Spotlight on Science Skills Grade 5

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New Nouveau Brunswick

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- Development Team:
    - Judson Waye – ASD-N
- NB Department of Education and Early Childhood Development
    - Kathy Hildebrand, Cathy Martin, Martha McClure
      Learning Specialists, Science and Mathematics
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Objective

The Atlantic Provinces' science curriculum is guided by the vision that all students will have an opportunity to develop scientific literacy.

> "Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge that 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." (*Foundation for the Atlantic Canada Science Curriculum*, page 11)

The *Spotlight on Science Skills* series of documents:

- Clusters the existing Atlantic Canada skill outcomes into nine scientific practices (questioning, predicting/hypothesizing, variables, experimental design, collecting data/observations, organizing/displaying data, analyzing data, making conclusions, applying learning).
- Provides educators with an elaboration of the scientific practice including explanations of specialized terminology. It indicates what students have learned in previous grades and what the focus is for learning in the current grade.
- Provides a list of achievement indicators with an accompanying rubric for each scientific practice to further clarify expectations and guide educators in determining whether their students have met the outcome.

Overview of Outcomes

GCO: Plan & Perform (PP) - Ask questions, make predictions about objects and events. Develop a plan for fair tests to investigate those questions. Conduct investigations about their environment. Work collaboratively to carry out science-related activities.

SCO: PP1 - Propose testable questions
SCO: PP2 - State a prediction and hypothesis
SCO: PP3 - Identify and describe variables
SCO: PP4 - Plan investigations
SCO: PP5 - Conduct investigations

GCO: Analyze & Explain (AE) - Interpret findings from investigations using appropriate methods. Communicate ideas and results.

SCO: AE1 - Classify, organize and display data
SCO: AE2 - Analyze data patterns
SCO: AE3 - Draw conclusions
SCO: AE4 - Apply learning

GCO: Plan & Perform (PP) - Ask questions, make predictions about objects and events. Develop a plan for fair tests to investigate those questions. Conduct investigations about their environment. Work collaboratively to carry out science-related activities.

SCO: PP1 - Propose testable questions

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
200-1 Ask Questions that lead to the exploration and investigating	204-1 Propose questions to investigate and practical problems to solve	208-2 Identify questions to investigate arising from practical problems and issues
200-2 Identify problems to be solved		
	204-2 Rephrase questions in a testable form	208-1 Rephrase questions in a testable form and clearly define practical problems
		208-3 Define and delimit questions and problems to facilitate investigation

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Connection to Communication
- Communicate questions, ideas, and intentions, and listen
- Ask others for advice or opinions

In Grade 4, students made the distinction between a good scientific question and a **testable question**. Questions leading to a simple "yes/no" answer should be reworded into a more useful form that students can investigate and collect specific evidence. The focus at Grade 5 is to further develop the skill of writing a good testable question.

The primary difference between a scientific question and a testable question is the presence of the variable to measure in the question. Both types of questions will require the subject of the question to reference the variable to be tested. Good science questions do not have answers that are opinions, but rather lead to identifying relationships. Questions leading to a simple "yes/no" answer can be reworded into a more useful form that students can investigate and collect evidence.

Testable questions are always about changing one thing to see what the effect is on another thing. Testable questions have two parts: **variable to test and variable to measure**
The **independent variable** (IV) is the variable that will be tested or changed by the scientist. A good experiment has only one independent variable. The **dependent variable** (DV) is the variable being measured in the experiment.

- Scaffold 1 - Does changing (variable to test) affect (variable to measure)?
- Scaffold 2 - How does changing (variable to test) affect (variable to measure)?
- Scaffold 3 - If (variable to test) is changed, will it affect (variable to measure)?

> "*If students wash their hands (variable to be tested), will the number of days students are absent because they are sick decrease (variable to measure)?*

This chart shows how questions can be changed to a testable format.

Initial Scientific Question (Variable to Test Only)	Testable Question (Variable to Test and Variable to Measure)
What happens if I use another tuning fork?	If we use different types of tuning forks, will the sound vibrations rate be the same?
What changes can be made to make this light work more efficiently?	Does changing the type of light bulb affect energy consumption?

A part of the refining process should be for students to understand that precise language is very important to writing a good testable question. For example, terms such as "better" should be replaced with the specific measure to be improved.

Achievement Indicators

Guiding Questions:
- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Write questions using language that suggest an investigation of two variables that are related.
ii. Develop testable questions that indicate the variable to test (independent variable).
iii. Develop testable questions that indicate the variable to be measured/observed (dependent variable).
iv. Use language that is specific and relevant to the question.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Testable Question	Write a scientific question in a testable form that includes the dependent variable and independent variable (**independently and consistently**)	Write a scientific question in a testable form that includes: • what is being tested (independent variable) • what is being measured and observed (dependent variable) • specific language relevant to the question	Write a scientific question that only includes the variable to test Language may not be specific (e.g., may use "better" or "improve")	Any other answer

GCO: Plan & Perform (PP) - Ask questions, make predictions about objects and events. Develop a plan for fair tests to investigate those questions. Conduct investigations about their environment. Work collaboratively to carry out science-related activities.

