GRADE 4 MATHEMATICS

Statistics and Probability (Data Analysis)

Grade 4: Statistics and Probability (Data Analysis) (4.SP.1, 4.SP.2)

Enduring Understandings:

Graphs are data displays that quickly reveal information about data.

Data can be collected and organized in a variety of ways.

Data can be used to answer questions.

It is not only important to be able to read and construct graphs, but it is important to be able to draw conclusions about the data.

Essential Questions:

How can data be recorded?

What kind of information can we get from different types of graphs?

How can data be organized and interpreted to answer questions and draw conclusions?

SPECIFIC LEARNING OUTCOME(S):	ACHIEVEMENT INDICATORS:
4.SP.1 Demonstrate an understanding of many-to-one correspondence. [C, R, T, V]	➤ Compare graphs in which different intervals or correspondences are used, and explain why the interval or correspondence was used. ➤ Compare graphs in which the same data has been displayed using one-to-one and many-to-one correspondences, and explain how they are the same and different. ➤ Explain why many-to-one correspondence is sometimes used rather than one-to-one correspondence. ➤ Find examples of graphs in which many-to-one correspondence is used in print and electronic media, such as newspapers, magazines, and the Internet, and describe the correspondence used.

SPECIFIC LEARNING OUTCOME(S):	ACHIEVEMENT INDICATORS:
4.SP.2 Construct and interpret pictographs and bar graphs involving many-to-one correspondence to draw conclusions. [C, PS, R, V]	➤ Identify an interval and correspondence for displaying a set of data in a graph, and justify the choice. ➤ Create and label (with categories, title, and legend) a pictograph to display a set of data using many-to-one correspondence, and justify the choice of correspondence used. ➤ Create and label (with axes and title) a bar graph to display a set of data using many-to-one correspondence, and justify the choice of interval used. ➤ Answer a question using a graph in which data is displayed using many-to-one correspondence.

Prior Knowledge

Students may have

- formulated questions and collected data using concrete objects, tallies, check marks, charts, or lists

- constructed and interpreted concrete graphs, pictographs, and bar graphs to solve problems

- collected and organized first-hand data

Background Information

Displaying data enables problems to be solved or information to be communicated. Graphs make data more accessible and easier to interpret. Reading data from a graph should reveal some sort of information at a glance.

Prior to Grade 4, students may have had opportunities to collect data, organize data using tally charts, and display data in pictographs and bar graphs. In Grade 4, students will be comparing, finding, constructing, and interpreting pictographs and bar graphs involving **many-to-one correspondence.** At this level, students may discover that the data they collect is too large to display in a graph using a one-to-one correspondence. Many-to-one correspondence is a representation of many objects by one object or interval in a graph. For example, in a pictograph, one happy face can represent 5 people, and in a bar graph, one rectangle on the graph paper can represent 10 years.

An **interval** is the distance or difference between two numbers or quantities. In graphing, the interval of numbers on one or both axes needs to have equal numerical spacing.

Pictographs use visual items to represent data. A **pictograph** uses uniform, representative pictures to depict quantities of objects or be the same size and shape to avoid misleading the audience.

