre stick to mark decimetres on their elastic, then use it to measure the distance across the classroom. Have them measure and record the distance three times. Then discuss their experience:
  - How similar were their three results?
  - If their results were not very similar, why do they think this was?
  - How confident are they about the real width of the classroom?
  - What was it about their tool that did not allow them to obtain accurate results? (It stretched, decimetre markings may have been thick, they had to judge where to put the elastic down to measure each metre.)
- As an extension, challenge students to develop demonstrations of precision (or lack of precision) and accuracy (or lack of accuracy) using other measuring tools, for example, balances, thermometers, and angles.

Instant Practice–Precision and Accuracy Answers, p. 542

1. If the student used the same thermometer for each measurement, the thermometer is precise, because it always gives the same reading, but it is not accurate, since we know the temperature of ice water is 0°C.
2. Student A had the more precise scale, since the range of measurements Student A obtained was less.

Science Skills Toolkit 6: Scientific Drawing, p. 543

Science Skills Toolkit 6 leads students through the important points they need to know about producing clear, accurate scientific drawings.

BACKGROUND INFORMATION

- From the earliest times, people have used diagrams to record knowledge about the human body, celestial movements, and mechanical devices. As time and technology progressed, the quality and detail of these diagrams steadily improved. Today's high-technology image-capturing tools enable us to construct diagrams of vastly improved quality and to record images and share knowledge quickly and easily.
- When people are not able to communicate using the same language, we often use diagrams and other non-verbal methods to do so. We may "talk with our hands" to give added meaning to our words. We may draw pictures.
- Diagrams in science are inferences of what researchers believe they observe. As much as possible, the investigator should avoid adding misleading information such as colour, or other artistic interpretations or representations. While these details have meaning for the researcher, they may be unclear to others. However, some latitude can be allowed on such additions as stippling if the teacher, class, or research group concur that it helps to clarify the diagram. Finally, diagrams are the researcher's scientific evidence. As such, they should be neat and formatted as described in the checklist shown below.

INSTRUCTIONAL STRATEGIES

- Initiate a discussion or have students brainstorm reasons why a scientific drawing requires a prescribed format. This could be modified with other groups playing "devil's advocate," (someone who takes a position he or she disagrees with for the sake of argument) brainstorming arguments against formatting. The groups of protagonists could then pair up and debate their group's view.
- As a group, develop potential parameters for science diagrams prior to exposing the students to the "official" view.
- Outline the requirements for a science diagram for students by presenting a checklist similar to the one provided below.

Checklist for Science Diagrams

On unlined white paper. Title is underlined.	1 1	/2
Diagram fills page. Diagram is neat. Diagram is in pencil.	0 1 2 0 1 2 1	/5
Labels are on right side of diagram. Labels are neat. Labels are in ink. Labels have horizontal (vertical where applicable) lines.	1 1 1 1	/4
Diagram summary present and good quality	0 1 2	/2
Magnification stated correctly Magnification positioned correctly in lower right-hand corner	1 2	/2
	Total	**/15**

You could present students with a series of diagrams that have certain components missing (titles, labels, description or summary, magnification) or that are poorly represented (e.g., coloured diagrams; labels on left; diagrams or labels using ink, lead, or coloured pencil inappropriately; poor descriptions or summaries). To assist students in their critical analysis, you might provide a checklist similar to the one shown above for students to use in evaluating the diagrams you have provided or any that they produce.

- Go over the steps in Making a Scientific Drawing with students and check that they understand by asking simple questions such as "Why is it a good idea to use unlined paper?" "Why should you use a pencil?" "Why is it not a good idea to make a very small scientific drawing?"
- Go over the steps in Drawing to Scale with the students, and have them examine the illustration in the right-hand column on page 478 of *BC Science 9*.
- You may wish to distribute BLM G-7, Scientific Drawing Checklist, or BLM A-25, Scientific Drawing Rubric, to help students assess their own drawings.

ADDITIONAL SUPPORT

- Students who require support with written or oral language might be more successful in learning from diagrams so they should be encouraged to develop skill in this area.

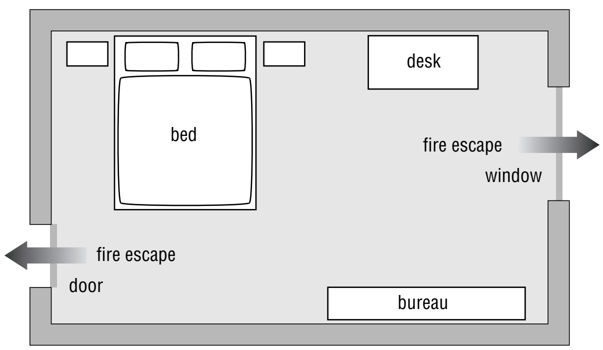
- The checklist could be used to indicate areas of concern about students' diagrams without generating a grade. The assessed work could then be returned to students for further attempts until students have overcome their difficulties.
- Students who are having particular difficulties could work with a classmate. Each could evaluate the other's diagrams, so that appropriate adjustments, based on the peer evaluation, could be made prior to final submission.
- Using the checklist, students could evaluate their own work, comparing it to a drawing that you provide. Students could then defend their grade. The "defence" may provide insight into any difficulty students might be experiencing.

