



What Size Pots?

Strands:	Suggested time
Algebra Spatial Sense Social Emotional Learning (SEL) Skills in Mathematics and the Mathematical Processes Cross-curricular Learning Visual Arts Social Studies	2 math periods
Topics:	Grade:
Mathematical Modelling Measuring area, capacity, and mass	3
Overall and Specific Expectations:	
Algebra - Mathematical Modelling - C4. apply the process of mathematical modelling to represent, analyse, make predictions, and provide insight into real-life situations. Spatial Sense - E2. compare, estimate, and determine measurements in various contexts. - E2.3 use non-standard units appropriately to estimate, measure, and compare capacity, and explain the effect	

that overfilling or underfilling, and gaps between units, have on accuracy

- E2.4 compare, estimate, and measure the mass of various objects, using a pan balance and non-standard units
- E2.7 compare the areas of two-dimensional shapes by matching, covering, or decomposing and recomposing the shapes, and demonstrate that different shapes can have the same area
- E2.8 use appropriate non-standard units to measure area, and explain the effect that gaps and overlaps have on accuracy
- E2.9 use square centimetres (cm²) and square metres (m²) to estimate, measure, and compare the areas of various two-dimensional shapes, including those with curved sides

Social Emotional Learning Skills in Mathematics and the Mathematical Processes

- A1. Throughout this grade, in order to promote a positive identity as a math learner, to foster well-being and the ability to learn, build resilience, and thrive, students will apply, to the best of their ability, a variety of social-emotional learning skills to support their use of the mathematical processes and their learning in connection with the expectations in the other five strands of the mathematics curriculum.

In this lesson, to the best of their ability, students will learn to **think critically and creatively** as they apply the mathematical processes of **reflecting** (demonstrate that as they solve problems, they are pausing, looking back, and monitoring their thinking to help clarify their understanding (e.g., by comparing and adjusting strategies used, by explaining why they think their results are reasonable, by recording their thinking in a math journal) and **representing** (select from and create a variety of representations of mathematical ideas (e.g., representations involving physical models, pictures, numbers, variables, graphs), and apply them to solve problems), so they can make connections between math and everyday contexts to help them make informed judgements and decisions.

Learning Goal:	Success Criteria:
We are learning ● to develop a mathematical model to help us make decisions and evaluate the success of what we do.	I can... ● use my model to make decisions. ● use my model to evaluate the decisions I have made.

• to measure an area using non-standard units and explain the effect that gaps and overlaps have on accuracy. • to use non-standard units to estimate, measure, and compare capacity of different containers. • to compare, estimate, and measure the mass of various objects.	• communicate my model so others can use the techniques to make their own decisions. • measure an area for our plants (or class garden). • use non-standard units to estimate the capacity of different pots. • use non-standard units to measure the capacity of different pots. • use non-standard units to compare the capacity of different pots. • compare the mass of different pots. • estimate the mass of different pots. • measure the mass of different pots.
Prior Learning:	Resources and Materials:
Students have had experience with the mathematical modelling process and are aware of the components.	- Two or three types of plants in small containers (e.g., 6 plants cello packs) such as different herbs (e.g., thyme, basil, parsley, chives), tomato, pansies, etc. - Three sizes of small pots - Soil to explore capacity - Pan balance
Teacher Notes	
This lesson can be used in conjunction with Lesson 3 'Planning a Plant Sale' although it stands on its own. The teacher should decide the purpose of the plant growing before presenting this lesson - are the plants for a sale or are they to be taken home (either as gifts or for the students' own use)? What time of year will you complete this lesson? What can the students do with the plants?	

Consider the home situations of your students when selecting the plants you might use (e.g., herbs can grow on a window sill, tomato plants would require outdoor access for families, plants that are significant culturally for the students and their families, plants that are a source of food).

Your students may be interested in why pot size is important. This is a topic that some students may wish to research as part of their science program.