Example of a pictograph:
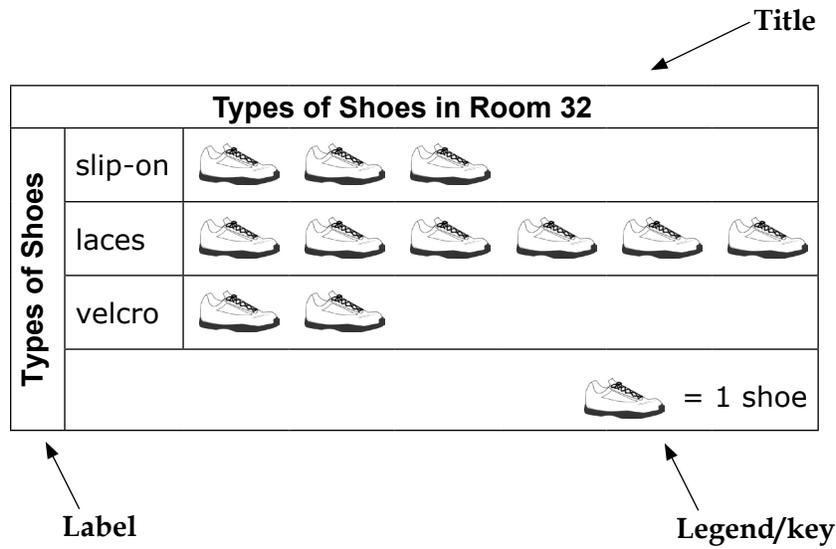
Pictographs need to have a title, labels, and pictures. Legends/keys are needed when the pictures or symbols are used to represent more than one quantity (many-to-one correspondence).

Note: The legend of a pictograph may be called its key. Other resources call it a scale or scale statement.

Marian Small (Small, *Grades 4–8,* 180) suggests the following important points about pictographs with scales:

■   The scale must be clearly stated in the legend/key.

■   The same symbol should be used throughout the graph. This symbol may or may not reflect the context of the data.

■   The first symbol in each category starts at the same level or baseline.

■   The symbols in each category are equally spaced.

■   The symbol chosen should allow for partial symbols that are easy to interpret.

■   Pictographs can be vertical or horizontal.

■   It is important to include labels and a concise but meaningful title to help the reader understand the graph.

A **bar graph** is a graph that uses horizontal or vertical bars to display data.

Example:
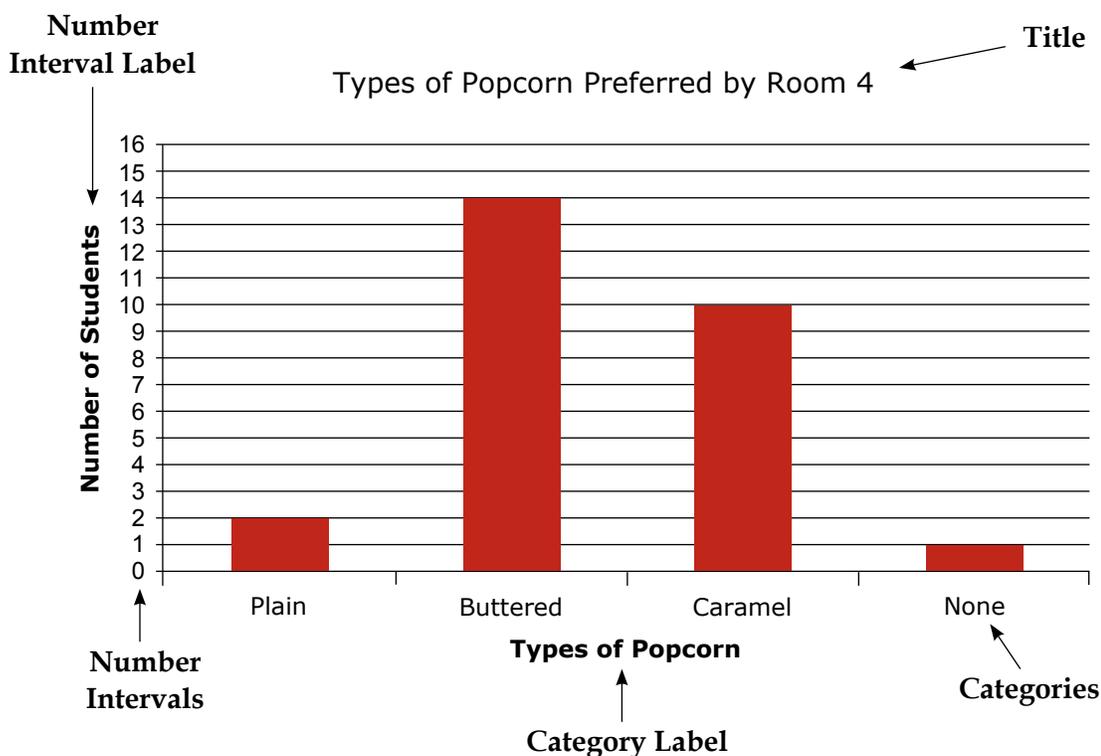
A bar graph needs the following labels:

- title
- categories
- category label
- number intervals (Note: Numbers are labelled on the line not the space.)
- number interval label

Generally the data graphed at the elementary level is discrete data (data attained by counting in whole numbers). In this case, there are always spaces left between the bars.

Marian Small (Small, *Grades 4–8,* 183) suggests the following important points about bar graphs:

- A grid square is used to represent the same quantity throughout.
- Bars should be separated to indicate that they represent discrete data.
- If there are no pieces of data for a category or interval, a space can be left where the bar would be, although it is not required.

- Both axes should be labelled. Each bar should have a label, which might be a discrete topic category, a discrete number category, or a numerical interval category. The other axis, the scale axis, is labelled numerically.

- Axes headings should be used for clarity.

- It is important to include a concise but meaningful title to help the reader understand the graph.

Bar graphs compare the frequency of discrete data. Data are displayed using a number of rectangles (bars) that are the same width. Each bar represents one of the categories that the data have been sorted into. The bars are displayed either horizontally or vertically with a space between them. The height or length of a bar represents the number of observations in that category. The numbers on the y-axis of a vertical bar graph or the x-axis of horizontal bar graph are called the scale.

To get students ready to interpret data on graphs and use them as a problem-solving tool, have them gather meaningful data and learn how to construct graphs. Students will learn that graphs must be clearly labelled and titled so that they communicate information concisely and visually. Interpreting graphs can help students become aware of the features of a graph that can lead to understanding and making sense of the data displayed. Curcio (2001) identifies three levels of graph comprehension: reading the data, reading between the data, and reading beyond the data.

Reading the Data

This level of comprehension requires a literal reading of the graph. The reader simply "lifts" data explicitly stated in the graph, or the information found in the graph title and axes labels, from the graph. There is no interpretation at this level. Reading that requires this type of comprehension is a very low-level cognitive task.

Reading between the Data

This level of comprehension includes the interpretation and integration of the data in the graph. It requires the ability to compare quantities (e.g., greater than, tallest, smallest) and the use of other mathematical concepts and skills (e.g., addition, subtraction, multiplication, division) that allow the reader to combine and integrate data and identify the mathematical relationships expressed in the graph.

Reading beyond the Data

This level of comprehension requires the reader to predict or infer from the data by tapping existing schemata (i.e., background knowledge, knowledge in memory) for information that is neither explicitly nor implicitly stated in the graph. Whereas reading between the data might require the reader to make an inference that is based on the data presented in the graph, reading beyond the data requires that the inference be made on the basis of information in the reader's head, not in the graph.
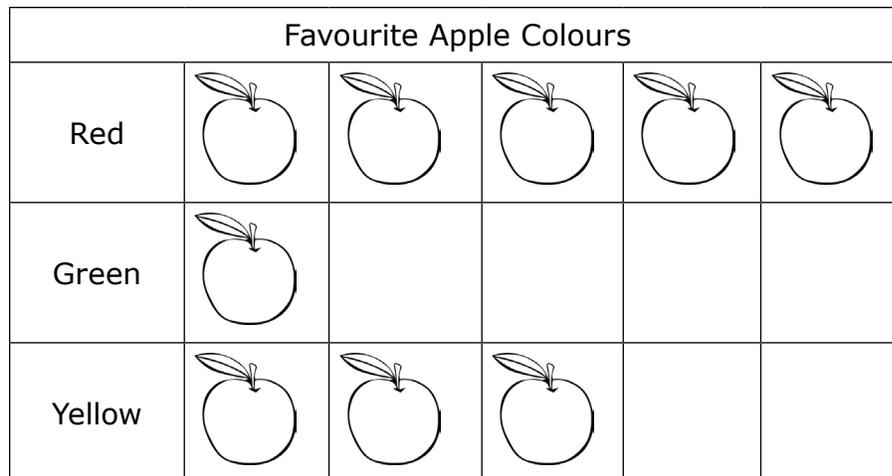
MATHEMATICAL LANGUAGE