Ideas for Communicating

- Students could generate a booklet of diagrams from a series of observations of various events. One of the diagrams could be turned into a poster, either by the student or teacher (on an enlarging photocopier), to display and share with the class as exceptional work or to illustrate a course theme.
- Students could attempt to record all work in their science logs as a series of pictograms for a certain period of time.

Instant Practice–Scale Drawings Answer, p. 478

Answers will vary, but may include:



Example scale: 1:50 (cm)

Science Skills Toolkit 7: Creating Data Tables, p. 545

Science Skills Toolkit 7 will help students to organize data into tables for effective communication of scientific results.

BACKGROUND INFORMATION

- Organized data make it easier for others to understand the results of an investigation and also give the researcher credibility.
- Simple tables have columns with heads that show what is being recorded and rows with heads that show data items. It is acceptable to reverse the function so that columns are used for data items and rows are used for what is being recorded, in order to make the table fit a horizontal or vertical format.
- More complex tables, like the one on page 545 of the student textbook, subdivide the rows or columns to include subcategories of data.
- Word processing software or spreadsheet software provide good templates for data tables, allowing students to add or subdivide rows or columns, and to revise data, without having to recreate the table.

INSTRUCTIONAL STRATEGIES

- Show examples of tables from newspapers or magazines. Discuss them with students, asking students to interpret the data in each one, and to comment on the effectiveness of the presentation.
- Divide students into small groups, and have each group design a table that they could use to record the number of dandelions growing in six different sections of the school yard. Invite groups to share their results, and comment on why they set up their table as they did.
- Then ask each small group to design a table that they could use to record data from the investigation described on page 545 of the student textbook: an investigation of the water quality of a stream. Samples will be taken at three different locations. At each one, the numbers and types of organisms will be recorded, as well as the pH. Invite groups to share the table they created and explain why they set it up as they did. Have students compare their tables with the one on page 545 and discuss similarities and differences. What makes the table on page 545 effective for this data? What makes their table effective?
- For students who are not familiar with creating tables on the computer, use a projector to demonstrate how to create and customize tables using word processing or spreadsheet software.
- BLM G-23, Data Tables provides templates for some simple tables for students working by hand who require support.

Instant Practice–Creating Data Tables Answers, p. 545

1. Answers may vary, but could resemble the table shown on page 545. Headings would be: "Week," "Type of Weed," and "Number of Weeds."

2.

Day	Plant	Amount of Fertilizer	Height of Plant
1	Plant 1	5 mL	5 cm
2	Plant 2	10 mL	10 cm
3	Plant 3	15 mL	15 cm
4	Plant 4	20 mL	20 cm

Students may report that they heights of the plants cannot be recorded without seeing the actual data.

Science Skills Toolkit 8: Using a Microscope, p. 546

Science Skills Toolkit 8 acquaints students with the various parts of the light microscope and with its use and care.

BACKGROUND INFORMATION

- There are many types of microscopes used to study micro-organisms. The microscopes used in classrooms are usually compound light microscopes. These microscopes usually have better illumination than microscopes used with mirrors, although their power of resolution can be inadequate. Resolution of a microscope is the ability of the instrument to separate and distinguish details between two objects. The light microscope used in class frequently cannot resolve detail finer than the size of a small bacterium (0.20 μm). Increasing the magnification to a maximum of 1500 times will only increase the blurriness. Modern light microscopes have improved the quality of the image but not the resolution. The ability to study cellular organelles is still limited by the wavelengths of light. Vast improvements in cytology (study of cell biology) were aided by the arrival of the electron microscope. Modern electron microscopes can achieve a resolution about a thousand times better than light microscopes.

INSTRUCTIONAL STRATEGIES

- To help students to appreciate how delicate and precise a microscope is, engage them in a discussion about cameras and their photographic capabilities. It should quickly become clear that the better and more capable a camera, the more care and cost go into constructing it and the more delicate the interior mechanism. Students can reflect on how much more is involved in building an instrument that can view objects as clearly and precisely as the microscope can.
- You may wish to use an overhead transparency of a light microscope (e.g., BLM G-20, Parts of a Microscope) and have students point out the various parts and describe what they do. Students may create a table, titled "The Compound Light Microscope," with two columns, headed "Part" and "Function," and then enter the following subtitles: tube, eyepiece or ocular lens, objective lens, revolving nosepiece, arm, coarse- and fine-focus knobs, light source, stage, diaphragm, etc. Encourage students to use any strategy that helps them become more familiar with this instrument.
- Have students complete the Instant Practice on page 547 of *ON Science 9.* While students are explaining the parts of the microscope, observe the interaction between students and examine their drawings to see how well they have absorbed the information.