SCO: PP2 - State a prediction and hypothesis

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
200-3 Make predictions, based on an observed pattern	204-3 State a prediction and a hypothesis based on an observed pattern of events	208-5 State a prediction and a hypothesis based on an observed pattern of events

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Connection to Communication

- Communicate questions, ideas, and intentions, and listen

In the elementary grades, students are expected to make scientific predictions. The term “hypothesis” will be introduced in middle school.

A **scientific prediction** is related to the question. When students are asked to make a prediction in response to a problem or question, they should be using what they already understand about the subject to explain their prediction.
For example:

- Question: Will adding fertilizer make grass grow taller?
- Possible prediction:
  - I predict that adding fertilizer will make grass grow taller, because the bean plants in our class with fertilizer grew taller than the others that didn’t have fertilizer.

A prediction is never considered right or wrong. Results are described as expected or unexpected. The conclusion, supported by experimental results, does not have to match the prediction, but this needs to be discussed in the conclusion.

As students develop their understanding of scientific thinking their ability to make a science-based prediction should advance as well. In previous grades, students have been making predictions based mostly on personal experiences. In Grade 4, some emphasis was placed on students using their scientific experiences to justify their predictions. As students engage in more inquiry-based tasks, they will begin to develop the capacity to make more scientific-based predictions. Grade 5 students will continue develop their skill of making scientific predictions.

For example:

Grade 3	Grade 4	Grade 5
If I add fertilizer then the grass will grow bigger, because when my dad added it the flowers they grew big.	If I add fertilizer then the grass will grow taller, because our bean plants with fertilizer grew taller than the others.	If I add fertilizer then the grass will grow taller, because it will give the plants more nutrients that have been shown to support growth.

Students need to learn how to write their predictions using "if...then...because" in the statements. This will scaffold the transition towards students making a true hypothesis in middle school. In Grade 4, students learned to include a justification in their statement using "because".

Prediction…Justification	If...then...because
I predict that….because…	**If** the (variable to test) is (describe the changes), **then** the (variable to measure) will (predict the effect), **because** (state your science justification).

Depending on the context, **estimation** is a skill that can enhance the ability to make an accurate scientific prediction. Estimation is a strategy for determining approximate values or quantities, usually by referring to benchmarks or using referents, or for determining the reasonableness of calculated values. In relation to the grade level expectations, students should use estimation strategies where appropriate (see *NB Mathematics Curriculum,* Grade 1 to Grade 5).

Achievement Indicators

Guiding Questions:

- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Write prediction statements that are testable ("if, then" scaffold); though variables may be general and not specific enough to measure (e.g., better, worse).
ii. Write prediction statements which include **"if, then, because"** stating a plausible reason for the prediction, based on an observed pattern or scientific knowledge (from personal learning and experiences)

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Prediction	Make predictions relevant to question with a plausible rational supported by scientific learning using "if, then, because" (**independently and consistently**) **All variables are specific** enough to measure	Make a prediction which is: • relevant to the question • testable Includes "if, then, because" and a plausible reason, usually based on scientific learning Variables may not be specific enough to measure	Make a prediction including a reason, which may be relevant, but is not clearly expressed Does not include "if, then" in the prediction statement	Make a prediction, but the justification is missing or irrelevant Any other answer

GCO: Plan & Perform (PP) - Ask questions, make predictions about objects and events. Develop a plan for fair tests to investigate those questions. Conduct investigations about their environment. Work collaboratively to carry out science-related activities.

SCO: PP3 - Identify and describe variables

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
	204-4 Define objects and events in their investigations	208-7 Formulate operational definitions of major variables and other aspects of their investigations
	204-5 Identify and control major variables in investigations	208-6 Design an experiment and identify major variables

Elaboration

Guiding Questions:
- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Connection to Communication
- Communicate questions, ideas, and intentions, and listen
- Ask others for advice or opinions
- Identify problems as they arise and work cooperatively with others to find solutions

Students were introduced in Grade 3 to the concept that **variables** are an element in many scientific investigations. A **variable** is a set of attributes that can vary (e.g., be high or low). A typical example of a variable would be temperature. It changes, going higher or lower based on external conditions.

The focus of this section is the identification of variables to ensure a **fair test**. In practice, a fair test means identical procedures must be performed where only one variable is changed at a time.