categories	least
label	bar graph
title	compare
data	pictograph
tallies	survey
match	interval
more	list
less	axes
same amount as	many-to-one correspondence
most	legend

Assessing Prior Knowledge

Present students with the following pictograph.

Favourite Apple Colours					
Red	🍎	🍎	🍎	🍎	🍎
Green	🍏				
Yellow	🍎	🍎	🍎		

Ask the following questions:

- What does the pictograph show? How do you know?
- What does this tell about the colours of apples?
- Which colour of apple is liked more—yellow or green? How do you know?
- How many people were surveyed? How do you know?

Have students then create a bar graph from the data in the pictograph.

The student

- ❐ describes the data represented in the pictograph
- ❐ answers questions pertaining to the pictograph
- ❐ uses mathematical language correctly
- ❐ identifies an interval and correspondence for displaying a set of data in a graph, and justifies the choice
- ❐ creates a bar graph correctly, including labelling the title and axes

- **Compare graphs in which different intervals or correspondences are used, and explain why the interval or correspondence was used.**
- **Compare graphs in which the same data has been displayed using one-to-one and many-to-one correspondences, and explain how they are the same and different.**
- **Explain why many-to-one correspondence is sometimes used rather than one-to-one correspondence.**
- **Find examples of graphs in which many-to-one correspondence is used in print and electronic media, such as newspapers, magazines, and the Internet, and describe the correspondence used.**

Suggestions for Instruction

BLMs
4.SP.1.1
4.SP.1.2

- **Many-to-One Correspondence:** Provide students with several pictographs and bar graphs (examples are provided in BLMs 4.SP.1.1 and 4.SP.1.2) that show the same data using different scales and intervals.

  (Note: BLM 4.SP.1.1 shows one-half a symbol. A discussion may need to occur to ensure that students understand the meaning of one-half of a symbol.)

  Sample questions that can be asked include the following:

  - Why do they look different?
  - Do the pictographs/bar graphs show the same data?
  - How could you arrange the intervals differently on the bar graph?
  - Why do we use different ways to represent numbers in the legend/key in a pictograph?
  - What conclusions might a person make by looking at these graphs?

- **Tiger Math:** Read the book *Tiger Math: Learning to Graph from a Baby Tiger* by Ann Whitehead Nagda and Cindy Bickel. The story is about an orphaned baby tiger who is hand-raised at a zoo. Different kinds of graphs including pictographs and bar graphs track a variety of data. The format of the book keeps all the graphing on the left side of the book and the story of the tiger on right side. Have a discussion with the students about the implication of the scale used on page 8. The book allows for conversations about why graphs are used and are important.

- Have students find examples of pictographs and bar graphs in which many-to-one correspondence is used and have students describe and justify the scale chosen.

  Guided questions to the discussion can include the following:

  - What does each symbol represent?

  - How many does one symbol represent?

  - Why do you think this scale representation is appropriate? Would you use another representation and why?

  - How does the legend affect the appearance of a pictograph?

  - How do the intervals affect the appearance of a bar graph?