TROUBLESHOOTING

- Following are common microscope problems encountered by students and how to deal with them.

  Problem: The field of view is small and dark.
  Solution: Check the diaphragm. Ensure that the correct aperture is open.
  Problem: The image seen in the microscope is too large (i.e., it is outside the field of view).
  Solution: Change to the lower objective lens to bring the desired section into the field of view.
  Problem: The image cannot be seen well.
  Solution: Start with the low-power objective lens. Once the image is obtained and focussed in the low-power lens, students can move to a higher power without damaging the specimen or the lens.
- Additional troubleshooting tips:
  - When moving to the next higher objective lens, make sure students do not adjust the coarse adjustment knob once the microscope is focussed at low power. There is a chance that the objective lens will crash into the specimen slide. The image should be adjusted with the fine-adjustment knob.
  - Ensure that students use the stage clips to hold the specimen slides.
  - When changing the objective lens, have students pay attention to the lens as it moves into the lens groove and clicks into position. Remind them to listen for or feel the click.

- If there is any malfunction (e.g., poor focussing, loose knobs), remind the students that they must inform you; they should never try to repair any part of the microscope themselves.
- Remind students to report all damages and injuries to you (or to the teacher in charge).

Science Skills Toolkit 9: Using Electrical Circuit Symbols and Meters, p. 548

Science Skills Toolkit 9 provides information about circuit symbols and the correct use of electrical meters. Students are provided with the opportunity to draw circuit diagrams, identify the correct placement of meters, and practise reading an analogue meter.

BACKGROUND INFORMATION

- Circuit diagram symbols are a common method of simplifying a complex electrical circuit. Circuit symbols provide an international language when conveying information about circuits. Most of the symbols resemble the actual electrical component they represent. The long (+) and short (−) posts on the cell symbol represents the two dissimilar metals in the cell. The battery, which contains more than one cell, is therefore symbolized by several cells connected together. Traditionally, chemical cells had a maximum potential difference of around 1.5 V so a 6.0 V battery would be symbolized as four cells connected together. Modern technology has produced chemical cells that can produce more than two volts. Because of this, it is difficult to predict how many cells are in a modern battery. It is now acceptable to draw the battery symbol as a single cell and simply write the total battery voltage beside the symbol.
- There are many types of electric meters used today to analyze electric circuits. Analogue meters usually measure only either voltage or current. The advantage of this is that students differentiate between a voltmeter and an ammeter. The disadvantage of analogue meters is that grade 9 students may have difficulty determining the correct value displayed on the scale. As well, analogue meters must be connected correctly in order to avoid damaging the meter. Care must be taken to make sure that the positive terminal (red) is always connected to the positive side of the circuit. On some meters, the negative terminal (black) is sometimes called "common." If the meter is connected backwards, the needle will try to deflect in the wrong direction and damage could occur.
- Digital meters tend to combine several meters into one. A meter that can measure current, voltage, and other electric concepts is called a multimeter. Even though students may find a digital multimeter easier to read, care must be taken to make sure the meter has been connected and set to the appropriate scale. That is, if the digital multimeter is to be used as a voltmeter, the connection terminals and settings are different than if it is to be used as an ammeter. Unlike an analogue meter, if a digital meter is connected backwards (positive side of the meter to the negative side of the circuit), the display will place a negative sign in front of the displayed value. This will not damage the meter, but students should reverse their connections so that the meter is connected correctly.

- Regardless of whether the meter is digital or analogue, an ammeter should always be placed in series with the circuit. That is, the circuit must be disconnected and the ammeter inserted so that all the current flows through the meter. Ammeters are designed to have a very low resistance so that they do not significantly change the resistance of the circuit when they are inserted. Because of an ammeter's low resistance, it should never be connected directly across a battery. The large current drawn by the low resistance ammeter will damage it.
- A voltmeter is always connected in parallel to the load or source of potential difference. Voltmeters are designed to have a very large resistance so that they do not significantly change the resistance of the circuit when placed in parallel with a component.

INSTRUCTIONAL STRATEGIES

- Students can make flashcards with the symbol on one side and the name on the other. Then the actual electrical components could be randomly placed on a table and the students could be asked to match the symbol with the component.
- If the students will be using analogue meters, give students: an ammeter, a voltmeter, a red connecting wire, and a black connecting wire. Call out a certain meter and scale setting, and check to see if students have the correct connections and/or settings. For example, you might say "A voltmeter on the 25 V scale."
- If the students will be using multimeters, give students: a multimeter, a red connecting wire, and a black connecting wire. Call out a certain meter and scale setting, and check to see if students have the correct connections and/or settings. For example, you might say "An ammeter on the 200 mA scale." Go over the information on pages 548–549 regarding connecting a voltmeter and connecting an ammeter.