Learning and Teaching Activities

Understand the Situation		
Explain to the students that they will be growing plants as part of their science program. These plants could be for a variety of purposes such as gifts (e. g. Mother's Day, birthdays), for Earth Day, or for a plant sale as a fundraiser (see Mathematical Modelling Lesson 3 Planning a Plant Sale). Present the situation "I have some tiny plants that we are going to grow in the classroom. They are small right now but will be getting larger before we are finished. We aren't sure what materials we need or how to organize the plants." Point out that... "One of the things we need to consider when we plant something is the amount	Teacher Moves: Note to teachers: Students might have had experience growing plants during Mathematical Modelling Lesson 3 Planning a Plant Sale. If not, have some plants available to start this lesson. "How do we feel when we are jammed together in a small space? "	 At home, students can ask their families to tell them stories about their own attempts to grow plants. What kinds of plants did they grow? How did they decide which ones to try growing? Did they grow them indoors or outside? Students can then share their stories with the rest of the class.

of space the plant needs to grow. We know from our science classes that sun, water, and soil are important. But what about space ? Does that matter? ” Show the students where the plants will grow and point out that the trays of plants fit easily now. But how will they find out if there is enough space for the plants when they grow larger? “What information do we need to decide if the plants will have enough room to grow?” Have the students share one or two ideas to start them thinking, then form groups of 2 or 3 students and have them brainstorm more ideas. After the students have developed their ideas, regroup as a class and sort their ideas. • "Which questions do we need to answer before we start ? “ • “Which questions might be answered as we look after our plants ?”	“If space matters, why don’t we just put all the plants in huge pots ?” Circulate and listen to student’s ideas. Students may suggest: • How big will the plants grow? • What size pots are there? • What size pot does each kind of plant need? • How many pots can we fit on the table? • How many big pots can we fit on the table? • Will bigger plants get in the way of smaller plants? • How much soil do we need? • Will we have to transplant them more than once? • What’s wrong with just getting a bunch of big pots?	Students who are not in the physical classroom will need to be provided with specific information about space and sizes of available surfaces. Students can participate in these discussions while they are in a virtual meeting space. If possible, capture the students’ ideas in a slide, virtual document, or using a tool such as Jamboard so as to be able to bring ideas together. Opportunities for Differentiation Provide some sample questions so that students can benefit from examples. It may be a good idea to pair 2 groups together to further their thinking. This may instigate more question ideas.
Analyze the Situation		