- **Create and label (with categories, title, and legend) a pictograph to display a set of data using many-to-one correspondence, and justify the choice of correspondence used.**
- **Answer a question using a graph in which data is displayed using many-to-one correspondence.**

Suggestions for Instruction

Note: When students are constructing pictographs and bars graphs, many-to-one correspondence should be the focus. If the data is less than 20, one-to-one correspondence is appropriate. For larger numbers, intervals of 2, 4, 5, 10, 25, 100, or 1000 should be used based on the data being graphed. As students construct their graphs, data collected should be of a larger data amount. Students should be able to discuss their data displays and be able to explain why they chose their scale. It is important for students to ensure that the intervals in their graphs are consistent. When creating pictographs, students make decisions about what symbol to use based on the data being used. Discussions are needed to help students create their own pictographs, and they should be prepared to justify their symbol choice.

- **Creating a Pictograph:** Have pairs of students place 40 two-colour counters in a bag. Have each group dump the counters out of the bag and record on a chart how many of one colour is seen. Have the students do five trials and record each result of how many times the one colour is shown. Have students graph the data in a pictograph using a symbol that represents more than one counter. Ensure that the pictograph is appropriately labelled. Have each group discuss how they decided on the legend. Ask students if they needed to use fractions of symbol in their pictographs. Ask students if they could have used a legend so that there would be no fraction.

- **Constructing a Pictograph:** Present the following information to students:

  A taste test at an ice cream store had these results:
  - 80 people liked chocolate
  - 60 people liked vanilla
  - 20 people liked butterscotch
  - 30 people like strawberry

  Have students construct pictographs based on the data. They must decide on which many-to-one correspondence to use. When the graphs have been created, have students share and discuss them. A discussion can follow on the
  - symbols chosen to represent the ice cream
  - legends used
  - advantages and disadvantages of their symbols and legends

  Repeat the activity as needed using other data involving large numbers. Ideas include the following:
  - size of community and habitat populations (connections to social studies and science)
  - measurements (connections to science)

Assessing Understanding

Develop criteria with the students about how to assess the construction of a pictograph. Possible criteria may include the following:

- appropriate title
- legend/key presented in order to show how much each symbol represents
- same symbol throughout graph
- symbols start at the same level and are equally spaced
- appropriate labels

- **Create and label (with axes and title) a bar graph to display a set of data using many-to-one correspondence, and justify the choice of interval used.**

- **Answer a question using a graph in which data is displayed using many-to-one correspondence.**

Suggestions for Instruction

- **Constructing a Bar Graph:** Have students conduct school-wide investigations to find out what additional types of equipment students would like to see in their playground. Have students come up with choices such as curved slide, basketball hoop, swinging bridge, rock wall, or tunnel.

  - Students survey each classroom by preparing blank tickets for the survey choice.

  - When the data has been collected, guide the students in organizing the data by asking "What would be an easy way to count the tickets?" Students may suggest grouping in 10s or 5s. Have the students justify their choices. Discuss the problem of units left over.

  - Have students in pairs make bar graphs using intervals of their choice. Students discuss their choice.

  - Have each group present their graphs to the rest of the class, discussing the following questions:
    – What three things do you know from looking at the data?
    – What type of equipment was most popular?
    – Why did you choose the interval for your graph?
    – Is a bar graph a good graph to use to represent this data to the rest of the school?

- **Graphing Raisins:** Provide each student with a small box of raisins. Have students estimate and justify the number of raisins in the box. Have students count and record the number of raisins in each box. Have the class pool the results and discuss how to display the information. Discuss the possibility of grouping the data (counts between 15–20, 21–26, etc.). Have the students create a bar graph with the data. Create a bar graph that shows the grouping of the data. Discuss what data can be derived from the graph. Discuss the advantages and disadvantages of each graph. Ask students the impact of using intervals of different sizes to represent the data. Have students answer the following questions about their bar graph:

  - Which count occurred most frequently?

  - Which count occurred the fewest number of times?

- Which count is the lowest?
- Which count is the highest?
- How can we determine which is the best graph form to use to display our data?
- How do you think another brand of raisins would compare?
- What other questions come to mind when looking at the data on the graph?
- Who do you think would be interested in this data?