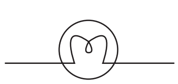
Use the diagrams on page 549 to emphasize the following points:

1. The positive side of the meter is always connected to the positive side of the circuit.
2. When using an ammeter, the circuit must be disconnected so that the ammeter can be placed into the circuit.
3. When using a voltmeter, the circuit does not have to be manipulated. The voltmeter is placed directly across either a load or a source of potential difference.

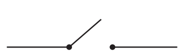
- You may wish to use a handout displaying various analogue meter readings and have students record the values (e.g., BLM G–12, Reading an Analogue Meter).
- Have students complete the Instant Practice on page 550 of *ON Science 9.*

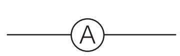
Instant Practice–Using Circuit Symbols and Electric Meters Answers, p. 550

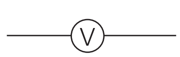
1. a. 

b. 

c. 

d. 

e. 

f. 

2. a. Red
   b. Black
3. The positive terminal of the meter should be connected to the positive side of the power source.
4. The circuit must be disconnected before inserting an ammeter.
5. Set the meter on the largest scale to obtain an approximate value. Then, lower the scale until you have the highest possible reading without going off scale.
6. a. Use the 2.5 scale and multiply your value by 10.
   Answer = 6.5 V
   b. Use the 5 scale and multiply your value by 100.
   Answer = 285 V
   c. Use the 1 scale and multiply your value by 10.
   Answer = 8.8 V
   d. Use the 1 scale and multiply your value by 100.
   Answer = 44 mA

Science Skills Toolkit 10: Using Models and Analogies in Science, 551

This Science Skills Toolkit helps students understand the value of models and analogies to scientific communication.

BACKGROUND INFORMATION

- Models are defined on text page 551 of the student book as "a picture, a mental image, a structure, or even a mathematical formula." Analogies are defined as "a comparison between two things that have some characteristics in common." Each attempts to explain a concept or hypothesis. Models and analogies are usually simplifications of the concept they represent so that the concept can be studied or more easily understood.
- Scientific models can take many different forms, but they fall into two major categories, physical and mental. Some of the more common forms can include the following physical models: equations, symbols, formulas, drawings, diagrams, scale models, quantitative modelling (statistics), simulations (computer and otherwise), and mental models such as the particle theory of matter and atomic theory. Even the processes of science (scientific methodologies) used in the *ON Science 9* program are expressed in model form. The flowcharts found on pages 529, 532, and 536 are models of these scientific processes.
- Although the concept of two types of models (physical and mental) is implicit in the definition provided, at this level the focus is on physical models, and students are not expected to differentiate between physical and mental models.

  Much recent scientific work entails the use of statistical modelling. This type of model includes as much quantitative and qualitative data as possible and then generates equations that are viewed as lines on graphs (or other graphical conceptions). Scientists can change certain values of data and play "what if?" in an attempt to gain a deeper understanding of the system under study.

- When astronomers realized that planets orbited the Sun, they first thought the planets' orbits were circular. Further study and observation, however, showed that the circles (and their describing equations) did not adequately account for the positions of the planets. In the early 17th century, Johannes Kepler tried fitting a number of other curve patterns to the data and eventually determined that the ellipse best fit the data. Since then, the general shape of the planetary orbits is understood to be elliptical, but the actual equations have been adjusted to account for a number of other pieces of data. As a result of more accurate data and equations, astronomers were able to predict the existence and location of undiscovered heavenly bodies such as Uranus and Pluto.

INSTRUCTIONAL STRATEGIES

- At the simplest level, the graphing of data and the analysis of those graphs in some of the investigations in *ON Science 9* involve models. Graphing skills are very important to students who are attempting to understand relationships between variables. As a result, students should be given as many opportunities as possible to develop their graphing skills. Although students will not be determining equations from these models, they should be assisted in determining trends and patterns (lines of best fit) that are particularly apparent in line graphs. This type of modelling work is significant in the development of student-designed investigations for many of the same reasons.
- In some activities, building or drawing a physical or working model, or stating an analogy, may be helpful in understanding the relationships (in terms of physical association) between the pieces of the model.
- If working on scientific questions, students should be encouraged to make predictions—if a variable (or a number of variables) changes in some way, then (an) other variable(s) changes in some way—and to suggest possible theoretical reasons for the predictions (i.e., the variables change in this way because …). These rationales can be supported by the data produced in the investigation as well as the models that are developed based on them.
- Alternatively, when working on technological problems, students should be encouraged to develop a number of possible solutions to the problem being investigated. At times, each of these problems may need a model to be developed so that an informed decision can be made as to which solution is more suitable for further work. Often, students at this age level need to be encouraged to look at various alternatives rather than focussing on one solution only. In the same way, students will need to be encouraged to continue to modify the solution they settle on so that it becomes an even better fit to the requirements of the situation.

ADDITIONAL SUPPORT

- ELL Analogies, especially, can be very helpful to English language learners, helping them to understand a new term by relating it to one they already know.
- Encourage students who have difficulty with manual graphing to use dedicated-purpose computer graphing packages or general-purpose spreadsheet programs. The dedicated-purpose programs are generally easier to use since they have fewer options. Encourage the students to analyze the patterns in the graphed data and draw in their own line of best fit, rather than having the computer determine the trend line.