In Grade 4, students were introduced to the three main types of scientific variables:
- **Controlled Variables** - the variables that are kept constant or monitored to minimize any effects on the experiment.
- **Variable to Test** (independent variable) - the variable in the experiment that is purposely changed or manipulated, either in quantity or quality, also referred to as the *manipulated variable* or *independent variable.*
- **Variable to Measure** (dependent variable) - the variable in an experiment that changes in response to the independent variable and, therefore, is also referred to as the *responding variable* or the *dependent variable*.

The variable to test and variable to measure are factors in writing a **testable question**. Grade 5 students need to continue to deepen their understanding of scientific variables.

If the initial scientific question is, “How effective are plant-based insect repellants?” the possible variables to consider are shown in the chart on the next page.

Variable to Test	Possible Variables to Measure
Different brands of plant-based repellents	• total number of insect bites • size of insect bites (mm) • color and/or itchiness of insect bites • length of time (min)

Achievement Indicators

Guiding Questions:
- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Distinguish between what is being tested, what is being measured or observed, and what is controlled.
ii. Identify specific variables to measure that are related to the variable that is being tested.
iii. Select one variable to test (independent variable), and create a list of possible variables to measure or observe (dependent variable) with all other variables controlled.

Note: the focus of this outcome is for students to understand the concept of the different types of variables, but students should be encouraged start to use the terminology described below.

Achievement Rubric

<table>
<tr><th></th><th>Excelling - 4</th><th>Meeting - 3</th><th>Approaching - 2</th><th>Working Below - 1</th></tr>
<tr><td rowspan="2">Controlled variables</td><td rowspan="3">Select all relevant variables to control, test, and measure or observe and describes them in detail using the terminology of independent and dependent

(independently and consistently)</td><td rowspan="2">Identify and control most or all of the necessary variables</td><td>Control only some of the relevant variables</td><td rowspan="3">Any other answer</td></tr>
<tr><td>Control variables that are not relevant to the investigation</td></tr>
<tr><td>Variable to test</td><td>Select one variable to be tested (independent variable) that fits the question</td><td>Identify one variable to be tested (independent variable) not relevant to the question</td></tr>
<tr><td>Variable to measure or observe</td><td>Identify and list variables to be measured or observed (dependent variable) that fits the question</td><td>Identify one variable to be measured or observed (dependent variable) not relevant to the question</td><td></td></tr>
</table>

GCO: Plan & Perform (PP) - Ask questions, make predictions about objects and events. Develop a plan for fair tests to investigate those questions. Conduct investigations about their environment. Work collaboratively to carry out science-related activities.

SCO: PP4 - Plan investigations

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
200-4 Select and use materials to carry out their own explorations	204-6 Identify various methods for finding answers to given problems, and ultimately select one that is appropriate	208-4 propose alternative solutions to a given practical problem, select one, and develop a plan
200-5 Identify materials and suggest a plan for how they will be used	204-7 Plan a set of steps to solve a practical problem and carry out a fair test of a science-related idea	208-6 Design an experiment and identify major variables
	204-8 Identify appropriate tools, instruments, and materials to complete their investigations	208-8 Select appropriate methods and tools for collecting data for solving problems
201-7 identify and use a variety of sources of science information and ideas	205-8 Identify and use a variety of sources and technologies to gather pertinent information	209-5 Select and integrate information from various print and electronic sources or from several parts of the same source

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Students were introduced to experimental design in Grade 4. The focus of Grade 5 is to continue with experimental design with the addition of **minimizing bias**. Students should be able to design a step-by-step plan that they will use to fairly test an initial idea or question in a safe manner. In practice, a fair test means identical procedures must be performed where only one variable is changed at a time. The focus of these outcomes is the planning of steps and experimental design. There are a variety of components that make up experimental design.

Requirements of experimental design:

- Identify needed equipment and materials
- Identify variables: (controls, variable to test, variable to measure or observe)
- Plan a set of steps that:
  - test a single question
  - may incorporate multiple trials, if appropriate, to increase accuracy
  - can be repeated by someone else
  - design minimizes bias

Connection to Communication

- Communicate procedures and results, using lists, notes in point form, sentences, charts, graphs, drawings, and oral language
- Work with team members to develop and carry out a plan
- Ask others for advice or opinions
- Identify problems as they arise and work cooperatively with others to find solutions
- Ensure safety of self and others

Grade 5 Language Arts Reading and Writing Standards
Form: Instructions/Procedures
Purpose: to tell how to do something
Goal or aim: identifies topic by title or opening statement(s)
Materials/Ingredients: lists materials
Method/process: includes key steps in correct order with adequate details focusing on how/when
Conclusion or Evaluation: includes a closing statement or an evaluation (*To taste like mine you should add maple syrup)*
Special Features

- May include headings, illustrations, diagrams or labels
- Numbered-steps or words showing sequence (first, next, then)
- Point form or full sentences starting with a sequence word or verbs
- Present tense
- May be written in second person (*first, you*…)

Multiple Trials

This concept was introduced in Grade 4 and the use of multiple trials, where appropriate, is expected in Grade 5. It is important to test multiple trials of an experiment to ensure that the results are accurate, reliable, and reproducible. If a variable was accidentally changed in the first trial, this becomes obvious in the following trials and can be corrected. The number of trials required depends on the amount of time needed to conduct the experiment and the nature of the investigation.