Examples:

Raisins in Box

Raisins in Box
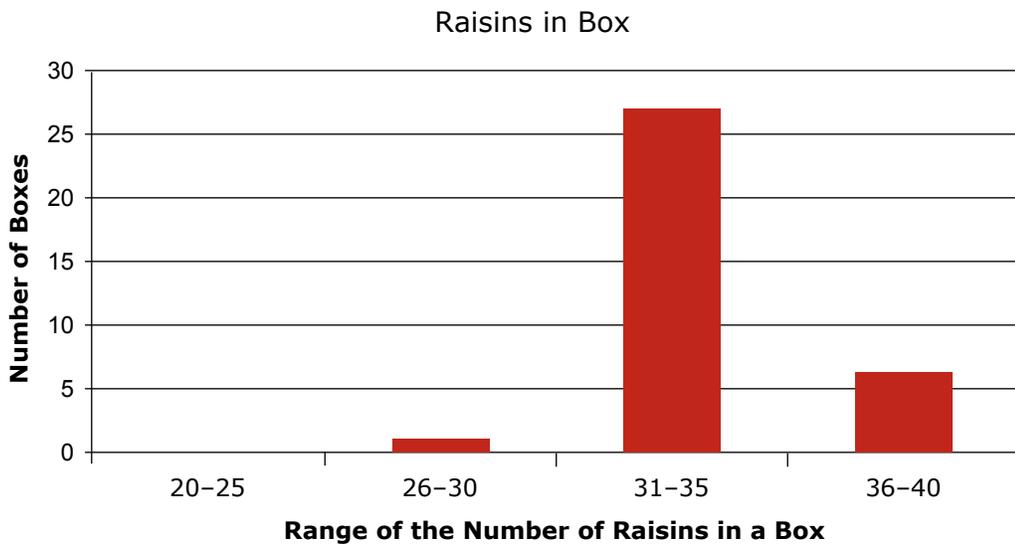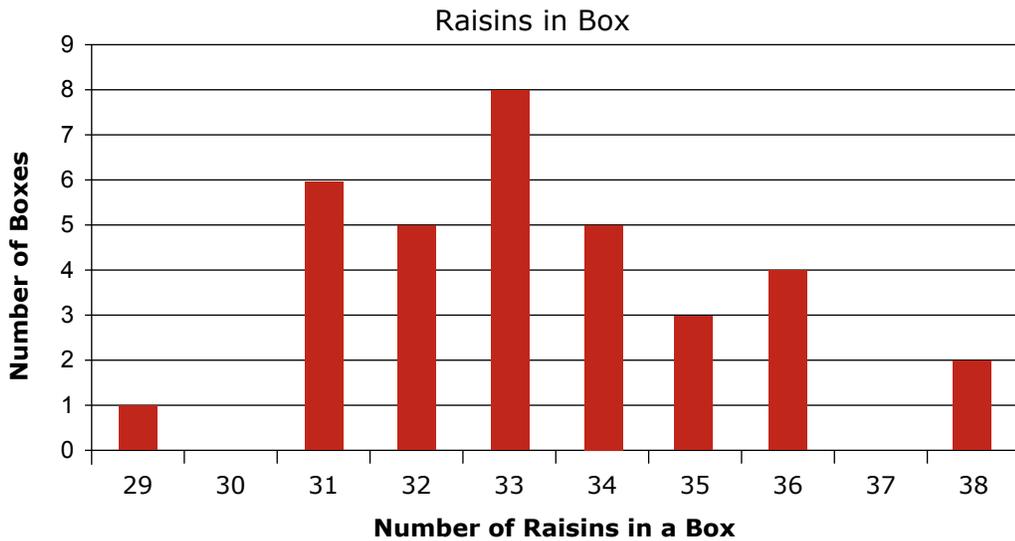
- Have students find pictographs and bar graphs from magazines and newspapers or use previously collected data from students. In groups, discuss and analyze the graphs. Have students identify general statements that can be verified by the data presented in the graphs. Students' analyses of the graphs should focus on drawing conclusions and encourage questions about the data.