- DI Many materials are appropriate for use by kinesthetic learners in making models. These include plaster of Paris, paper, papier-mâché, modelling clay, wood, sticks and balls, chemistry sets, and so on. Whenever appropriate, provide such materials for the students' use.

Ideas for Communicating

- Students should be given the opportunity to present and explain their models and analogies to small groups, to the teacher, or the entire class. The explanations should focus on how the model conforms to the data.
- When several groups have designed investigations that are closely related (in that they have several variables in common or they are attempting to explain similar phenomena), each group should share data and models with peers while attempting to arrive at a consensual understanding. This would model scientific conventions.

Instant Practice–Using Models Answers, p. 551

Answers will vary. Sample answers:

a. Architects use scale models of their buildings in order to get a 3-dimensional view of the project and its surroundings. The model can be used to show the building to prospective investors or buyers. It can also be tested for resistance to earthquakes and wind.

b. Aviation engineers test models of airplanes in wind tunnels for the amount of lift that the wings produce and the amount of wind resistance.

c. Theatre directors use models of the sets that they will use in plays to determine where the actors will get the best exposure and where the set elements will provide the best viewing.

d. Geographers use maps that show the heights of the lands so that when they are surveying they are able to determine the best routes.

e. Landscape designers map out where they are going to put particular plants and features like rock walls and sprinklers.

Instant Practice–Using Models Analogies Answers, p. 551

Answers will vary. Students may say a food web is like relationships in a classroom, where students have lots of different kinds of connections to several other students. (Naming the relationship a food "web" is already an analogy!)

Science Skills Toolkit 11: How to Do a Research-Based Project, p. 552

Science Skills Toolkit 11 outlines the steps of a research project, as well as some things to keep in mind at each step.

BACKGROUND INFORMATION

- Students have been asked to research in school or years, but some parts of the process may be new to them:
  - They may not have experience formulating their own topic or question.
  - They may not have experience evaluating sources of information.
  - They may not have been expected to uphold rigorous standards of copyright, and taught how to avoid plagiarism.

- They may not have had the opportunity to consider different methods of presentation and choose one to suit their data and their audience.

INSTRUCTIONAL STRATEGIES

- Ask a student to relate the process they used to research for a recent school project. (You may need to reassure them that they are not being set up to be criticized.) As the student describes what he or she did, write key steps on the chalkboard. Key steps might include:
  1. Ask some general questions about the topic.
  2. Find sources of information.
  3. Use the sources to look for information that help to answer the questions.
  4. Ask more questions to help completely cover the original topic.
  5. Repeat steps 2 and 3.
  6. Choose a method to present your results, and create a presentation.
- Use the steps you record as discussion points as you talk about the material in Science Skill 11 with students.
- For each of the steps above, give an example of a project, and ask students what they might do for that particular project. For example, for a project about possible careers related to chemistry, what sources might you consult? For a project about the formation of the solar system, how might you communicate your results to other Grade 9 students and parents?

Instant Practice Answers, p. 553

1. Steps might include:
   1. Ask some general questions about the topic.
   2. Find information from reliable sources to help answer your questions. Record the sources, too.
   3. Ask more questions to help you revise and complete your research.
   4. Find information to answer these questions, and record the answers.
   5. Repeat steps 1–4 as necessary to answer your original question.
   6. Consider your audience and choose a method of communicating your results. Develop your presentation.
2. Answers will vary. For example, "What are the characteristics of the Moons of Jupiter?"
3. Answers will vary. For example, students might suggest including visuals or multimedia to keep the younger students interested, as well as using simple vocabulary.

Math Skills Toolkit 1: The Metric System and Scientific Notation, p. 554

Math Skills Toolkit 1 presents a review of the metric system and unit conversion.

BACKGROUND INFORMATION

- Scientists have agreed that the metric system (*Système international d'unités*) will be the system of measurement for science. The metric system has fixed standards of measurement for easy comparison. The Imperial system was based upon measurements such as the length of a certain king's foot, while the inch was the width of a thumb. Obviously these things could and would change from one individual to another. Further, British Imperial units of measurement did not always match those of American units. For example, a British gallon is larger than an American gallon. To avoid confusion, the metric system has been universally adopted. Imperial measurement is still used in some cases. Wood is still sold and purchased in Imperial units, and students might be interested to learn that horses are still measured in hands, the unit used to indicate the height of a horse from its front hoof to its shoulder. As well, the fathom is still used to measure the depth of water. A fathom is the measure of a length of rope that is stretched between two extended hands, traditionally considered to be six feet. This measure was used to detect the depth of water under the hull of a boat as a weighted rope was slowly lowered over the side and the number of arm's lengths of rope was counted.