Bias

The concept of bias is introduced in this grade. Having a scientific bias means to unfairly favour one variable over another. In order for a test to be deemed fair, it must be done in a way that ensures one variable does not have an advantage. Procedures must be identical and uniformly performed. For example, to test the effect different types of paper has on the flight of a standard type of paper airplane each of the airplanes must be thrown in the same way, regardless of the type of paper used.

Achievement Indicators

Guiding Questions:

- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Identify appropriate equipment and materials for an investigation.
ii. Explain how the investigation will be set up with one variable to test, one variable to measure or observe, and other major variables controlled.
iii. Describe what will be measured or observed, and how and when this will be recorded.
iv. Plan procedures to minimize experimental bias and ensure safety.
v. Explain the steps of the procedure with enough detail that someone else could repeat the investigation in the same way.
vi. Include multiple trials to increase accuracy, if appropriate.

Achievement Rubric

<table>
<tr><th></th><th>Excelling - 4</th><th>Meeting - 3</th><th>Approaching - 2</th><th>Working Below - 1</th></tr>
<tr><td rowspan="7">Plan an investigation</td><td>Perform <u>all</u> of the following independently and consistently:</td><td>Perform <u>most or all</u> of the following:</td><td>Perform <u>some</u> of the following or need support:</td><td rowspan="7">Any other answer</td></tr>
<tr><td colspan="3">Identify appropriate equipment and materials for an investigation</td></tr>
<tr><td colspan="3">Explain how the investigation will be set up with one variable to test, one variable to measure or observe, and other major variables controlled</td></tr>
<tr><td colspan="3">Describe what will be tested, measured or observed, and how and when this will be recorded</td></tr>
<tr><td colspan="3">Plan procedures to minimize experimental bias</td></tr>
<tr><td colspan="3">Explain the steps of the procedure with enough detail that someone else could repeat the investigation in the same way</td></tr>
<tr><td colspan="3">Include multiple trials to increase accuracy, if appropriate</td></tr>
</table>

GCO: Plan & Perform (PP) - Ask questions, make predictions about objects and events. Develop a plan for fair tests to investigate those questions. Conduct investigations about their environment. Work collaboratively to carry out science-related activities.

SCO: PP5 – Conduct investigations

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
201-4 Observe, using one or a combination of the senses	205-5 Make observations and collect information relevant to a given question or problem	209-4 Organize data, using a format that is appropriate to the task or experiment
201-5 Make and record relevant observations and measurements, using written language, pictures, and charts	205-7 Record observations using a single word, notes in point form, sentences, and simple diagrams and charts	

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Previously, students have focused on making observations relevant to the question asked. In Grades 3 and 4, students learned about the two different types of data: some information is measured (quantitative) and other information is observed (qualitative) (see outcome AE1). When recording quantitative data, students need to make it as accurate as possible and include appropriate units. Qualitative data needs to be objective and not influenced by what students already know (e.g., assume that all spiders eat flies). Because students have now been introduced to the concept of variables, they can determine the most appropriate type of data to collect for the identified variable.

Students are expected to accurately record what is observed even when results differ from what is expected. It is important that students understand that they should suspend judgment during data collection and record results honestly. Results from investigations are never right or wrong. They are described as expected or unexpected. Unexpected results still convey important information.

Connection to Communication

- Communicate procedures and results, using lists, notes in point form, sentences, charts, graphs, drawings, and oral language
- Ask others for advice or opinions
- Identify problems as they arise and work cooperatively with others to find solutions
- Ensure safety of self and others

In Grade 5 mathematics, students extend their understanding of decimal numbers to thousandths. This could be applied to their measurements, if appropriate.

The Kindergarten - Grade 5 mathematics curricula include the following measurement concepts:

- Kindergarten: direct comparison of two objects based on a single attribute
- Grade 1: compare attributes: filling, covering, matching
- Grade 2: non-standard units to compare and order objects by length, height, distance around, and mass
- Grade 3: length (centimetres and metres), mass (grams and kilograms) and the passage of time (seconds, minutes, hours, days, months, weeks, and years); perimeter
- Grade 4: area of 2-D shapes
- Grade 5: length (millimetres, kilometres), volume, capacity (millilitres and litres)

Safety

Students are also expected to follow and carry out procedures safely (both teacher-directed and student-designed) using appropriate materials and tools effectively (refer to *Science Safety Guidelines* document).