Assessing Understanding

Develop criteria with the students about how to assess the construction of a bar graph. Possible criteria may include the following:

- both axes labelled
- categories labelled
- numbers labelled on the lines
- spaces between bars
- bars filled in correctly

PUTTING THE PIECES TOGETHER

Food Labels

Organization:

Groups of 2 or 3

Materials:

A collection of food labels from different foods (students can choose a food category such as cereal, crackers, beverages, etc.).

Context:

BLMs
4.SP.2.1

The class wants to raise money for a field trip. The class decided to sell snacks at recess time. The principal told the class the snacks must be healthy and told the class to prepare a presentation with graphs showing data about the food they want to sell. The presentation must include the following:

- a pictograph or bar graph that represents many-to-one correspondence
- an analysis of the data from the food labels
- a statement about why the snacks will be good choice to sell to the students at the school

Show and discuss how to read a food label, using labels such as the one shown in BLM 4.SP.2.1. Information about food labels can be found at https://www.canada.ca/en/health-canada/services/understanding-food-labels/nutrition-facts-tables.html. This discussion can match outcomes from the Grade 4 Physical Education/Health Education curriculum.

Nutrition Facts
Valeur nutritive

Per 37 crackers (20 g) / pour 37 craquelins (20 g)

Amount Teneur	% Daily Value % valeur quotidienne
Calories / Calories 90	
Fat / Lipides 3.5 g	5 %
Saturated / saturés 1 g + Trans / trans 0 g	5 %
Cholesterol / Cholestérol 5 mg	
Sodium / Sodium 170 mg	7 %
Carbohydrate / Glucides 13 g	4 %
Fibre / Fibres 1 g	4 %
Sugars / Sucres 0 g	
Protein / Protéines 2 g	
Vitamin A / Vitamine A	0 %
Vitamin C / Vitamine C	0 %
Calcium / Calcium	2 %
Iron / Fer	6 %

INGREDIENTS: ENRICHED WHEAT FLOUR, CHEDDAR CHEESE (MILK, BACTERIAL CULTURE, SALT, MICROBIAL ENZYME, ANNATTO), VEGETABLE OIL (CANOLA AND/OR SUNFLOWER), SALT, YEAST, SUGAR, AUTOLYZED YEAST, SEASONING (CONTAINS CELERY, ONION POWDER), BAKING POWDER, AMMONIUM BICARBONATE.
INGRÉDIENTS : FARINE DE BLÉ ENRICHE, CHEDDAR (LAIT, CULTURE BACTÉRIENNE, SEL, ENZYME MICROBIEN, ROCOU), HUILE VÉGÉTALE (CANOLA ET/OU TOURNESOL), SEL, LEVURE, SUCRE, LEVURE AUTOLYSÉE, ASSAISONNEMENT (CONTIENT DU CÉLÉRI, POUDRE D'OIGNON), POUDRE À PÂTE, BICARBONATE D'AMMONIUM.

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Brainstorm with the class different categories of food they could sell (crackers, beverages, granola bars, etc.). Give each group a category and have them research the nutritional facts of food within the category. Each group must decide on 4 specific food items that are healthy to sell. Groups must present their information to the whole class. The presentation must include the following:

- a pictograph or bar graph that represents many-to-one correspondence
- an analysis of the data from the food labels
- a statement about why the snacks will be a good choice to sell to the students at the school

Get the students to vote on what food items would be good to sell at school. Have students make a graph of the votes. Have students answer the following questions about the vote by using the information gathered from each group.

- What was the favourite food of the class?
- Do you think it would sell to other students in the school?
- What are the top three favourite food choices in the class?
- Do you think the top three food choices are healthy? Why?
- Do you think the food will sell?

