Spotlight on Science Skills Grade 6

January 2017

New Nouveau Brunswick

Acknowledgements

The New Brunswick Department of Education and Early Childhood Development gratefully acknowledges the contributions of the following groups and individuals toward the development of the New Brunswick Spotlight on Science Skills – Grade 6.

- Development Team:
    - Judson Waye – ASD-N
    - Adam Hayward – ASD-N
- NB Department of Education and Early Childhood Development
    - Kathy Hildebrand, Cathy Martin, Martha McClure
      Learning Specialists, Science and Mathematics
- Science Subject Coordinators and science teachers of New Brunswick who provided invaluable input and feedback throughout the development and implementation of this document.

2017
Department of Education and Early Childhood Development
Educational Programs and Services

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 a 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
	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
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

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

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

Previous learning may lead to research, new ideas for innovation, or a new investigation. Before writing a **testable question**, students will pose a general scientific question drawing from this previous learning.

From an initial scientific question, students will then develop a testable question. This type of question is one that can be answered by designing and conducting an investigation. It should be written in an unbiased way.

Testable questions are always about changing one thing to see what the effect is on another thing. In any experiment there can be only variable to test or change and, at this grade level, only one variable to measure.

The variable that will be changed is called the **independent variable (IV).** The variable that will be measured is called the **dependent variable (DV)**. In Grade 6 students are expected to be using this terminology.

- Scaffold 1- Does changing (**independent variable**) affect (**dependent variable**)?
- Scaffold 2 - How does changing (**independent variable**) affect (**dependent variable**)?
- Scaffold 3 - If we change (**independent variable**) does it affect (**dependent variable**)?

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

General Scientific Question	Examples of Testable Questions
What happens to the sound if I use another tuning fork?	If we use different types of tuning forks (IV), will the sound be the same (DV)?
Do different light bulbs use less energy?	Does changing the type of light bulb (IV) affect energy consumption (DV)?
Will washing hands mean students will be healthier and miss less school?	If students wash their hands (IV), will the number of days students are absent decrease (DV)?

Students should understand that precise language is very important to writing a good testable question. A testable question must clearly identify the **specific variable to test** and the **specific variable to measure**. Students should be encouraged to change terms such as "better" and "improve" with the specific measure.

For example:

"If I change the wheels, will it **improve** how the car rolls?"

- is a statement that is only approaching expectations, since the variable to be measured
- is not specific and is open to interpretation.

"If I change the wheels, will it increase the distance travelled?"

- is a statement meeting expectations because it indicates specifically what will be measured.

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 suggests an investigation of two variables that are related.
ii. Indicate **specifically** what will be tested and what will be measured.
iii. Develop testable questions that indicate the independent variable (variable to test)
iv. Develop testable questions that indicate the dependent variable (variable to be measured or observed).
v. Use the terminology of **independent** and **dependent**.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Testable Question	Write a scientific question is in a testable form that includes the dependent variable and independent variable uses specific language (**independently and consistently**)	Write a scientific question is in a testable form that includes: • independent variable (what is being tested) • dependent variable (what is being measured and observed) • specific language to name variables • specific language relevant to the question Use the terminology of independent and dependent variables	Write question in a testable form and measureable/ observable Language may not be specific: variables are not specific (may use "better" or "improve") Identify the variable to test and the variable to measure	Unclear as to which variable is being tested and which variable is being measured 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

Connection to Communication
- Communicate questions, ideas, and intentions, and listen

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

Students used an "If, then, because" scaffold in the elementary grades for writing predictions with a supporting reason. In Grade 6, the term **hypothesis** is introduced. Hypothesis statements are plausible predictions of a relationship between two variables, supported by information from a student's current understanding.

Based on previous experience and knowledge, students will predict a relationship between two variables. This prior knowledge could come from a variety of sources such as a previous experiment, a demonstration, research, a television program, or what someone has told them is true. During middle school, students will work on the skill of developing hypotheses with the expectation of mastery at high school.

A useful scaffold for writing a **hypotheses** is the "**If**, **then, because**" format.

