Mathematics

Planning Guide

Grade 5 *Capacity*

Shape and Space (Measurement)

Specific Outcome 5

This Planning Guide can be accessed online at:
http://www.learnalberta.ca/content/mepg5/html/pg5_capacity/index.html

Table of Contents

Curriculum Focus 2

What Is a Planning Guide? 2

Planning Steps 3

Step 1: Identify Outcomes to Address 5
Big Ideas 4
Sequence of Outcomes from the Program of Studies 6

Step 2: Determine Evidence of Student Learning 8
Using Achievement Indicators 8

Step 3: Plan for Instruction 9
A. Assessing Prior Knowledge and Skills 9
Sample Structured Interview: Assessing Prior Knowledge and Skills 11
B. Choosing Instructional Strategies 13
C. Choosing Learning Activities 14

Sample Activities for Teaching the Comparison of Capacities
Sample Activity 1: Conservation of Capacity 16
Sample Activity 2: Direct Comparison of Capacities 17
Sample Activity 3: Indirect Comparison of Capacities 18

Sample Activities for Teaching the Measurement of Capacity Using Nonstandard Units
Sample Activity 1: Measuring Capacity Using Nonstandard Units 20
Sample Activity 2: Using Different Sized Units to Measure the Same Capacity 21
Sample Activity 3: Making a Calibrated or Graduated Beaker 22

Sample Activities for Teaching the Use of Referents for mL or L in Estimating Capacity and Then Finding the Actual Capacity using Standard Units
Sample Activity 1: Standard Units for Capacity 24
Sample Activity 2: Sorting Containers by Capacity 25
Sample Activity 3: Referents for Capacity and Estimating Capacity; Finding the Actual Capacity 26
Sample Activity 4: Estimate–Measure–Estimate–Measure Sequences 27

Sample Activities for Teaching the Relationship between mL and L
Sample Activity 1: Using Manipulatives to Connect Millilitres and Litres 28
Sample Activity 2: Using a Combination of Smaller Containers to Fill a 1 L Container 29
Sample Activity 3: Frayer Model for Capacity 30

Step 4: Assess Student Learning 33
A. Whole Class/Group Assessment 33
B. One-on-one Assessment 37
C. Applied Learning 37

Step 5: Follow-up on Assessment 38
A. Addressing Gaps in Learning 38
B. Reinforcing and Extending Learning 39

Bibliography 40

Planning Guide: *Grade 5 Capacity*

Strand: Shape and Space (Measurement)
Specific Outcome: 5

This *Planning Guide* addresses the following outcomes from the Program of Studies:

Strand: Shape and Space (Measurement)	
Specific Outcome:	5. Demonstrate an understanding of capacity by: • describing the relationship between mL and L • selecting and justifying referents for mL or L units • estimating capacity, using referents for mL or L • measuring and recording capacity (mL or L).

Curriculum Focus

The changes to the curriculum targeted by this sample include:

- The general outcome focuses on using direct or indirect measurement to solve problems; whereas the previous math curriculum focused on using measurement concepts, appropriate tools and results of measurements to solve problems in everyday contexts.
- The specific outcome focuses on most of the same concepts related to capacity as the previous math curriculum, including estimating, measuring and recording capacity; however, the previous curriculum included these concepts in Grade 4, not in Grade 5. The previous math curriculum included ordering containers by capacity, which is not included in the present curriculum.
- The specific outcome includes referents for the units mL or L; whereas the previous math curriculum does not.
- The specific outcome includes the relationship between mL and L; whereas the previous curriculum uses conversions among commonly used SI units for capacity in Grade 6.

What Is a Planning Guide?

Planning Guides are a tool for teachers to use in designing instruction and assessment that focuses on developing and deepening students' understanding of mathematical concepts. This tool is based on the process outlined in *Understanding by Design* by Grant Wiggins and Jay McTighe.

Planning Steps

The following steps will help you through the Planning Guide:

- **Step 1: Identify Outcomes to Address** (p. 5)
- **Step 2: Determine Evidence of Student Learning** (p. 8)
- **Step 3: Plan for Instruction** (p. 9)
- **Step 4: Assess Student Learning** (p. 33)
- **Step 5: Follow-up on Assessment** (p. 38)

Step 1: Identify Outcomes to Address

Guiding Questions

- What do I want my students to learn?
- What can my students currently understand and do?
- What do I want my students to understand and be able to do based on the Big Ideas and specific outcomes in the program of studies?

Big Ideas

Van de Walle and Lovin (2006) define capacity as "the amount that a container will hold" (p. 265). Standard units of capacity include millilitres (mL) and litres (L). Van de Walle and Lovin (2006) explain that these units are generally used for "liquids as well as the containers that hold them," but "the term volume can also be used to refer to the capacity of a container" (p. 266).

The unit model for capacity is "a small container that is filled and poured repeatedly into the container being measured" (Van de Walle and Lovin 2006, p. 267).

By estimating a measure first and then using measuring instruments to measure, students develop measurement sense. Cathcart (1997) states, "… students should be encouraged to estimate before they measure and to record their results as they find the capacities of a variety of containers using a nonstandard unit" (p. 218). Estimation in measurement is defined as follows:

> "Measurement estimation is the process of using mental and visual information to measure or make comparisons without the use of measuring instruments. It is a practical skill" (Van de Walle and Lovin 2006, p. 278).

In using any type of measurement, such as length, area or volume/capacity, it is important to discuss the similarities in developing understanding of the different measures. First identify the attribute to be measured, then choose an appropriate unit and finally compare that unit to the object being measured (NCTM 2000, p. 171). As with other attributes, it is important to understand the attribute of capacity before measuring. An attribute of an object is an aspect of that object that can be measured. "The measure of an attribute is a count of how many units are needed to fill, cover, or match the attribute of the object being measured" (Van de Walle and Lovin 2006, p. 253).