As a whole class, organize the questions with the students to decide which ones need to be answered through researching, through reading and asking experts, and which ones are answered through experimenting with actual plants, soil, or pots. Have the students form groups and assign the task of finding answers to the important questions. Provide one or two science, math, or literacy periods to conduct research. Students can explore the capacity of the pots, compare the mass of the soil in various pots, learn about the size of mature plants, learn about the effects of pots that are too small or too large, etc.	Teacher Moves: Prompts to help the students determine needed information through hands on experimenting might include: • “How much soil does a big pot hold? How full should it be ?” • “If we need this much soil to fill one pot, how much do we need to fill ten pots ?” • “How much space does the plant’s roots need ?” • “How many big pots will fit in a row? How many little pots ?” • “Can we fit more pots if you make a pattern like big pot, little pot ?” • “How heavy will the plants get ? Will they tip over the pots ? How can we figure that out ?” • “How many small pots of soil are the same as one large pot of soil?” • “How heavy is a pot full of soil ?” Can we take them home easily ?”	Opportunity for Differentiation Generally, encourage the groups to complete at least two questions - one research based and one through observation and collecting data (hands on); however, you may recommend some groups engage in just hands on exploration.  Students who are working from home can gather data about the sizes of pots they have at home. They can also be given more online research-style questions to investigate and bring back their findings to the group. Encourage students to add screen captures to their work to record their research efforts. If students are measuring pots at home and if they have not been part of the whole class conversations, they may need to be provided with a list of prompts that were developed by the teacher or the students in the class. Opportunities for Assessment Observe students and note:
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Bring the students together to discuss the data they have collected. Remind them that the goal is to grow plants in the right pots so they will look good and be healthy. However, they also need to know how many pots the classroom has space for. Ask if they have any new questions before they plan how to pot the plants. "How can we find the answers to our new questions?" When the students are satisfied that they know a lot about pots, plants, and soil, tell them that it would be useful to build a model that would help them plan the pot locations. Remind them that whenever we make a mathematical model, we make some assumptions about the situation, our data, and model.	• "Do different types of plants need different amounts of sun and water, or could we plant more than one type of plant in each pot?" Remind the students to keep clear notes of their learning. If possible, invite a nursery worker or avid gardener to talk with the students. Some student assumptions may include: • We will need three sizes of pots because we have three different plants.	• their measuring of an area using non-standard units • deciding and justifying the use of the pot bottom or pot top as a unit of measure • the effectiveness of their explanations of the effect that gaps and overlaps have on accuracy • their use of non-standard units to estimate, measure, and compare capacity of different containers • their ability to determine the capacity of various pots • their ability to compare the mass of various pots with and without soil • their selection and use of useful texts for research • the degree to which the methods used for recording data and information for future discussion are organized A student working from home might benefit from creating a record/journal of what they did, using words, sketches, photographs, screen captures, and numbers to help them describe their process.
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Model how we make assumptions to help with this decision making. For example: "We assume that the pots can touch each other and the plants won't grow over the edge of the pot. This is important because if the plants go over the edge, then we need more space between the pots." Send the students off in groups to discuss assumptions they might make while planning how to place the pots or when picking the pot needed for a specific plant. Then have the students come back together to share and analyze their assumptions. Facilitate a class discussion about these ideas. Explain that when making assumptions, it is up to us to challenge our own thinking and to think about assumptions from other viewpoints.	• We can use the same size pot for all three kinds of plants. • Smaller pot sizes mean we can grow more plants. • We can sell more plants if the pots are sturdy/attractive. • We assume that the pots can touch each other and the plants won't grow over the edge of the pot. • We won't have to transplant them again while they are at school. • The plants will all need the same amount of sun and water so we can mix the plants and water them all easily. Challenge the thinking behind students' assumptions by asking questions such as: • "Why do you think that ?" • "How did you come to that conclusion ?" • "Is there another way to do this or another way to solve this problem ?" • "How can we be certain ?" • "What would happen if...?" Support the students as they strive to think critically while providing feedback	Having students keep notes or journals provides an opportunity for students to reflect on their thinking and for teachers to assess learning. Opportunities for Differentiation Provide additional sample assumptions for students who have more difficulty with this concept.
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	to their peers or as they respond to feedback about their own assumptions.	
Create a Mathematical Model		
Form the students into pairs or small groups. Tell them they will be creating a plan that will be able to be used by various classes who might be joining in on this project that includes what materials would be needed and how the plants can be organized into an ideal layout. Since each classroom has a different size, different shape, and different furniture available to them, and because different classes may decide to grow different plants, or fewer or more plants, the layout needs to be flexible. The one thing that will not change from class to class is the sizes of pots from which to choose. Other classes will need to be able to use your plan to adjust the plan to their own needs. We sometimes call this a “modular design”. Students should first decide a plan for a surface the size of a desktop. Then they need to create a model that can be adjusted for more or less space or for more or fewer plants. For example, they plan a good layout for one desk. Will the model work for two desks ? The classroom planting table ? What if they	Teacher Moves: Discuss how they can use other tools to do the task if they don’t have enough pots to work with. You may choose to have students mark an area on the classroom floor or hallway to represent the planting table so multiple groups can test their desktop models on a larger area. Encourage them to discuss how they can describe their model mathematically so it can be changed for different situations (e.g., one desk to three desks).	Opportunities for Differentiation You may wish to spend additional time reviewing the concept of making an assumption with some students and help them recognize assumptions inherent in the class work. Opportunities for Differentiation Be sure to have enough pots available for students to manipulate and use to explore the available area. Work with any small group that finds it hard to move from placing pots to seeing how this can become a model that is adjustable to need. For groups who finish quickly: ask them to determine: the amount of soil needed for their pot plan