If the __IV*__ is __(describe the change)__
then the __DV*__ will __(predict the effect)__
because __(state the justification)__

*Independent Variable - (IV) Dependent Variable - (DV)

Hypothesis examples:

- **If** salt concentrations in soil are increased **then** the rate of plant growth will decrease, **because** plants growing near salt water are smaller. (supported by research or observations)
- **If** air temperature is reduced, **then** leaf colour will change, **because** leaves change colour in the fall when it starts to get cooler. (supported by observations)
- **If** the cones of a tree are pink rather than yellow, **then** flies will lay more eggs in them, **because** initial observations seem to show this trend. (supported by observations)

- **If** exposure to UV light is increased **then** more people will get skin cancer, **because** research shows that people in warmer climates get more skin cancer than people in cold climates. (supported by research)

Students were taught to use "If, then, because" statements in Grade 5 for writing predictions, but were not expected to use the terms, independent and dependent variables. In Grade 6, the term hypothesis will be used. The hypothesis statement will be more specific and/or may suggest a more complex investigation than in previous grades.

In addition, Grade 6 students will be introduced to writing a hypothesis in the passive voice. The passive voice reinforces that scientific work is done as objectively as possible. It clearly expresses descriptions and procedures so they can be compared and reproduced.

The following is an example of appropriate "If, then, because" statements by Grade level:

Grade 3: "I predict that adding fertilizer will make grass grow bigger, **because** when my dad added it the flowers grew big."

Grade 4: "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.

Grade 5: "**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."

Grade 6 (passive voice): "**If** the amount of fertilizer is increased **then** the grass will grow tall faster, **because** the fertilizer **will** provide more nutrients that have been shown to support growth.

Supporting a Hypothesis
A hypothesis is a statement which may or may not be supported by the results of an investigation. It is important to recognize that positive or negative results are equally valuable and valid.

For example:
The hypothesis is: **If** salt concentrations in soil are increased **then** the rate of plant growth **will** decrease, **because** plants growing near salt water are smaller.
- If plant growth decreases, the hypothesis is supported.
- If plant growth stays the same or increases then salt (at concentrations tested) do not decrease plant growth

Estimation
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 or hypothesis statements that are testable with variables that are **specific** enough to measure.
ii. Write hypothesis statements using the **"If, then, because"** format, including a plausible reason (from previous learning and/or research); may use tentative words such as "*evidence suggests"* and "*may"*.
iii. Write prediction and hypothesis statements in the **third person.**

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Prediction and Hypothesis	Make a prediction and hypothesis statements that are testable with specific variables Make a hypothesis using "If, then, because" **strongly supported by previous investigations or research** Write hypothesis in third person (**independently and consistently**)	Make a hypothesis that is testable and name **specific variables** Make a hypothesis using **"If, then, because"** with a plausible reason Write hypothesis in **third person**	Make a prediction or hypothesis that is not clearly testable Make a hypothesis using "If, then, because" with a reason that may be relevant, but is not clearly expressed Write prediction or hypothesis in first person	Make a prediction or hypothesis that not testable Make a hypothesis, with a reason that is not clearly expressed, 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?*

In Grade 6, students should be able to identify a variable to test or change (independent variable), a variable to measure or observe (dependent variable), and the major variables that need to be controlled (kept the same). This will allow a **fair test** in which only one variable is changed at a time, and the same procedures will be carried out for all the measurements.

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

Independent Variable (IV) - the variable in the experiment that is purposely changed or manipulated, either in quantity or quality, also referred to as the *manipulated variable* or *variable to test.*

Dependent Variable (DV) - the variable in an experiment whose response to the changing independent variable is measured and, therefore, is also referred to as the *responding variable* or the *variable to measure*.

Controlled Variables - the variables that are kept constant or monitored to minimize any effects on the experiment. Failure to control variables can bias and influence the results. For a test to be deemed fair, it must be done in a way that keeps all procedures and all major variables the same, except for those being tested or measured. For example, when testing if paper type affects flight of paper airplanes, the force at which it is thrown must be the same every time.

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

Independent variable to test

- Different brands of insect repellants.