Key ideas in understanding the attribute of capacity include:

- conservation—an object retains its size when the orientation is changed or it is rearranged by subdividing it in any way
- iteration—the repetitive use of an identical non-standard or standard unit of capacity to entirely fill a container
- additivity—adding the measures of the capacity for each part of a container to obtain the measure of the entire container

- proportionality—there is an inverse relationship between the size of the unit used to measure capacity and the number of units needed to measure the capacity of a given container; i.e., the smaller the unit, the more you need to measure the capacity of a given container
- transitivity—when direct comparison of two capacities is not possible, use a third item that allows comparison; e.g., to compare the capacity of two containers, find the capacity of one container using non-standard or standard units and compare that measure with the capacity of the other container (if A = B and B = C, then A = C)
- standardization—using standard units for measuring capacity such as millilitre (mL) and litre (L) facilitates communication of measures globally
- unit/unit-attribute relations—units used for measuring capacity must relate to capacity; e.g., mL must be used to measure capacity and not cm or cm^2.

Sequence of Outcomes from Program of Studies

See http://education.alberta.ca/teachers/core/math/programs.aspx for the complete program of studies.

Grade 4	Grade 5	Grade 6
Specific Outcomes	**Specific Outcomes**	**Specific Outcomes**
3. Demonstrate an understanding of area of regular and irregular 2-D shapes by: • recognizing that area is measured in square units • selecting and justifying referents for the units cm^2 or m^2 • estimating area by using referents for cm^2 or m^2 • determining and recording area (cm^2 or m^2) • constructing different rectangles for a given area (cm^2 or m^2) in order to demonstrate that many different rectangles may have the same area. 4. Describe and construct right rectangular and right triangular prisms.	5. Demonstrate an understanding of capacity by: • describing the relationship between mL and L • selecting and justifying referents for mL or L units • estimating capacity, using referents for mL or L • measuring and recording capacity (mL or L).	2. Develop and apply a formula for determining the: • perimeter of polygons • area of rectangles • volume of right rectangular prisms.

Step 2: Determine Evidence of Student Learning

Guiding Questions

- What evidence will I look for to know that learning has occurred?
- What should students demonstrate to show their understanding of the mathematical concepts, skills and Big Ideas?

Using Achievement Indicators

As you begin planning lessons and learning activities, keep in mind ongoing ways to monitor and assess student learning. One starting point for this planning is to consider the achievement indicators listed in the program of studies. You may also generate your own indicators and use them to guide your observation of the students.

The following indicators may be used to determine whether or not students have met this specific outcome. Can students:

- use direct comparison to compare the capacity of two containers?
- use nonstandard units to measure the capacity of containers?
- make indirect comparisons by using nonstandard units to measure the capacity of containers?
- measure a container using larger then smaller nonstandard units of measure to establish that the smaller the unit of measure the more you need to measure the capacity of a given container?
- construct a graduated or calibrated beaker using nonstandard units of measurement for capacity?
- demonstrate that 1000 millilitres is equivalent to 1 litre by filling a 1 litre container using a combination of smaller containers?
- provide a referent for a litre and explain the choice?
- provide a referent for a millilitre and explain the choice?
- determine the capacity unit of a given referent?
- estimate the capacity of a given container using personal referents?
- determine the capacity of a given container using materials that take the shape of the inside of the container (e.g., a liquid, rice, sand, beads) and explain the strategy?

Sample behaviours to look for related to these indicators are suggested for some of the activities listed in **Step 3, Section C: Choosing Learning Activities** (p. 14).

Step 3: Plan for Instruction

Guiding Questions

- What learning opportunities and experiences should I provide to promote learning of the outcomes and permit students to demonstrate their learning?
- What teaching strategies and resources should I use?
- How will I meet the diverse learning needs of my students?

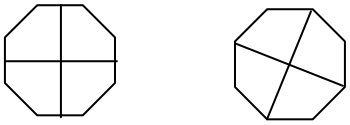
A. Assessing Prior Knowledge and Skills

Before introducing new material, consider ways to assess and build on students' knowledge and skills related to capacity. For example:

Have the students complete Part A (Estimating Area) and hand it in. Then provide them with Part B (Finding Area), along with centimetre rulers, centimetre grid paper, triangular or isometric dot paper, pattern blocks and other manipulatives they may wish to use.

Part A: Estimating Area

1. For the following pair of congruent shapes, decide if one of the four parts of the first figure has the same area as one of the four parts of the second figure. Explain your thinking.



2. Estimate the area of the following rectangle. Explain the referent you used in making the estimate.

Part B: Finding Area

1. Compare the areas of the following two rectangles. One rectangle is 4 cm by 12 cm. The other rectangle is 6 cm by 8 cm.
   a. Draw a diagram on cm grid paper and use words to explain your thinking.
   b. Explain how you could compare the areas of these two rectangles by rearranging one rectangle.

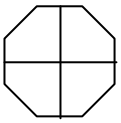
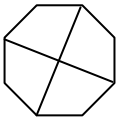
2. Explain why area is measured in square units.

3. Lisa and her dad are building a rabbit hutch for their rabbits. They decide that the hutch will have an area of 18 m^2.
   a. Draw all the possible rectangular pens that have the area of 18 m^2 on cm grid paper. The sides of the rectangles must be measured in whole numbers. Each centimetre on the grid paper will represent 1 metre.
   b. Explain how you know that you have drawn all the possible rectangular pens.

4. Marie measured a pattern block design with red trapezoids and said that the measure of the area was 6 trapezoids. Jaden measured the same design and said the area was 18 green triangles. Could both be correct? Why or why not? Draw a diagram and use words to explain your thinking. Use the triangular dot paper provided.