Achievement Indicators

Guiding Questions:

- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Set up investigation and follow the procedures as they are described.
ii. Collect data that is relevant to the question being tested.
iii. Collect and record quantitative data accurately, including units.
iv. Collect and record qualitative data objectively (not influenced by prior knowledge).
v. Record data with labels and in an organized manner
vi. Follow safety procedures.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Conduct investigations	Follow all steps (**independently and consistently**)	Follow all of the steps as described; minimize bias	Follow most of the steps as described	Any other answer
	Collect and record data with labels in an organized manner (**independently and consistently**)	Collect and record data with labels in an organized manner	Collect data that is irrelevant or needs support to identify relevancy Data may not be labeled or organized	
	Collect and record data accurately and records with units (**independently and consistently**)	Collect and record quantitative data accurately and records with units	Record data that is inaccurate and/or missing units	
	Collect and record qualitative data objectively (**no inferences**) with additional detail (**independently and consistently**)	Collect and record qualitative data objectively (not influenced by prior knowledge)	Collect and record qualitative data that may include inferences based on what they already know	
	Follow safety procedures			

GCO: Analyze & Explain (AE) - Interpret findings from investigations using appropriate methods. Communicate ideas and results.

SCO: AE1 - Classify, organize and display data

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
202-1 Use personal observations when asked to describe characteristics of materials and objects studied	206-1 Classify according to several attributes and create a chart or diagram that shows the method of classification	210-1 Use or construct a classification key
202-2 Place materials and objects in a sequence or in groups according to one or more attributes		
202-3 Identify the most useful method of sorting for a specific purpose		
204-4 Construct and label concrete-object graphs, pictographs, or bar graphs	206-2 Compile and display data, by hand or by computer, in a variety of formats including frequency tallies, tables, and bar graphs	210-2 Compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, line graphs, and scatter plots
		210-3 Identify strengths and weaknesses of different methods of collecting and displaying data

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Connection to Communication

- Communicate procedures and results, using lists, notes in point form, sentences, charts, graphs, drawings, and oral language
- Work with group members to evaluate

Once data is collected, it is important to organize the information to help analyze it. As noted previously, there are two types of data: qualitative and quantitative.

Qualitative Data – Data that can be observed but not measured. It usually describes characteristics or qualities. Examples include: colour, odour, texture, appearance, or data described by category (e.g., the hardness scale for minerals).

Organizing qualitative data: In Grade 4, students need to be able to identify important characteristics that distinguish or are in common across a variety of items or organisms. It is expected that this information would be organized and displayed (e.g., chart, list).

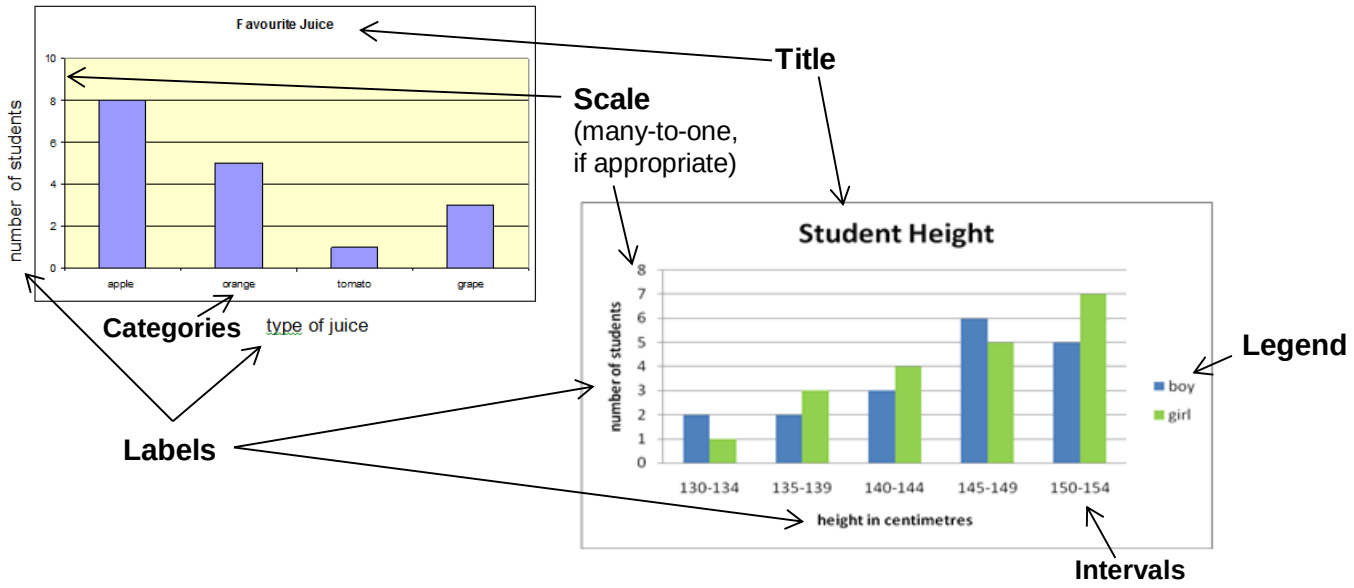
"In Grade 2, students need to build on their prior experiences to sort objects and shapes using two attributes." (NB Mathematics Grade 2 Curriculum, p.70)