Possible **dependent variables** to measure

- total number of insect bites
- size of insect bites (mm)
- colour of insect bites (scale of redness?)
- itchiness of insect bites (scale?)
- length of time each brand provides protection (min)

Controlled variables

- same person trying all three brands
- bites from all three brands at the same time
- number of insect bites measured the same for each brand
- same type of insect bite

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 tested, what is 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 **independent** variable, create a list of possible **dependent** variables (and how to measure them), and a list of **controlled** variables.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Independent	Identify most or 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**)	Identify one independent variable (variable to be tested) that fits the question Uses the terminology of independent	Identify one independent variable (variable to be tested) not relevant to the question	Any other answer
Dependent		Identify dependent variables (variable to be measured) that fits the question Uses the terminology of dependent	Identify one dependent variable (variable to be measured) not relevant to the question	
Controlled		Identify and control most or all of the necessary variables depending on the complexity of the investigation,	Control only some of the relevant variables Control variables that are not relevant to the investigation	

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

Elaboration

Guiding Questions:

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

In the previous outcomes (PP1-PP3), students develop a testable question, determine a prediction and hypothesis, and identify the independent, dependent and controlled variables. This outcome focuses on students designing an investigation and communicating their plan clearly.

For their science investigation students need to: identify needed equipment and materials; name the independent, dependent and controlled variables; plan procedures that are safe and unbiased; control variables; change only the independent variable; measure the dependent variable at given time intervals, and incorporate multiple trials to increase accuracy. Their plan should also ensure that bias is minimized, which was introduced in Grade 5.

Students also need to communicate their plan, a skill which links directly to the outcome to “Explain how to do something” in the *Grade 6 Language Arts Reading and Writing Standards*.

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

This Language Arts outcome requires students to identify the topic, list materials and explain procedures with key steps, in the correct order and with adequate detail focusing on how and when. The following special features also apply:

- May include headings, illustrations, diagrams or labels;
- Numbered-steps or words showing sequence (first, next, then);
- Point form or full sentences starting with sequence word or verbs;
- Present tense often written as commands;
- Technical language – verbs, adverbs and adjectives (e.g., *whip the cooled cream vigorously)*.

Multiple Trials

Where appropriate, multiple trials should be included when planning an investigation. Running multiple trials will allow a student to see how consistent their results are, while recognizing that some variation in results is to be expected. After multiple trials are run, the data points need to be compared to find the value that accurately reflects the result. In later grades, students will calculate the average of the data set to determine this. Students in this grade should organize the data to determine the value that is the most expected result.

Running multiple trials will also highlight data points that are clearly so far different from a pattern that they must be a result of an error of method of equipment. These "outliers" can be removed from the data set.

Experimental Bias

The concept of experimental bias was introduced in Grade 5. 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 independent variable (to test), one dependent variable (to measure), and other major variables controlled.
iii. Describe what will be measured or observed, and how and when it will be recorded.
iv. Plan procedures to **minimize experimental bias** and **ensure safety**.
v. Include **multiple trials** to increase accuracy, if appropriate.
vi. Explain the procedure with enough detail that someone else will know how to do the investigation in the same way.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Plan an investigation	Students can perform <u>all</u> of the following **independently and consistently**: • Identify equipment and materials for an investigation • Explain how the investigation will be set up with one variable to test, one variable to measure, and other major variables controlled • Describe what will be measured or observed, and how and when it will be recorded • Plan procedures to minimize experimental bias and ensure safety • Include multiple trials to increase accuracy, if appropriate • Explain the procedure with enough detail that someone else will know how to do the investigation the same way	Students can perform the following: • Identify equipment and materials for an investigation • Explain how the investigation will be set up with one variable to test, one variable to measure, and other major variables controlled • Describe what will be measured or observed, and how and when it will be recorded • Explain the procedure with enough detail that someone else will know how to do the investigation the same way Students can perform the following with support: • Plan procedures to minimize experimental bias and ensure safety • Include multiple trials to increase accuracy, if appropriate	Students can perform <u>some</u> of the following: • Identify equipment and materials for an investigation • Explain how the investigation will be set up with one variable to test, one variable to measure, and other major variables controlled • Describe what will be measured or observed, and how and when it will be recorded • Plan procedures to minimize experimental bias and ensure safety. • Include multiple trials to increase accuracy, if appropriate • Explain the procedure with enough detail that someone else will know how to do the investigation the same way	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: 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	205-2/4 Select and use tools in manipulating materials, building models, measuring.	209-4 Organize data, using a format that is appropriate to the task or experiment
	205-3 Follow a given set of procedures.	
	205-9 Use tools and apparatus in a manner that ensures personal safety and the safety of others.	
	205-5 Make observations and collect information relevant to a given question or problem	
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?*

Students should be able to record all relevant information measured (**quantitative**) and observed (**qualitative**) in a format appropriate to the type of data. In previous grades, students learned that quantitative data gives a number value, while qualitative data provides a description.