If a student appears to have difficulty with these tasks, consider further individual assessment, such as a structured interview, to determine the student's level of skill and understanding. See **Sample Structured Interview: Assessing Prior Knowledge and Skills** (p. 11).

Sample Structured Interview: Assessing Prior Knowledge and Skills

Directions	Date:	
	Not Quite There	**Ready to Apply**
Place the following figures before the student:   Say, **"For this pair of congruent shapes, decide if one of the four parts of the first figure has the same area as one of the four parts of the second figure. Explain your thinking."**	Explains that the two parts do not have the same area because they do not have the same shape. Or, says that the two parts do have the same area but is unable to explain why.	Explains that the two parts have the same area because they are each one-quarter of congruent shapes.
Place the following rectangle before the student:  Say, **"Estimate the area of this rectangle. Explain the referent you used in making the estimate."**	Estimates the area but the estimate is inaccurate; i.e., different from the actual area by more than 20%. Does not use a referent to make the estimate.	Uses a referent to estimate the area of the rectangle to within 20% of the actual area. Explains how the referent is used to find the estimate.
Provide the student with centimetre grid paper. Present the following problem to the student: **"Compare the areas the two rectangles. One rectangle is 4 cm by 12 cm. The other rectangle is 6 cm by 8 cm.** **a. Draw a diagram on cm grid paper and use words to explain your thinking.** **b. Explain how you could compare the areas of these two rectangles by rearranging one rectangle."**	Draws the rectangles inaccurately on the grid paper. Compares the areas of these two rectangles incorrectly with an unsuccessful attempt at rearranging one rectangle. Or, compares the areas of these two rectangles correctly but is unable to rearrange one rectangle to show it has the same area as the other rectangle.	Draws the two rectangles accurately on the grid paper. Compares the areas of the two rectangles correctly by rearranging one rectangle so that it can be superimposed perfectly onto the other rectangle, proving that the areas of the two rectangles are the same.

<table>
<tr>
<td>Say, "Explain why area is measured in square units."</td>
<td>Provides a vague or no explanation of why area is measured in square units.</td>
<td>Provides a clear explanation of why area is measured in square units using appropriate mathematical language.
Example:
Squares do not leave gaps when used to cover a 2-D shape and there is only one shape for a square, so everyone knows the shape of a square unit.</td>
</tr>
<tr>
<td>Provide the student with centimetre grid paper.
Present the following problem to the student:
"Lisa and her dad are building a rabbit hutch for their rabbits. They decide that the hutch will have an area of 18 m^2.
a. Draw all the possible rectangular pens that have the area of 18 m^2 on cm grid paper. The sides of the rectangles must be measured in whole numbers. Each centimetre on the grid paper will represent 1 metre.
b. Explain how you know that you have drawn all the possible rectangular pens."</td>
<td>Draws one or more but not all the possible rectangular pens.

Does not explain convincingly how he or she knows that all the possible rectangular pens have been drawn.</td>
<td>Draws all the possible rectangular pens.

Explains clearly how he or she knows that all the possible rectangular pens have been drawn.
Example:
The student uses patterns in a chart.
<table>
<tr><th>Length</th><th>Width</th></tr>
<tr><td>1 cm</td><td>18 cm</td></tr>
<tr><td>2 cm</td><td>9 cm</td></tr>
<tr><td>3 cm</td><td>6 cm</td></tr>
</table>
The student explains that a 3 cm by 6 cm rectangle is the same as a 6 cm by 3 cm rectangle. Therefore, all the possible rectangles with whole number dimensions are included in the chart.</td>
</tr>
<tr>
<td>Provide the student with triangular or isometric dot paper.
Present the student with the following problem:
"Marie measured a pattern block design with red trapezoids and said that the measure of the area was 6 trapezoids. Jaden measured the same design and said the area was 18 green triangles. Could both be correct? Why or why not? Draw a diagram and use words to explain your thinking. Use the triangular dot paper provided."</td>
<td>Guesses that both Marie and Jaden could be correct or incorrect but does not provide justification by drawing diagrams or explaining with words.</td>
<td>States that both Marie and Jaden are correct and proves it by drawing appropriate diagrams and explaining using correct mathematical language.

Example:
There are 3 green triangles that cover the same area as 1 red trapezoid. Therefore, 6 trapezoids have the same area as 18 green triangles because $3 \times 6 = 19$.</td>
</tr>
</table>

B. Choosing Instructional Strategies

Consider the following general strategies for teaching capacity (Van de Walle 2001):

- Access prior knowledge on using perimeter, area and volume in the real world.
- Introduce capacity by drawing on familiar and accessible contexts to illustrate uses of capacity (NCTM 2000).
- Review the process used in developing understanding of perimeter, area and volume and use a similar process in developing understanding of capacity, stressing that the attribute changes but the process is similar:
  - Explain that the attribute to be measured is capacity.
  - Check for conservation of capacity; e.g., pour liquid to the same level in two identical containers and then pour the liquid from one of the containers into a taller or shorter container and compare the amount of liquid.
  - Always estimate prior to comparing or measuring capacity.
  - Make direct comparisons; e.g., compare the capacity of two containers by pouring the content of one container into the other container.
  - Estimate the capacity of a container using nonstandard units of measure; e.g., plastic caps or liquid medicine cups. Use various techniques for estimating capacity:
    - Referents—use a referent for the single unit of measure and iterate this unit mentally to obtain the estimate; e.g., use a handful as a referent for about 25 mL.
    - Chunking—estimate the capacity of a smaller portion of a container initially and use this estimate to estimate the entire capacity of the container; e.g., estimate the capacity of a smaller section of a container and then multiply that answer by the number of these sections in the entire container.
    - Iteration—iterate a unit mentally or physically; e.g., use a single unit repeatedly to visually estimate the capacity of a container (Van de Walle and Lovin 2006).
  - Have the students share their strategies for estimating capacity.
  - Accept a range of estimates—within 30% of the actual measure is reasonable (Van de Walle and Lovin 2006, p. 279).
  - Encourage the students to measure the capacity after each estimate so that they develop a better sense of capacity.
  - Use nonstandard units of measure that have the same attribute as the item being measured; e.g., use plastic caps or liquid medicine cups to measure capacity of a container.
  - Make indirect comparisons using a nonstandard unit of measure that has the same attribute as the item being measured; e.g., use plastic caps or liquid medicine cups to measure the capacities of containers for the purpose of comparison.
  - Measure the capacity of a container using larger then smaller nonstandard units of measure to establish that the smaller the unit of measure, the more you need to measure the capacity of a given container; e.g., more small plastic capfuls are needed than larger plastic capfuls to measure the capacity of a given container.
  - Explain the need to use standard units to measure capacity to facilitate communicating the measurements globally.