A further discussion can be held with the class that can lead to drawing conclusions about the data collected. Questions include the following:

- What impact on your eating habits may result from hearing the data presented?
- Will the data presented encourage you to look at food labels?
- Do words and images on packages mislead people about what is actually in the food?
- How can nutritional information on labels help you find out how nutritional the food is?

Look for the following:

- ❒ Graphs were completed correctly.
- ❒ Data were represented correctly.
- ❒ Data were summarized correctly.
- ❒ Students were able to compare quantities in the graph.
- ❒ Conclusions were valid.

Notes
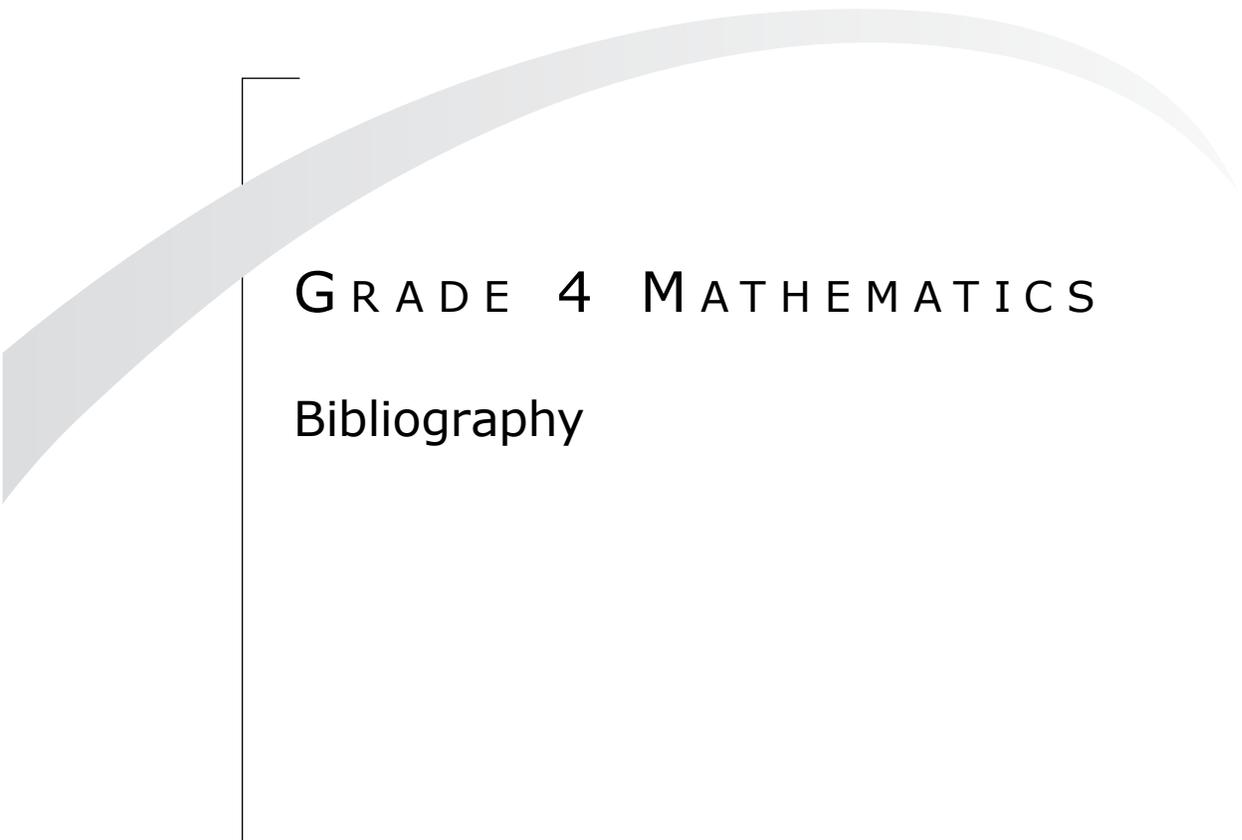
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Bibliography