"By grade 4, students are expected to use more sophisticated sorting tools such as a Carroll or Venn diagram. These organizational tools are particularly useful as a form of data display when the categories for the sorting situation overlap. A Venn diagram is typically drawn with one, two or three circles. It is important to draw a rectangle around Venn diagrams to represent the "universe" or entire group that is being sorted. This will show the items that do not fit the attributes of the circle(s) outside of them, but within the rectangle. Carroll diagrams are tables that work much like Venn diagrams. A table is created with four cells to show the four possible combinations of these two attributes. Either the items themselves, or the count of how many items of each type, are put in the cells." (NB Mathematics Grade 4 Curriculum, p.58)

Quantitative Data – Data that can be measured; numbers with units of measurement are recorded. Examples include: length, height, area, volume, mass, speed, time, temperature, humidity, sound level, cost, age.

Organizing quantitative data: Students need to be able to take number based data and display it in an appropriate format. The focus is taking raw data and creating charts or graphs (e.g., pictographs, single bar graphs, double bar graphs) that are appropriate to the task. Refer to the mathematics curriculum for the expectations at each grade level.

Sample of expectations for bar graphs in Grades 4 and 5



In Grade 5 Mathematics, students learn to use double bar graphs and the difference between first and second-hand data (see NB Mathematics Grade 5 Curriculum, Outcomes SP1 and SP2).

*"Students should be aware that sometimes when two pieces of data are collected about a certain population, it is desirable to display both sets of data side by side, using the same scale. For example, census data often shows male and female data separately for different years. This is usually done using a **double bar graph**. A **legend** is used to help the reader interpret a double bar graph.*
*It is essential that students **include titles, horizontal and vertical axis** headings and **scale, legends** and **category labels** in the **legend**. The pairs of bars should be separated and the order of the colours must remain the same in the graph." (NB Mathematics Grade 5 Curriculum, p.94)*

Achievement Indicators

Guiding Questions:

- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Classify according to relevant characteristics that are the same or different among objects or organisms to sequence and sort them.
ii. Organize and display information about characteristics appropriately (e.g., tally marks, list, chart, line plot, Venn diagram, Carroll diagram, single bar graph).
iii. Use graphs:
    a. Select appropriate type of graph for data (e.g., pictograph, single bar graph, double bar graph);
    b. Plot data accurately;
    c. Use an appropriate scale (one-to-one or many-to-one);
    d. Include a title, appropriate labels, units if applicable, and legend where appropriate.
iv. Use charts:
    a. Display information clearly and accurately;
    b. Include a title and units if applicable;
    c. Label columns and rows (table, Carroll diagram) or areas (Venn diagram) accurately.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Classify by characteristics	Classify according to relevant characteristics **(more than one)** that are the same or different among objects or organisms (**independently and consistently**)	Classify according to relevant characteristics (one or more) that are the same or different among objects or organisms to sequence and sort	Classify according to characteristic (one) that is the same or different among objects or organisms (inconsistently or with support)	Any other answer
Compile and display data	Include all appropriate titles and labels in charts and graphs; information is plotted clearly and accurately (**independently and consistently**) **May use multiple displays of data**	Select appropriate type of graph or table to display data (e.g., pictograph, single bar graph, double bar graph, Venn diagram, Carroll diagram) Include all appropriate titles and labels in charts, diagrams, and graphs Information is plotted/displayed clearly and accurately Use appropriate scale (many-to-one, if appropriate; e.g., 2s, 5s, 10s)	Make minor error in the labels; data or information is plotted accurately	Any other answer

GCO: Analyze & Explain (AE) - Interpret findings from investigations using appropriate methods. Communicate ideas and results.

SCO: AE2 - Analyze data patterns

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
202-5 Identify and suggest explanations for patterns and discrepancies in observed objects and events	206-3 Identify and suggest explanations for patterns and discrepancies in data	210-4 Predict the value of a variable by interpolating and extrapolating from graphical data
		210-9 Calculate theoretical values of a variable
		210-6 Interpret patterns and trends in data, and infer and explain relationships among the variables
		210-7 Identify and suggest explanations for, discrepancies in data
		210-5 Identify the line of best fit on a scatter plot and interpolate or extrapolate based on the line of best fit
		210-10 Identify potential sources and determine the amount of error in measurement

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Interpreting and analyzing data is a critical-thinking process used by scientific researchers to review the data gathered in the course of an investigation. Drawing conclusions is a separate outcome though it is expected that they would be learned together.