– Measure the capacity of a given container using an appropriate instrument with standard units of measure; e.g., use a graduated beaker marked in millilitres to measure the capacity of a container.

C. Choosing Learning Activities

The following learning activities are examples of activities that could be used to develop student understanding of the concepts identified in Step 1.

Sample Activities:

Teaching the Comparison of Capacities

1. **Conservation of Capacity** (p. 16)
2. **Direct Comparison of Capacities** (p. 17)
3. **Indirect Comparison of Capacities** (p. 18)

Teaching the Measurement of Capacity Using Nonstandard Units

1. **Measuring Capacity Using Nonstandard Units** (p. 20)
2. **Using Different Sized Units to Measure the Same Capacity** (p. 21)
3. **Making a Calibrated or Graduated Beaker** (p. 22)

Teaching the Use of Referents for mL or L in Estimating Capacity and then Finding the Actual Capacity using Standard Units

1. **Standard Units for Capacity** (p. 23)
2. **Sorting Containers by Capacity** (p. 25)
3. **Referents for Capacity and Estimating Capacity; Finding the Actual Capacity** (p. 26)
4. **Estimate–Measure–Estimate–Measure Sequences** (p. 27)

Teaching the Relationship between mL and L

1. **Using Manipulatives to Connect Millilitres and Litres** (p. 29)
2. **Using a Combination of Smaller Containers to Fill a 1 L Container** (p. 30)
3. **Frayer Model for Capacity** (p. 31)

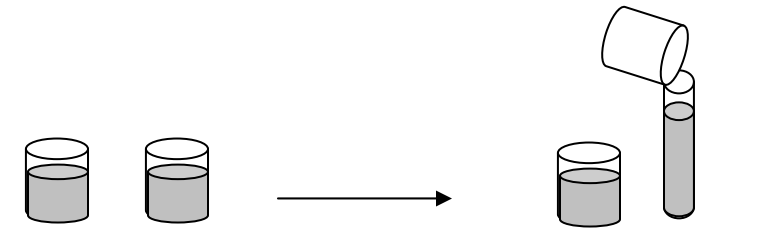
Teaching the Comparison of Capacities

Sample Activity 1: Conservation of Capacity

This activity adapted from W. George Cathcart, Yvonne M. Pothier and James H. Vance, *Learning Mathematics in Elementary and Middle Schools* (2nd ed.) (Scarborough, ON: Prentice Hall Allyn and Bacon Canada, 1997), p. 217. Used with permission of Pearson Canada.

Show the students two identical glasses placed side by side. Pour water into one of the glasses. Have a student pour water into the other glass so that it contains the same amount; i.e., the water level in the two glasses is the same.

Then pour the water from the first glass into a taller narrow glass and ask if it contains more, less or the same amount of water as the student's glass. Encourage the students to justify their answers.



Look For …

Do students:

- ☐ conserve capacity?
- ☐ compare the capacities of two containers by using direct or indirect comparison?

Sample Activity 2: Direct Comparison of Capacities

This activity adapted from W. George Cathcart, Yvonne M. Pothier and James H. Vance, *Learning Mathematics in Elementary and Middle Schools* (2nd ed.) (Scarborough, ON: Prentice Hall Allyn and Bacon Canada, 1997), p. 215. Used with permission of Pearson Canada.

Hold up two empty containers. Choose two containers, ensuring that one container fits inside the other container. Ask the students to predict which container holds more. Then place one container inside the other container to show which container holds more and to check the predictions.

Have the students suggest other containers that could be used to compare the capacities directly. Then guide the discussion to the idea that for many containers the capacities cannot be compared directly; therefore, indirect comparison must be used.

Sample Activity 3: Indirect Comparison of Capacities

Hold up two empty containers. Choose two containers, ensuring that one container does not fit inside the other container. Ask the students for suggestions as to how they could compare the capacities of these two containers. Guide the discussion to include the following ways to compare the capacities of the two containers indirectly:

- Fill one container with water, sand or rice and pour the contents into the other container to see if it fills, overflows or does not fill this container.
- Use nonstandard units such as liquid medicine cups or small yogurt containers and count how many of these nonstandard units are needed to fill each of the containers.

Teaching the Measurement of Capacity Using Nonstandard Units

Sample Activity 1: Measuring Capacity Using Nonstandard Units

Provide the students with a variety of different sized containers along with water, sand or rice to fill the containers. Have the students find the capacity of one of the larger containers by finding out how many times a smaller container must be filled in order to hold the same amount as the larger container. Encourage the students to write the measure of capacity by using a number and a unit; e.g., the margarine container holds the same amount as three cream cheese containers.

Explain that a nonstandard unit for measuring capacity that is related to the body is the "handful." Ask the students to estimate and then measure how many handfuls of peas, beans or corn it takes to fill a margarine container. Have the students compare their results using handfuls as a unit of measurement. Guide the discussion to generalize that the smaller the handful, the more handfuls are needed to fill a given container.