INSTRUCTIONAL STRATEGIES (The metric system)

- To introduce the students to the relationship of prefixes in measurement, provide each student with a metre stick. Inform the students that the stick represents a metre. Point out to them how it can be divided into units of 10 (decimetres):
  1 metre = 10 decimetres

  Within a decimetre (starting on the left), have the students count the number of major divisions. Tell the students that these major divisions represent centimetres. Help them to make the inference that 1 dm = 10 cm.

  Finally, have students count the number of markings between centimetres. Help them to make the inference that 1 cm = 10 mm. Get students to then correlate between the minor units of measurement in the metric system:
  10 cm = 1 dm
  10 dm = 1 m
  100 mm = 1 dm

  To reinforce these ideas, play *Jeopardy!* With teams of contestants and conversion problems.

- To help students develop some facility with conversions, use a stair format or unit number line. In the stair format, which is illustrated for students on BLM G-28, Metric Conversions, the larger units are written at the top left of the stairs. Descending units are written on lower rungs. The number is written on the stair with a decimal place. Moving up or down is done by moving the decimal, and zeros are added on the vacant stairs between the original number and the new unit.

  For example:
  30 cm = 0.3 m

  kilometre
  hectometre
  decametre
  metre 0.3
  decimetre 3.0
  centimetre 30
  millimetre

Using a unit line applies the same principle in a linear fashion. For example,

3 m = 300 cm

kilo	hecto	deca	root unit	deci	centi	milli
			3.0			
kilo	hecto	deca	root unit	deci	centi	milli
			3	0	0.	
kilo	hecto	deca	root unit	deci	centi	milli

Do one or two examples on the chalkboard with students, then provide an example to pairs of students. Students should try to complete the stair or unit number line and then exchange with their partner to see if they have inserted the same numbers. Discuss the examples on page 554 of *ON Science 9,* copying them onto the chalkboard, if necessary. Ensure that all students appreciate which way the conversion is going (from a larger to a smaller unit or vice versa). Using the examples, demonstrate to students how this can help them to assess whether their answers are right or wrong. When students are comfortable with conversions, have them complete the Instant Practice on the bottom right of page 554.

ADDITIONAL SUPPORT

- If students are having difficulty, it may be worthwhile to find material from appropriate mathematics textbooks for additional problems.

Instant Practice–Using Metric Measurements Answers, p. 554

1. 3500 mg

2. 0.350 L of acetic acid

3. 230 cm wingspan

4. 2.5 mL

INSTRUCTIONAL STRATEGIES (Exponents and Scientific Notation)

- To help students appreciate the usefulness of exponents, ask them to write one trillion as a numeral. Ask them to imagine what it would be like to have to write or type this number each time they wanted to refer to it. Point out that a trillion in Europe has six more zeros than a trillion in North America. Writing 10^{12} makes it very clear to the reader what number is being referred to.
- To help students to understand exponents, review the relationship between bases and powers. Have students work with examples you provide, such as:

  $10^2 = 10 \times 10$
  $10^3 = 10 \times 10 \times 10$
  $10^{-1} = 0.1$
  $10^{-2} = 0.01$
  100 = 1
- When students seem comfortable working with exponents, have them complete the Instant Practice on page 555.
- Use BLM G-29, Using Scientific Notation for further practice, as well as practice multiplying and dividing numbers written in scientific notation.

ADDITIONAL SUPPORT

- If students are having difficulty, you might wish to find material from appropriate mathematics textbooks for additional problems.

Other Problem-Solving Ideas

- Have students take some common measures such as the length of the class, diameter of a car, number of students in the school, and size of the lottery jackpot, and represent these numbers in larger and smaller units, converting from standard to scientific notation where appropriate.

Instant Practice–Scientific Notation Answers, p. 555

1. **a.** 4×10^{11} stars
   b. 2.3×10^{19} km
   c. 8×10^{23} km
   d. 1.7×10^{-24} g
2. **a.** 980 000 m
   b. 2 300 000 000 kg
   c. 0.000 055 L
   d. 0.000 000 000 65 s

Math Skills Toolkit 2: Significant Digits and Rounding, p. 556

Math Skills Toolkit 2 provides students with strategies to deal with uncertainty and level of precision in measuring, rounding, and calculating.

BACKGROUND INFORMATION

- As students saw in Science Skill 5, Precision and Accuracy, no measurement is exact. On a metre stick, for example, you can measure to the nearest millimeter, for example, 1.724 m. With a more precise tool, you can measure to the nearest micrometer, for example, 1.724530 m. The number of decimal places in the measurement tell the reader how precise the measurement is. It is important that students not add zeros to a measure, as that would convey a false degree of precision.
- In calculating with measurements, we use their precision to determine the precision of the final result. For example, if a rectangle is measured as 2 m × 3 m, we can say that its area is 6 m^2. This tells the reader that the area is between 5.5 m^2 and 6.4 m^2. If the area is measured with a more precise tool and found to be 2.12 m × 3.24 m, we can write its area as 6.74 m^2—a much more precise value. Note that the number of digits in the area is the same as the number of digits in the least precise measurement. This is one of the rules of calculating with significant digits.