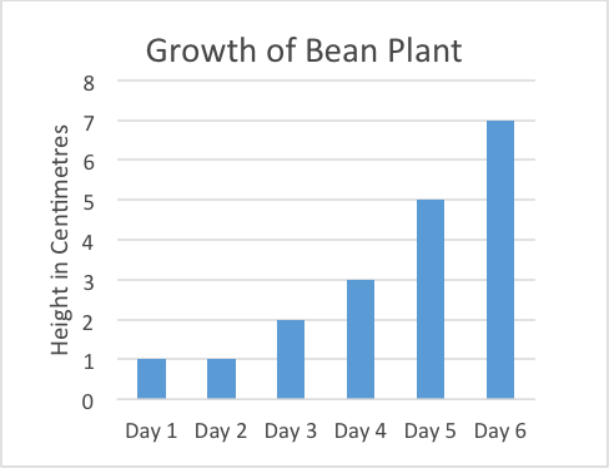
Connection to Communication

- Communicate procedures and results, using lists, notes in point form, sentences, charts, graphs, drawings, and oral language
- Work with group members to evaluate

By Grade 5, students should be able to identify and explain **patterns and trends** in data. Students should be able to describe the **relationship** the pattern/trend indicates. Interpreting data involves sorting into useful arrangements, looking for similarities and differences, thinking about missing data or errors, and summarizing what the data might mean.

As students progress into higher grade levels, they should be able to include a greater degree of detail in their analysis.

The chart below provides an example of this based on the data in the "Growth of Bean Plant" graph.



Grade 3	Grade 4	Grade 5
The bean plant is getting taller as the days go by	The bean plant is getting taller faster as it gets bigger	The bean plant is growing taller faster as it gets bigger; 1cm a day between Days 2 and 4 and 2cm a day between Days 4 and 6.

Regardless of the type of data, students should be able to identify a **discrepancy** within the data. A discrepancy is a value or observation that deviates from the standard or norm (an outlier). Discrepant data do not fall within the observed pattern and can usually be explained by measurement error or lack of control of variables. It is important to record all data. However, discrepant data can be ignored when describing overall patterns or trends. Students are expected to suggest reasonable explanation(s) when they note possible sources of error such as discrepancies.

Achievement Indicators

Guiding Questions:
- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Identify and explain a general pattern, trend, and/or relationship in data.
ii. Recognize that with multiple trials, there will be variation in data.
iii. Identify a discrepancy in data (outliers) and provide an explanation for these and any sources of error.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Analyze data	Identify and explain multiple or less obvious patterns, trends, and/or relationships (**independently and consistently**)	Identify and explain an appropriate pattern, trend, and/or relationship Omit discrepant data (outliers) in explanations	Identify and explain a pattern, trend, and/or relationship, but it is not clear or overly simplistic	Any other answer
	Identify a discrepancy and suggest an explanation for it and any possible sources of error (**independently and consistently**) Suggest **change to experimental design to eliminate the occurrence of the source of error**	Identify a discrepancy and provide an explanation for it and any possible sources of error	Identify a discrepancy, but is unable to suggest an explanation Unable to explain possible sources of error	Any other answer

GCO: Analyze & Explain (AE) - Interpret findings from investigations using appropriate methods. Communicate ideas and results.

SCO: AE3 - Draw conclusions

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
202-7 Propose an answer to an initial question or problem and draw a simple conclusion based on observations or research	206-5 Draw a conclusion, based on evidence gathered through research and observation, that answers an initial question	210-11 State a conclusion, based on experimental data, and explain how evidence gathered supports or refutes an initial idea
202-8 Compare and evaluate personally constructed objects with respect to their form and function	206-6 Suggest improvements to a design or constructed object	210-13 test the design of a constructed device or system
		210-14 Identify and correct practical problems in the way a prototype or constructed device functions
	206-7 Evaluate personally constructed devices with respect to safety, reliability, function, appearance, and efficient use of materials	210-15 Evaluate designs and prototypes in terms of function, reliability, safety, efficiency, use of materials, and impact on the environment

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Students should use information from readings, previous learning, prior knowledge, and evidence gained through investigation to draw conclusions.

To make simple **conclusions** means that students are able make a statement based upon logic and the evidence that is available. Whether the initial prediction is supported or contradicted is not a measure of success or failure, since scientific knowledge is advanced by either result.

Connection to Communication

- Communicate procedures and results, using lists, notes in point form, sentences, charts, graphs, drawings, and oral language
- Work with group members to evaluate

Where possible students should compare the results of their investigation to those of others and recognize that and explain why results may vary. Comparison of findings to those of similar investigations can add weight to the conclusion.
The conclusion:

- should be framed around the initial question that was tested. As the student looks at the data, they should ask: “Did what I change make a difference?”
- must express whether the prediction is supported based on the results. Whether the prediction is supported or not, the findings are valid and are not considered “wrong”.
- should include a statement on whether the investigation was a fair test by describing the variables.
- should suggest improvements to their experimental design.