This paragraph adapted from W. George Cathcart, Yvonne M. Pothier and James H. Vance, *Learning Mathematics in Elementary and Middle Schools* (2nd ed.) (Scarborough, ON: Prentice Hall Allyn and Bacon Canada, 1997), p. 218. Used with permission of Pearson Canada.

Look For …

Do students:

- ☐ estimate the capacity of a container using a nonstandard unit?
- ☐ repeatedly use a nonstandard unit of measurement to measure the capacity of a container?
- ☐ record the nonstandard measure of capacity using a number and a unit?
- ☐ show with examples that more nonstandard units are needed to measure a given container when the nonstandard units are smaller?
- ☐ use nonstandard units to make a calibrated beaker?

Sample Activity 2: Using Different Sized Units to Measure the Same Capacity

Provide each group of students with a large container, such as a 1 L milk carton, and smaller containers, such as frozen juice, cottage cheese and margarine containers. Also, provide water, sand or rice to fill the containers.

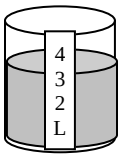
Have the students use one of the smaller containers (e.g., a frozen orange juice container) to fill the 1 L milk carton and note the measure of the carton's capacity using a number and a unit. Then have the students predict what will happen if they use a smaller unit (e.g., cream cheese container) to fill the same large container. Encourage them to explain why more of these units will be needed to fill the 1 L container. Then have them check their predictions by repeatedly pouring the contents of the smaller container into the large container.

Through discussion, have the students generalize; e.g., to compare capacities, the same size unit of measure must be used (i.e., either a cream cheese container or a frozen juice container). Review the fact that the smaller the unit used to measure capacity, the more of these units are needed.

Sample Activity 3: Making a Calibrated or Graduated Beaker

This activity adapted from W. George Cathcart, Yvonne M. Pothier and James H. Vance, *Learning Mathematics in Elementary and Middle Schools* (2nd ed.) (Scarborough, ON: Prentice Hall Allyn and Bacon Canada, 1997), p. 218. Used with permission of Pearson Canada.

Have the students make their own calibrated or graduated beaker by placing a strip of masking tape along the length of a tall, clear glass. Then have the students mark with a felt pen the water level for 1, 2, 3 and 4 smaller containers. Suggest that they use their calibrated beaker to find the capacity of various containers using this nonstandard unit for measuring capacity.



Teaching the Use of Referents for mL or L in Estimating Capacity and Then Finding the Actual Capacity Using Standard Units

Sample Activity 1: Standard Units for Capacity

Review the linear units (centimetre and metre) used to find the perimeter of 2-D shapes. Explain that these standard units of measure were used to find perimeter so that the perimeters of shapes could be compared and communicated clearly. Similarly, review the standard units for area and volume. Connect the need for standard units in finding perimeter, area and volume to the need for standard units in finding capacity.

Review the discussion on using a cubic unit for volume found in the end-to-end plans for volume. Show the students a hollow unit cube for overhead base ten blocks. Fill the unit cube with water and explain that this amount of water is called 1 millilitre. Pour the water into the 1 mL measuring spoon to verify.

Another way to introduce the millilitre is to have the students use a graduated beaker with a scale marked in millilitres. Instruct them to drop a solid centicube into a graduated cylinder partially filled with water and note the rise in the water level. The students should conclude that the water level rises 1 mL when the centicube is submerged.

These hands-on activities connect volume to capacity; i.e., 1 cm^3 occupies the same space as 1 mL of water. Therefore, 1 mL is used as a standard unit of capacity.

Look For …

Do students:

- ☐ recognize the difference between the standard units for perimeter, area, volume and capacity?
- ☐ use a personal referent for estimating capacity that relates well to the standard units?
- ☐ explain clearly how to estimate the capacity of a given container?
- ☐ estimate the capacity prior to measuring the capacity and then compare the actual capacity to the estimated capacity?

Through discussion, conclude that the standard units used for capacity are mL and L. Provide hands-on experience using graduated beakers to show that 1000 mL is the same as 1 L. Have the students use a variety of familiar containers, such as a 1 L milk carton and a 4 L ice cream pail, to develop an understanding of one litre and the repeated use of this standard unit of measure for capacity.

Sample Activity 2: Sorting Containers by Capacity

Provide a variety of containers with a capacity of more than a litre, less than a litre or equal to a litre. Have the students sort the containers into groups, label each group and justify their sorting rules.

Sample Activity 3: Referents for Capacity and Estimating Capacity; Finding the Actual Capacity

Review the referents used for centimetre (width of the pinky finger) and metre (distance from the teacher's finger tip to his or her opposite shoulder). Ask the students to suggest a suitable referent for mL and explain why they think it would work.

Have the students use their referent for 1 mL to estimate the capacity of a small container in millilitres. Then have them find the capacity of the container by filling it with water, sand or rice and pouring the contents into a graduated beaker. Another method is to repeatedly use the 1 mL measuring spoon to fill the container and write the number of mL used. Then have the students compare their answers to their estimated answers.

Similarly, discuss possible referents for 1 L after the students see containers that hold 1 L, such as a 1 L milk container. Have the students use their referents and estimate the capacity of a pail or other large container. Use the 1 L milk container by repeatedly filling it with water to find the capacity of the pail. Remind the students that measures are approximate and never exact.

Sample Activity 4: Estimate–Measure–Estimate–Measure Sequences

Select pairs of containers that are related or close in measure but not the same; e.g., two jars of different sizes. Have the students estimate the capacity of the first container and then measure its capacity using standard units of measure. Then have the students estimate the capacity of the second container and check the estimate by measuring its capacity (Van de Walle and Lovin 2006, p. 280). With this sequence of estimate and then measure, students practise applying their knowledge about estimating the capacity of one container to estimating the capacity of another container, and thereby improve their estimating skills.