Quantitative data is measured as numbers and recorded with units of measurement. Examples include: length, height, area, volume, weight, speed, time, temperature, humidity, sound level, cost, age.

In mathematics in previous grades, students have learned the basic units of the metric system (millimetres, centimetres, metres, kilometres, grams, kilograms, litres, millilitres) and how to find perimeter, area, and volume. In Grade 6, they learn formulas for some area and volume calculations. They have also extended in previous grades their understanding of the number system to thousandths.

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

Qualitative data can be observed, but not measured with numbers. It usually describes characteristics or qualities. Examples include: colour, odour, texture, appearance, or data that is described by category.

Observations require the use of one or more of the five senses. Students should be careful to record only their observation when collecting qualitative data, and not to be influenced by prior knowledge. For example, when you see steam rising from a cup of coffee you should only record the observation, and not infer that the coffee is hot.

- "steam is rising from the cup of coffee" (observation)
- "the coffee is hot" (inference based on prior knowledge).

The dependent variable will determine the type of data collected. 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.

Students should understand that to measure accurately they must use scientific devices and equipment properly.

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 an investigation and follow the procedures as they are described.
ii. Make observations and collect data that is relevant to the question being tested
iii. Collect and record qualitative data objectively (not influenced by prior knowledge).
iv. Collect and record quantitative data accurately including units.
v. Record data in an organized manner and label appropriately.
vi. Follow safety procedures when using materials and equipment.

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 relevant data accurately with labels in an organized manner (**independently and consistently**)	Collect and record relevant data accurately 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?*

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.

Organizing qualitative information

For qualitative data, students classify according to attributes or characteristics that distinguish or are in common across a variety of items or organisms and display this information as a chart or diagram. Students have also been developing their sorting and displaying skills in mathematics.