first plan a layout for 10 plants and now need to plant 16 plants ? Does the model let them change the number of plants ? Provide time for them to work with actual pots and determine their plant layout. Have the groups record their ideas in diagrams on chart paper.		- the mass of the pots and plants that will be resting on the table (Is it strong enough ?) - a way to compare the mass of different pots  If a student does not have a supply of physical pots available, they may need to be provided the dimensions of the pots students are using in the class so that they can also make a plan. Then, they can take photos of all their attempts to create a final plant layout and create a sort of storyboard of what they tried, Then they can be asked to describe what caused them to try a different design and why they settled on their final design.
Analyse and Assess the Model		
Tell them it is time to evaluate their models in their small groups. They will revisit the assumptions they made and consider if those assumptions still seem reasonable/valid. Then tell them that they are to consider: “How will your model help you put plants on four desks in a row ? What if you put four desks in a square ? Does your model still work ?” “We now have two tables for plants. How can you use your model to decide the best way to use two tables ? Does it change your model ?”	Teacher Moves: As the students analyse and assess their models, reflect on using questions such as: - Are the assumptions that we made reasonable ? - Would our model need to change if the situation changes ? - What information should you include to present your models clearly ?	Opportunities for Assessment Observe how students choose to layout the pots. - Are they considering any gaps between the pots ? - Are they arranging the pots in an organized manner to cover the area ?

• “What changes, what remains the same?” • “What if you can only use half a table ?” Have them decide if their model addresses the new situations. How might they improve it ? Tell students that mathematical models are often written in mathematical language so others can use them. A model needs to work whether they have just a few plants or many plants. Have students work with their partner or small group to try to describe their model using mathematical language. Encourage them to convince each other that their model would be able to be adapted if the number of plants changed. (Ensure the students understand that “adapting” does not require starting over.) Have them test their math description using several scenarios, such as two tables or 28 plants. Then have students prepare to present their models and solutions to the rest of the class.	• What mathematical language can you use when you present your model to share your ideas clearly? (Consider developing a list of related vocabulary such as area, surface area, mass, capacity.) Encourage discussion about the strengths and challenges of each model (e.g., Will those large plants block the small ones behind them ? Why did you put that much space between rows ?)	Do the students use only concrete materials to determine their plan or can they use some actual pots along with other tools or strategies (e.g., tracing pots and using the circles on their table or filling a part of the table and then multiplying to cover the whole table) ? Observe and note: • Multiplicative thinking • Working with fractional parts • Accurate use of standard units • Accurate use of non-standard units • Careful measuring skills • Use of mathematical language while discussing their models.
Consolidation of Learning		

Have each group present their model to the rest of the class. Work with the students to identify commonalities and differences among the presentations. Consider the strengths and limitations of each model. Note and summarize the mathematics that was developed during the previous parts of the lesson (e.g., exploring capacity, mass, area, fractions, multiplicative thinking). Discuss the experience with the students: • “What parts of this project did you find challenging ?” • “What made it challenging ?” • “What did we do as a class to deal with the challenges ?” • “What did you do on your own when it was challenging for you ?” • “Why is it important to think about the process as we went through it as well as after ?” • What did you find the hardest to do in this math modelling ? Why ? Review the project with the students and point out the steps of the mathematical modelling process they used. Discuss points such as: • “Why was each step important ?” • “What might have happened if we did not do the early steps ?” • “How did the assumptions help us make decisions ?” • “Why are mathematical models useful ?”	As you are listening to students, observe the mathematical process of reflecting: • What did work and what did not work ? • How could this new knowledge be applied to future problems? Since students have recorded their thoughts / ideas in a learning journal, it may be possible to share some of these thoughts. As you are listening to students, observe the math process of representing: • How did they record their model? • How clear was their representation ?
Further Consolidation/Next Steps for students and teachers:	
If the class continues the process of transplanting the seedlings and growing the plants in pots, they can revisit the selected model in a few weeks to explore how the model worked. What might they change ? What assumptions were helpful ? The concept of plant spacing could be extended to planning a class garden. This lesson could be connected to Social Studies to discuss the lives of the people who lived here long ago and how they	

planted gardens to survive (e.g. [planting the three sisters](#), clearing land for a homestead or farm). (Social Studies, Grade 3: A.Heritage and identity: Communities in Canada, 1780–1850)

This lesson could be connected to the student learning associated with rural regions in Ontario and how fields are planned and laid out. (Social Studies, Grade 3: B.People and Environments: Living and Working in Ontario)

Connection to Visual Arts: Have students choose an appropriate pot for their plant(s) and ask them to decorate their pot(s) by creating a design applying elements and principles of design, and exploring forms and cultural contexts . (Arts, Grade 3: D.Visual Arts)