Teaching the Relationship between mL and L

Sample Activity 1: Using Manipulatives to Connect Millilitres and Litres

Provide the students with 250 mL chocolate milk cartons and a set of measuring spoons that includes 1 mL, 2 mL, 5 mL, 15 mL and 25 mL. Have the students fill the 1 mL measuring spoons with water, sand or rice to see how much 1 mL is. Then they can fill the 1 mL spoon repeatedly and pour the contents into the 25 mL spoon. Have the students suggest how many 25 mL spoonfuls are needed to fill the 250 mL milk carton. Finally, have the student fill the 250 mL carton with water four times and pour it into a large container. Have the student verbalize that 4 containers of 250 mL will fill a 1000 mL container, which is the same as 1 L.

Have the students suggest other ways to show that there are 1000 mL in 1 L.

Look For …

Do students:

- ☐ use standard units of measure to measure the capacity of containers?
- ☐ use a combination of smaller containers to show that 1000 mL is the same capacity as 1 L?
- ☐ demonstrate flexibility by showing the relationship between mL and L in more than one way?

Provide the students with a graduated 1000 mL beaker marked in 100 mL or 50 mL intervals to measure capacity. Have them measure the capacity of various containers by pouring the contents of each container into the graduated beaker and reading the scale marking the top of the contents. Emphasize the connection between the scale on the beaker and the markings on a ruler used to measure length (Cathcart 1997).

Sample Activity 2: Using a Combination of Smaller Containers to Fill a 1 L Container

Provide the students with a variety of labelled containers; some that have a capacity less than 1 L and some that have a capacity of 1 L. Each container has its capacity written on it.

Have the students sort the containers into two groups and label each group, explaining their sorting rules. Guide the students to sort the containers into a group labelled 1 L containers and another group labelled containers less than 1 L.

Have the students predict which of the smaller containers would hold the same amount of liquid as the 1 L container and explain their reasoning. Encourage the students to estimate the sum of the capacities of various containers. Then have the students check their estimates by filling the smaller containers with water, sand or rice and pouring the contents into the 1 L container.

Look For …

Do students:

- ☐ define capacity in their own words?
- ☐ describe the essential characteristics of capacity?
- ☐ create a problem that applies the concept of capacity?
- ☐ use visuals to show capacity?
- ☐ provide examples of where capacity is used in the real world?
- ☐ provide non-examples of capacity in the real world; i.e., distinguish among perimeter, area and capacity examples?

Sample Activity 3: Frayer Model for Capacity

Provide the students with a template for the Frayer Model and have them fill in the sections individually or as a group to consolidate their understanding of capacity. A sample of a Frayer Model follows.

Frayer Model for Capacity

Definition
Capacity is the amount that a container will hold.

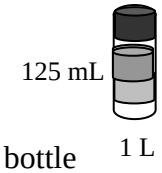
Characteristics
- The amount of liquid, sand or rice remains the same when placed in different shaped containers.
- Capacity can be measured in nonstandard or standard units for capacity.
- The smaller the unit of measure, the greater the number of units needed to measure the capacity of a given container.
- When comparing capacities, the same units must be used.
- Standard units for capacity include mL and L.

Real-life Problem and Visual Representation

Sarah is filling a 1 L clear plastic bottle with layers of various colours of sand as a decoration for her room. Which of the following containers filled with sand could she use to completely fill her bottle?

Container A: 355 mL
Container B: 225 mL
Container C: 125 mL
Container D: 420 mL
Container E: 160 mL

Sarah could use a variety of ways to completely fill her bottle. Three of the ways include:
- Use Container C and fill it 4 times to completely fill the 1 L bottle.
- Use Containers A, B and D each 1 bottle filled once to completely fill the 1 L bottle.
- Use Container D filled twice and Container E filled once to completely fill the 1 L bottle.



Capacity

Examples

Capacity is used in the following:
- sand in a sandbox
- water in a swimming pool
- juice in a pitcher
- grain in an elevator
- milk in a glass.

Non-examples

Capacity is not used in the following:
- fencing around a garden
- lace around a tablecloth
- painting walls
- tiling floors
- covering countertops.

Format adapted from D. A. Frayer, W. C. Frederick and H. J. Klausmeier, *A Schema for Testing the Level of Concept Mastery* (Working Paper/Technical Report No. 16) (Madison, WI: Research and Development Center for Cognitive Learning, University of Wisconsin, 1969). Adapted with permission from the Wisconsin Center for Education Research, University of Wisconsin-Madison.

Step 4: Assess Student Learning

Guiding Questions

- Look back at what you determined as acceptable evidence in Step 2.
- What are the most appropriate methods and activities for assessing student learning?
- How will I align my assessment strategies with my teaching strategies?

Sample Assessment Tasks

In addition to ongoing assessment throughout the lessons, consider the following sample activities to evaluate students' learning at key milestones. Suggestions are given for assessing all students as a class or in groups, individual students in need of further evaluation, and individual or groups of students in a variety of contexts.

A. Whole Class/Group Assessment

Estimating and Measuring Capacity
In this assessment task, the students will demonstrate their understanding of estimating and measuring capacity of containers, focusing on the standard unit, millilitres (mL). They will also demonstrate understanding of the relationship between millilitres and litres. There are two parts to this assessment task.

Part A: Given a small container, the students will estimate the capacity of the container using a personal referent and describe the process. The students will not use manipulatives that are marked with the standard unit of millilitres to make the estimate; therefore, it is necessary that the students submit their work on Part A before they start work on Part B.

Part B: The students will use the same container for Part A and Part B. For Part B, the students will use manipulatives that are marked with the standard unit of millitres and litres to measure the capacity of the container and explain the process. They will relate mL to L by using their containers and comparing these containers' capacity to a 1 L container.