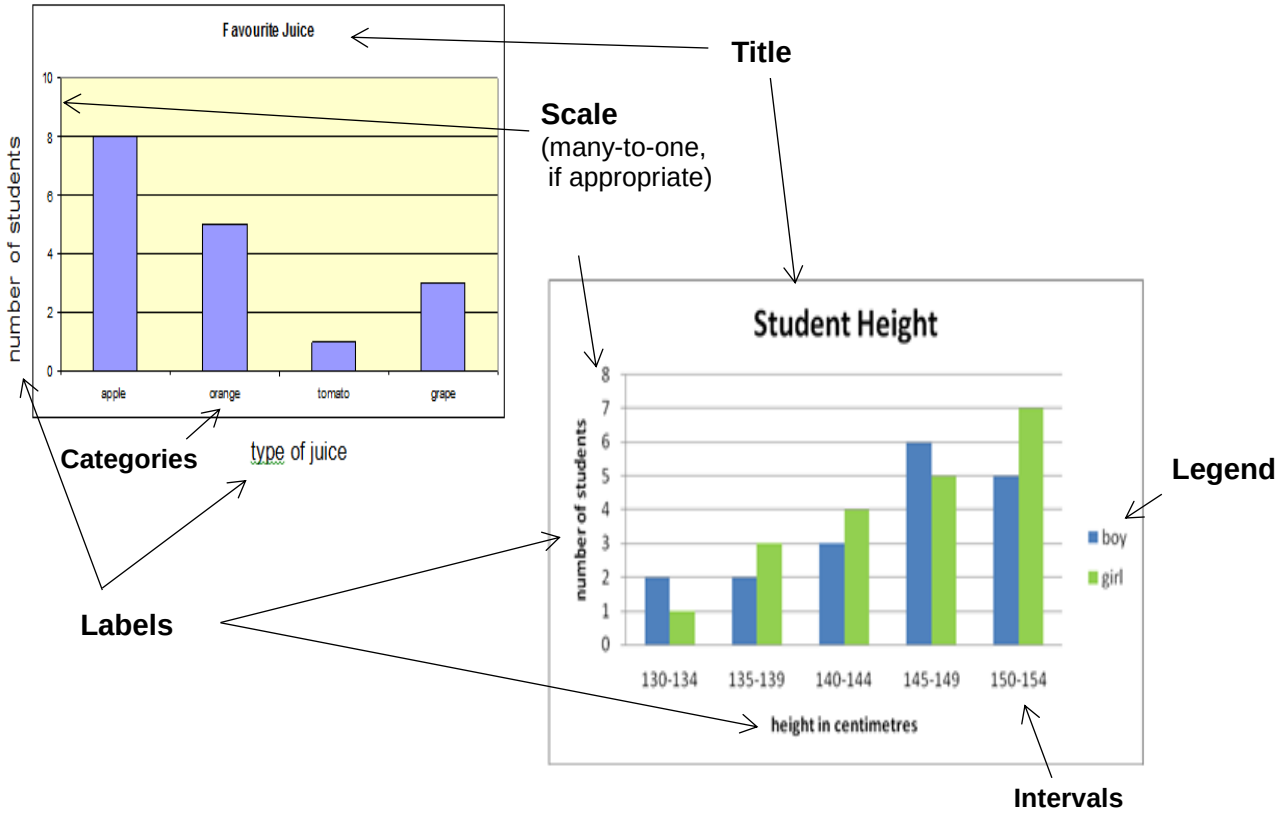
Connection to Communication

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

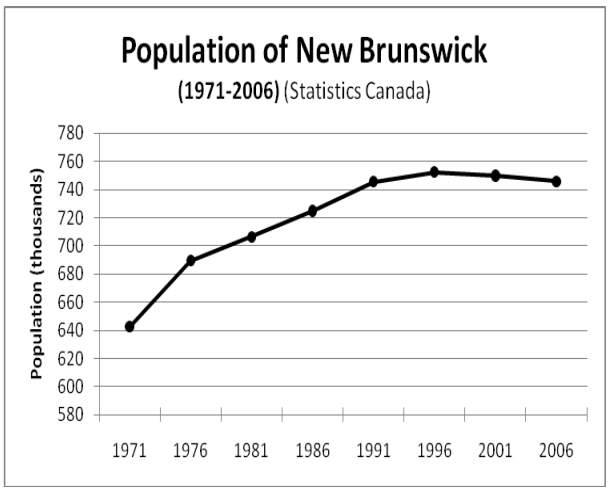
Organizing quantitative data

For quantitative data students first need to distinguish between continuous and discrete data. They then choose the appropriate chart or graph to display it. In the mathematics curriculum students were introduced to single bar graphs in Grade 3, double bar graphs in Grade 5, and line graphs in Grade 6. By Grade 6, they should be able to distinguish which of these graphs are most appropriate for the date collected.

<u>Sample of expectations for bar graphs in Grades 4 and 5</u>



Grade 6 **Line Graph**



"The purpose of a line graph is to focus on trends implicit in the data… Continuous data includes an infinite number of values between two points and is shown by joining the data points. Discrete data has finite values (i.e., data that can be counted such as the number of pets), and the data between the points have no value. As a result the points in the graph should not be connected and no inferences can be made about values between two data points". (Mathematics Grade 6 Curriculum, pg. 94)

When students create line graphs or plot points of discrete data, they should look for patterns and trends in the data.

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 items or organisms according to characteristics that are the same or different using qualitative data.

ii. Differentiate between discrete and continuous data using quantitative data.

iii. Organize and display qualitative or quantitative data using the appropriate type of chart or graph (e.g., pictograph, bar graph, double bar graph, line graph, Venn diagram, Carroll diagram).

iv. Use charts or diagrams.
   - Organize and display data clearly and accurately.
   - Label columns and rows (table, Carroll diagram) or areas (Venn diagram) accurately, and include a chart title.

v. Use graphs.
   - Plot data accurately with independent variable on the x-axis, dependent variable on the y-axis, and the correct scale.
   - Title the graph, label the x- and y-axis including units, and include a legend where appropriate.

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**)	Identify relevant characteristics Classify according to relevant characteristics (one or more) that are the same or different among objects or organisms to sequence and sort	Include some characteristics that do not distinguish between the groups 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		Distinguish discrete and continuous data Use appropriate display of data Show patterns and trends in the display of data	Plot data or information correctly, but scale is incorrect Omit titles or labels or are incorrect Do not use a display of data does that reveals patterns and trends	Use inappropriate display of data
	Plot the IV on the x-axis, and the DV on the y-axis **(independently and consistently)** May use multiple displays of data	Plot the IV on the x-axis, and the DV on the y-axis **with support** Plot data or information is correctly, with accurate scale Use appropriate titles and labels in charts and graphs Include a legend in double bar graphs Include correct units in labels		Plot data or information incorrectly Use incorrect scale is Omit titles or labels or are incorrect

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?*

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

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. By Grade 6, students should be providing detailed descriptions of trends.