Achievement Indicators

Guiding Questions:
- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. State a conclusion that answers the initial question.
ii. Indicate whether the data supports, contradicts, or is inconclusive about the initial prediction.
iii. Justify the conclusion by providing evidence from from data collected.
iv. Compare the results of an investigation to those of others and explain why results may vary.
v. Discuss fairness of experimental design and suggest improvements for a follow-up investigation.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Draw conclusions	State a **more detailed** conclusion that answers the initial question Justify the conclusion by providing **detailed** evidence Include **higher level** suggestions to improve investigation with explanation Discuss fairness of experimental the design and **improvements** Compare findings with **several** other similar investigations	State a conclusion that answers the initial question Indicate whether the prediction is supported Justify the conclusion by providing evidence Include suggestions to improve investigation Discuss fairness of experimental the design Compare findings with other similar investigations	Restate only the recorded results and observations in the conclusion	Any other answer

GCO: Analyze & Explain (AE) - Interpret findings from investigations using appropriate methods. Communicate ideas and results.

SCO: AE4 - Apply learning

Scope and Sequence of Outcomes

Grades K-3	Grades 4-6	Grades 7-9
202-6 Distinguish between useful and not useful information when answering a science question	206-4 Evaluate the usefulness of different information sources in answering a given question	210-8 Apply given criteria for evaluating evidence and sources of information
202-8 Compare and evaluate personally constructed objects with respect to their form and function	206-7 Evaluate personally constructed devices with respect to safety, reliability, function, appearance, and efficient use of materials	210-15 Evaluate designs and prototypes in terms of function, reliability, safety, efficiency, use of materials, and impact on the environment
	206-8 identify potential applications of findings	210-12 Identify and evaluate potential applications of findings
202-9 Identify new questions that arise from what was learned	206-9 Identify new questions or problems that arise from what was learned	210-16 Identify new questions and problems that arise from what was learned

Elaboration

Guiding Questions:

- *What do I want my students to learn?*
- *What do I want my students to understand and be able to do?*

Connection to Communication

- Ask others for advice or opinions
- Work with group members to evaluate

To apply their learning, students need to engage in **critical thinking**, including evaluating information and conceptualizing new questions or problems to investigate.

Students need to be provided with opportunities to **discuss and reflect** to help synthesize what they have learned. This will allow them to explore other perspectives and evaluate their own and other's thinking and explanations in terms of plausibility and scientific evidence. Question prompts such as the following can help in this process.

- What would happen if…?
- Based on what you know, how would you explain…?
- Can you think of another way…?
- How could you change (improve)…?
- What do you think of…?
- What would you recommend…?
- How would you justify…?
- Why was it better that…?
- Do you agree with…?

Students should be engaged in **metacognition** which is, put simply, thinking about one's thinking. The burden of learning does not fall on the teacher alone. Students need to be aware of what they need to do to learn, to self-monitor.

To help develop skills in metacognition, students should be given opportunities to:

- connect new knowledge to prior knowledge;
- self-assess by, for example, explaining their thinking to others through discussions or journal writing;
- test their ideas by, for example, designing follow-up investigations or solutions to a problem.

Achievement Indicators

Guiding Questions:

- *What evidence will I look for to know that learning occurred?*
- *What should students demonstrate to show their understanding of the Scientific Process Skill?*

Use the following set of indicators as a guide to determine whether students have met the corresponding specific outcome.

i. Extend what has been learned to develop new questions and problems to investigate.
ii. Apply what has been learned to other situations beyond the classroom.
iii. Do research and evaluate the sources of information for relevancy and reliability.
iv. Evaluate results in relation to other scientific investigations and knowledge.

Achievement Rubric:

<table>
<tr><th></th><th>Excelling - 4</th><th>Meeting - 3</th><th>Approaching - 2</th><th>Working Below - 1</th></tr>
<tr><td rowspan="5">Apply Learning</td><td>Demonstrate evidence of critical thinking beyond the expectations for this grade level based on the criteria below (independently and consistently)</td><td>Demonstrate evidence of critical thinking appropriate for this grade level based on the criteria below</td><td>Demonstrates evidence of critical thinking slightly below this grade level based on the criteria below</td><td rowspan="5">Any other answer</td></tr>
<tr><td colspan="3">Extend learning to develop new questions and problems to investigate</td></tr>
<tr><td colspan="3">Apply what has been learned to other situations beyond the classroom</td></tr>
<tr><td colspan="3">Do research and evaluate sources of information for relevancy and reliability</td></tr>
<tr><td colspan="3">Evaluates results in relation to other scientific investigations and knowledge</td></tr>
</table>