Materials:

Part A: small labelled containers, each with a capacity of less than 500 mL
Part B: small labelled containers (same as for Part A), water, sand or rice to fill the containers, graduated beakers with a capacity of 1 L showing millilitres, measuring cups showing millilitres, set of measuring spoons (1 mL, 2 mL, 5 mL, 15 mL and 25 mL)

Each student will:

- estimate the capacity of a given container and record the estimate using a number and a unit that matches the attribute of capacity
- explain his or her choice of personal referent and the process used to estimate the capacity of the container
- measure and record the capacity of a container, using a number and a unit that matches the attribute of capacity; i.e., millilitres
- describe the relationship between mL and L by explaining how many containers measured in mL are needed to completely fill a 1 L container.

It is important that students not have the manipulatives showing the standard units of measure for capacity (mL and L) when they are estimating capacity in Part A. They are to use a personal referent for a millilitre and must visualize the amount of a millilitre when making the estimate. Once the estimate is made and handed in to the teacher, then the manipulatives showing the standard units of measure for capacity (mL and L) are distributed for Part B of the assessment task.

When estimating the capacity of the labelled container in Part A, the students should be within 30% of the actual capacity to receive an assessment of adequate.

Early finishers can estimate the capacity of other labelled containers provided in Part A. They can also explain how volume and capacity are related using examples. In addition, they can describe real-world examples of using capacity measured in millilitres and litres.

Estimating and Measuring Capacity—Student Assessment Task

Part A – Estimating Capacity

Choose a labelled container from the set of containers.

a. Write the name of the label below.

b. Estimate the capacity of the container by using a personal referent. Explain your choice of referent and the process used to make the estimate.

Give Part A to your teacher before you begin Part B.

Part B – Measuring, Recording and Representing Capacity

1. Measure the actual capacity of the container you chose for Part A. Explain your thinking by using diagrams, symbols and words.

2. If you had a container with a capacity of 125 mL, how many of these containers are needed to fill a 1 L pitcher? Explain your thinking by using diagrams, symbols and words.

Student _____

SCORING GUIDE
Estimating and Measuring Capacity

Level / Criteria	4 Excellent	3 Proficient	2 Adequate	1 Limited *	Insufficient/ Blank *
Estimating capacity **Part A**	Estimates to within 10% of the actual capacity of the container using a personal referent and correct units. Explains clearly and in detail the choice of referent and the process used to make the estimate.	Estimates to within 20% of the actual capacity of the container using a personal referent and correct units. Explains the choice of referent and the process used to make the estimate.	Estimates to within 30% of the actual capacity of the container using a personal referent and correct units. Provides limited explanation of the choice of referent and the process used to make the estimate.	Estimates outside of 30% of the actual capacity of the container and may not include the correct units. Makes no effort to explain the choice of personal referent or the process used to make the estimate.	No score is awarded because there is insufficient evidence of student performance based on the requirements of the assessment task.
Measuring and recording capacity **Part B** **Question #1**	Measures and records the capacity of the container within 2 mL of the correct answer and explains clearly and in detail with diagrams, symbols and words how the capacity was found.	Measures and records the capacity of the container within 5 mL of the correct answer and explains with diagrams, symbols and words how the capacity was found.	Measures and records the capacity of the container within 10 mL and provides limited explanation with diagrams, symbols or words (including one or two ways but not all three ways) how the capacity was found.	Measures and records the capacity of the container outside of ± 10 mL, omits the units and explains vaguely with diagrams, symbols or words (including only one way) how the capacity was found.	No score is awarded because there is insufficient evidence of student performance based on the requirements of the assessment task.
Relating millitres (mL) and litres (L) **Part B** **Question #2**	States correctly how many containers are needed to fill 1 L and explains clearly and in detail with diagrams, symbols and words how mL and L are related.	States correctly how many containers are needed to fill 1 L and explains with diagrams, symbols and words how mL and L are related.	States correctly how many containers are needed to fill 1 L and provides limited explanation with diagrams, symbols or words (including one or two ways but not all three ways) how mL and L are related.	States inaccuarately that some containers are needed to fill 1 L and explains vaguely with diagrams, symbols or words (including only one way) how mL and L are related.	No score is awarded because there is insufficient evidence of student performance based on the requirements of the assessment task.

***** When work is judged to be limited or insufficient, the teacher makes decisions about appropriate intervention to help the student improve.

B. One-on-one Assessment

Estimating Capacity
If the student has difficulty estimating capacity using standard units of measure, provide the student with a set of measuring spoons in metric measure and explain that smallest spoon holds 1 millilitre or 1 mL. Have the student suggest examples from real life that would illustrate a capacity of about 1 mL; e.g., a sip of water or a few drops (10 or so) from a medicine dropper. Similarly, have the student suggest containers that have a capacity of about 1 litre; e.g., a litre of milk. Encourage the student to describe a personal referent to represent 1 mL and 1 L.

Measuring and Recording Capacity
Provide the student with containers of different sizes and have the student estimate the capacity in millilitres or litres. Encourage the student to use his or her personal referent to estimate and also explain the process used in estimating. Immediately after estimating, have the student measure the capacity of the containers by emptying the container into a graduated beaker with appropriate markings for millilitres and litres or by repeatedly using a nonstandard or standard unit to fill the container. Remind the student that capacity must be recorded using a number and a correct unit to match the attribute of capacity.

If the student has difficulty measuring and recording the capacity of containers, fill the container being measured with water, sand or rice. Then have the student pour the contents of the container into a graduated beaker and record the level in millilitres. If the container is small, the student could use an appropriate measuring spoon labelled in millilitres to fill the container with water, sand or rice, counting the number of spoonfuls and multiplying by the number of millilitres in each spoon.