Appropriate description of trend:
The population of New Brunswick increased until 1996 and then decreased slightly.

Not acceptable descriptions of trend:

- The population went up and then it went down. (Lacks detail in description)
- It started out steep, and then it got flatter. (Vague language)
- Overall the population went up. (Oversimplification)

In many cases it is appropriate to run multiple trials. When analyzing data from multiple trials it is important to understand that the data collected will vary from trial to trial. To analyze, the values from each trial should be averaged. The more trials that are run, the closer the average will come to an accurate result.

When analyzing data it is also important to recognize that sometimes mistakes are made which result in incorrect data. A **discrepancy** in data is when values or observations deviate from the observed pattern or trend. Discrepant data (outliers) may due to measurement error or

uncontrolled variables. Discrepant data can be ignored when describing overall patterns or trends.

Incorrect data can also occur when methods or equipment used in an investigation are faulty. For example, this may be due to personal bias, damaged equipment, inaccurate measurements, uncontrolled variables, or careless observations. If results are far from those expected, or from what other investigators have found, methods and equipment should be checked.

The challenge in data analysis is to get as close as possible to an accurate result through multiple trials, removing outliers, and ensuring methods and equipment are accurate. Analyzing and interpreting data is more than working with numbers. It involves critically analyzing the results to understand how to answer questions or solve problems.

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 in detail patterns, trends or relationships in data.
ii. Recognize that with multiple trials, there will be a variation in data.
iii. Identify data points that do not follow the general pattern, trend or relationship (outliers).
iv. Explain possible sources of error in methods or equipment.

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 a discrepancy and suggest an explanation for it and any possible sources of error Suggest **change to experimental design to eliminate the source of error** (**independently and consistently**)	Identify and explain an appropriate pattern, trend, and/or relationship Omit discrepant data (outliers) Identify a discrepancy and provide an explanation for it and any possible sources of error	Identify and explain a pattern, trend, and/or relationship, but it is not clear or overly simplistic 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
	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
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

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

Student should draw conclusions from prior learning and logical reasoning as it applies to the evidence gained through investigation.

The **conclusion** should refer back to the initial question, and whether the change (independent variable) affected what was measured (dependent variable). As the student looks at the data, they should ask: “Did what I change make a difference?” It should indicate whether the data supports, refutes or is inconclusive about the prediction and what this indicates moving forward. It is important to note that the findings are valid and are not considered “wrong” even if the prediction was not supported.

Where appropriate, students should compare the results of their investigation to those of others, recognize that results may vary, and explain why. Comparison of findings to those of similar investigations can add weight to the conclusion. It can also lead to a reflection on the fairness of the experimental design and suggestions for improvements for a follow-up investigation.

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 logical conclusion that answers the initial question.
ii. Indicate whether the data supports, refutes or is inconclusive about the initial prediction.
iii. Justify the conclusion by providing evidence 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.
vi. Design, adjust and evaluate a device or system.

Achievement Rubric

	Excelling - 4	Meeting - 3	Approaching - 2	Working Below - 1
Draw conclusions	State a **more detailed** logical conclusion that answers the initial question Justify the conclusion by providing **detailed** evidence Compare findings with **several** other similar investigations Provide **higher level** explanation for the variation in results and suggestions to improve investigation and device or system with a **rationale** Discuss fairness of experimental the design and **improvements**	State a logical conclusion that answers the initial question. Indicate whether the data supports, refutes or is inconclusive about the initial prediction Justify the conclusion by providing evidence from data collected Compare the results of an investigation to those of others and explain why results may vary Design, adjust and evaluate a device or system Discuss fairness of experimental design and suggest improvements for a follow-up investigation.	State a conclusion that is not clear or logical Restate only the recorded results and observations in the conclusion or is a result of flawed reasoning	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
	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

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

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

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. Students should explore what they need for their own learning and how to self-monitor. This requires skills in **metacognition** which is, put simply, thinking about one's thinking.
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.

Question prompts such as the following can help start discussions:
- What would happen if….?
- Based on what you know, how would you explain…?
- Can you think of another way…?
- How could you change and improve….?
- What do you think of…?
- How would you justify…?
- Why was it better that…?
- Do you agree with…?

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

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>