INSTRUCTIONAL STRATEGIES

- If students are not familiar with the concepts of precision and accuracy, they should refer to Science Skill 5, Precision and Accuracy before they read about significant digits and rounding.
- Show students a small box and ask a student to measure the length, width and height to the nearest millimetre. Record these measurements on the chalkboard in metres. Have students calculate the volume of the box, for example:

  $0.314 \times 0.226 \times 0.187 = 0.013\ 270\ 268\ m^3$

Discuss with the students whether this number is realistic. First, is it reasonable, and second, does it make sense that we can calculate the volume of this box so precisely (to the nearest billionth of a cubic metre)? Explain that this is an example of why scientists developed rules to help us decide how many digits it is reasonable to include in a number you calculate from measurements.

- Read the left column of page 556 with students, and give them additional examples of each type of each rule. Consider having students write a number and challenge a classmate to decide how many significant digits it contains.
- Read Rules for Rounding together. This is a relatively simple rule, but consistent interpretation of scientific results depends on everyone agreeing on it.
- Read Adding or Subtracting Measurements and Multiplying and Dividing Measurements together. These are also simple rules, but important ones, as they ensure that scientific results will not be misinterpreted. Give students a few examples of measurements to calculate, and have them compare their answers with those of a classmate, to ensure they have included the correct number of significant digits.

Math Skills Toolkit 3: Organizing and Communicating Scientific Results with Graphs, p. 557

This Math Skills Toolkit introduces students to the principles and procedures used in the tabulation and representation of data. Students learn which graph is appropriate for various types of data and have opportunities to practise their graphing skills.

BACKGROUND INFORMATION

- Acceptance of new ideas is more likely if the individual who "discovers" something is credible. Credibility is enhanced if that individual displays or presents material in a format that is socially agreed upon to represent that area of knowledge. Professionally produced tables and graphs that contain data present a convincing argument. They are then available for further reference. Finally, they indicate the worth of a scientific investigation, given that this lies in the reliability and validity of the data produced.
- Data collected in science investigations need to be recorded into tables that organize the data into fields (rows and columns) of a variable (i.e., data on one variable are collected and recorded together). The table or data base will have several fields of related data organized either vertically or horizontally. The data should be in ascending (increasing) value of the manipulated variable or in rows of related data. Tabulated data can then be graphed to show potential relationships between data. Depending on the variables' relationships, different graphs are used.

  The table below shows the graph and variable relationship.

Variable Relationship	Type of Graph
Non-continuous words (or categories) and numbers	Bar graph
Continuous words and numbers	Histogram
Categories or divisions of one variable	Circle graph
Non-continuous comparison of numerical variables	Line graph, scatter graph
Continuous comparison of numerical variables	Line graph

In graphs, the *x*-axis generally represents the manipulated variable while the *y*-axis represents the responding variable.

INSTRUCTIONAL STRATEGIES

- Students frequently find graphing and interpretation of graphs difficult. To overcome this obstacle, students need repeated exposure to practise this skill. They will also benefit from a variety of jigsaw activities.
- Give a group of students different graphs that are labelled but not titled. Give another group of students a title for a graph. Have each group seek out the group that has the match to its title or graph.
- Play *Jeopardy!,* a game in which an untitled graph is presented and the students formulate a (causal) question to describe the graph.
- Present students with a number of titled graphs and ask them to interpret the relationship demonstrated in the graphs. To promote student understanding of the relationship between the variables of a graph:
  - supply students with a number of partial tables of data and a corresponding graph. They should then try to determine the missing field of data.
  - supply students with split tables of data (e.g., all one variable) and a number of graphs. Have students match the data and tables.
- You may want to distribute BLM-26, Interpreting Graphs, to provide practice and reinforcement.
- When students have mastered the ability to read graphs and understand the relationship between data points, they are ready to attempt to graph. Provide them with a checklist such as the following to ensure they include all components of a graph or table.

Format for Tables	Format for Graphs
All tables must have the following: • Title • Labelled columns or rows • Units of measurement included with data • Description or summary of the table's data • Appropriate size • Neat presentation	All graphs must have the following: • Title • Labelled *x*-axis • Labelled *y*-axis • Units of measurement included with data • Description or summary of the graph's data • Appropriate size • Neat presentation

- Line of best fit is another traditional area of difficulty for students. Explain that the line of best fit represents an average of a potential trend in the data, where, if possible, approximately the same number of data points should be on the line and at an equal distance both above and below the line. Place some scatter graphs on the chalkboard or use an overhead, and work with the students to develop a line of best fit for each. Then provide students with scatter graphs to add their own smooth lines of best fit. Remind students that the line does not have to be straight. A clear plastic ruler is a useful tool that allows students to see where all the data points are arrayed as they try to place the line in the best position. A piece of string can serve a similar purpose, especially with graphs with curving lines of best fit.