C. Applied Learning

Provide opportunities for the students to use their understanding of capacity in practical situations and notice whether or not this understanding transfers. For example, have the students find the capacity of a container such as a pop can or an empty juice bottle. Does the student:

- estimate the capacity prior to finding the actual capacity?
- use units that match the attribute of capacity?
- use nonstandard (e.g., liquid medicine cups or a cream cheese container) or standard units (e.g., measuring spoon for 1 mL or a milk carton f or 1 L) to measure the capacity of the container by filling it?
- use units of an appropriate size to measure the capacity?
- write the capacity using a number and the unit chosen?
- compare the estimated capacity with the capacity found by using nonstandard or standard units?
- apply this concept to other situations, such as finding the capacity of different containers that can be filled?

Step 5: Follow-up on Assessment

Guiding Questions

- What conclusions can be made from assessment information?
- How effective have instructional approaches been?
- What are the next steps in instruction?

A. Addressing Gaps in Learning

To improve their estimating skills, have the students always estimate before measuring and then compare their measurements to their original estimates. As they become more familiar with the units used in capacity measurements, the students will have a better sense of estimating the capacity in the required units. Remind the students to use referents and/or chunking when estimating capacity. Have the students share their estimates and strategies for estimating. Begin by having the students estimate by comparing the capacity of two different containers. Then have them estimate the capacity of containers. Accept a range of estimates and narrow the range as the students' estimating skills improve.

Conservation of capacity develops as students mature. Continue to provide opportunities for students to compare the amount of liquid, sand or rice in containers that have different shapes and have them communicate their thinking. Always start with two identical containers that have the same amount of liquid, sand or rice. Then pour the contents of one of the identical containers into another container that has a different shape so that the level of the liquid, sand or rice is higher or lower than the level in the original containers. Students who understand conservation of capacity will explain that the amount of liquid, sand or rice remains the same when it is poured into another container.

Students who have difficulty repeating the same unit when measuring capacity should have ample opportunities to explore using manipulatives such as 1 mL measuring spoons or 1 L milk cartons or beakers. Encourage the students to manipulate the concrete materials and explain how the unit is repeated in finding the capacity of a container.

Students who have difficulty describing the relationship between mL and L should use a variety of manipulatives, including a 250 mL milk carton, a set of measuring spoons (including sizes 1 mL, 2 mL, 5 mL, 15 mL and 25 mL) and a graduated 1000 mL beaker marked in 100 mL or 50 mL. See Step 3, Section C for a detailed description.

B. Reinforcing and Extending Learning

Students who have achieved or exceeded the outcomes will benefit from ongoing opportunities to apply and extend their learning. These activities should support students in developing a deeper understanding of the concept and should not progress to the outcomes in subsequent grades.

Consider strategies such as.

- Provide tips for parents on helping their children to estimate and find the capacities of containers. For example:
  - Ask the child to estimate the capacity of various sized containers. Have the child explain how he or she estimated the capacity by providing some explanation for the size of a millilitre and a litre.
  - Ask the child to measure the capacity of various sized containers by using measuring spoons (1 mL, 2 mL, 5 mL, 15 mL and 25 mL), a measuring cup marked in millilitres or a 1 L container, such as a milk carton. Where appropriate, have the child record the measure in millilitres and in litres.
  - Involve the child in reading the labels on liquid medication and measuring the correct amount for the age of the child.
- Provide the student with containers that all have about the same capacity, but have different shapes. Also, provide a variety of manipulatives to measure capacity, including measuring cups and spoons marked in mL, graduated beakers marked in mL and L, water, sand and rice. Have the student order the containers from the one with the least capacity to the one with the greatest capacity and explain his or her thinking.
- Pose the following problem to the student:
  Mark said that if you multiply the number of millilitres of liquid in a container by 1000, you will get the number of litres of liquid in that container. Do you agree with Mark? Why or why not?
- Guess the Unit
  Provide the student with a variety of different measurements found in newspapers, signs or other everyday contexts. Include the context and the measure but not the units. Have the student predict what unit of measure is used in each situation and justify his or her choice to the class (Van de Walle and Lovin 2006, p. 277).

Bibliography

Alberta Education. *The Alberta K–9 Mathematics Program of Studies with Achievement Indicators*. Edmonton, AB: Alberta Education, 2007.

_____. *Teaching Measurement Concepts, Grades 4–6.* Edmonton, AB: Alberta Education, 2006.

Barton, Mary Lee and Clare Heidema. *Teaching Reading in Mathematics: A Supplement to Teaching Reading in the Content Areas Teacher's Manual.* 2nd ed. Aurora, CO: Mid-continent Research for Education and Learning (McREL), 2002.

Burns, Marilyn. *About Teaching Mathematics: A K–8 Resource*. Sausalito, CA: Math Solutions Publications, 1992.

Cathcart, W. George, Yvonne M. Pothier and James H. Vance. *Learning Mathematics in Elementary and Middle Schools*. 2nd ed. Scarborough, ON: Prentice Hall Allyn and Bacon Canada, 1997.

_____. *Learning Mathematics in Elementary and Middle Schools*. Scarborough, ON: Allyn and Bacon Canada, 1994.

Frayer, D. A., W. C. Frederick and H. J. Klausmeier. *A Schema for Testing the Level of Concept Mastery* (Working Paper/Technical Report No. 16). Madison, WI: Research and Development Center for Cognitive Learning, University of Wisconsin, 1969.

National Council of Teachers of Mathematics. *Principles and Standards for School Mathematics.* Reston, VA: NCTM, 2000.

Van de Walle, John A. *Elementary and Middle School Mathematics: Teaching Developmentally.* 4th ed. Boston, MA: Addison Wesley Longman, Inc., 2001.

Van de Walle, John A. and LouAnn H. Lovin. *Teaching Student-Centered Mathematics: Grades 3–5*. Boston, MA: Pearson Education, Inc., 2006.