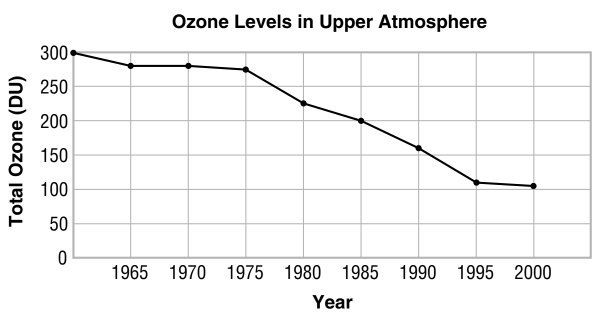
- Once students have conceptually mastered the skill of graphing, you can introduce them to spreadsheet programs that allow them to input data into fields, manipulate data with sort functions, and graph data. The ease and speed in which data are input and graphs produced will take away from the "procedural noise" of tabulating and plotting data that hampers students' understanding of the skill. If time is spent up front with the students becoming software literate, they can then copy tables or graphs from the database into a word-processing document. This will allow them to produce high-quality reports that are easily modified if oversights or mistakes are made.

Note: If your students are using a spreadsheet, make sure they input only one type of data into each cell.

INSTRUCTIONAL STRATEGIES (Drawing a Line Graph)

- Have the students examine Table 1 on page 557 of *ON Science 9* and compare it with the graph on page 557 in step 7. Ask them what information the two visuals contain. Ask which visual more efficiently and effectively communicates the information it contains. Alternatively, you could have half of the class examine the table while half examine the graph. Have a race to see which half of the class understands the information first. The students using the graph will probably understand the information more quickly.
- With the students, go over the steps in drawing a line graph to ensure that they understand how to perform each of the steps. For steps 3 and 4, you might want to provide several different types of examples so that the students develop a clear understanding of scale and its importance to a graph.
- Have the students do the Instant Practice on page 558.
- You may wish to distribute BLM G-25, Constructing Line Graphs, to provide practice and reinforcement.

Instant Practice–Line Graphs Answer, p. 473

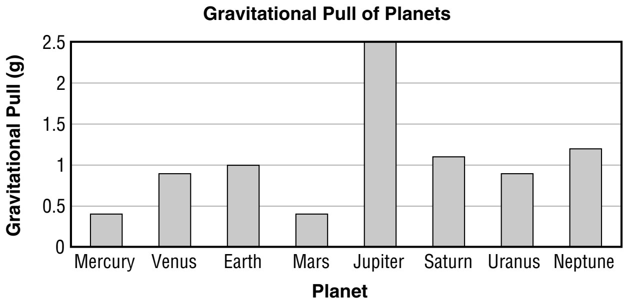


INSTRUCTIONAL STRATEGIES (Constructing a Bar Graph)

- Discuss with the students the information presented in Table 3 on page 559. Have them examine the bar graph on page 559 and think how they might present that information in a line graph. They should quickly be able to see that the information would be difficult to present as a line graph and such a representation would be less effective and less useful. Remind students that each type of graph has a specific purpose and that when they are preparing presentations for which graphing would be useful, they need to take into account the type of information that will be graphed and choose the appropriate graph.

- Have students do the Instant Practice on page 559.

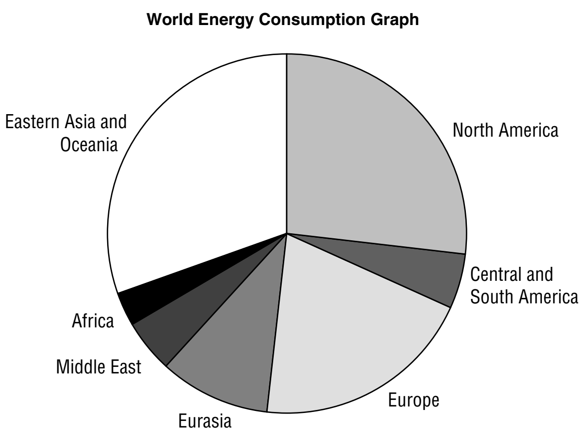
Instant Practice–Bar Graphs Answer, p. 474



INSTRUCTIONAL STRATEGIES (Constructing a Pie Graph)

- Students will probably be familiar with circle graphs from earlier grades. Remind them that such graphs are also called pie graphs, pointing out that when a piece of pie is cut from a whole pie, it is easy to see how much has been cut and how much is left. If the pie is cut into several slices, it is easy to tell whether one slice is much bigger than the others, so a circle graph is a good way of displaying data when it is necessary to see how much of the whole (what percent) a portion of the data represents.
- Go over the steps in constructing a pie graph with the students and then have them do the Instant Practice on page 560.

Instant Practice–Circle Graphs Answers, p. 560



Further Practice

- You may wish to use BLM G-26, Interpreting Graphs, and BLM G-25, Constructing Line Graphs, for students who require more support or review.