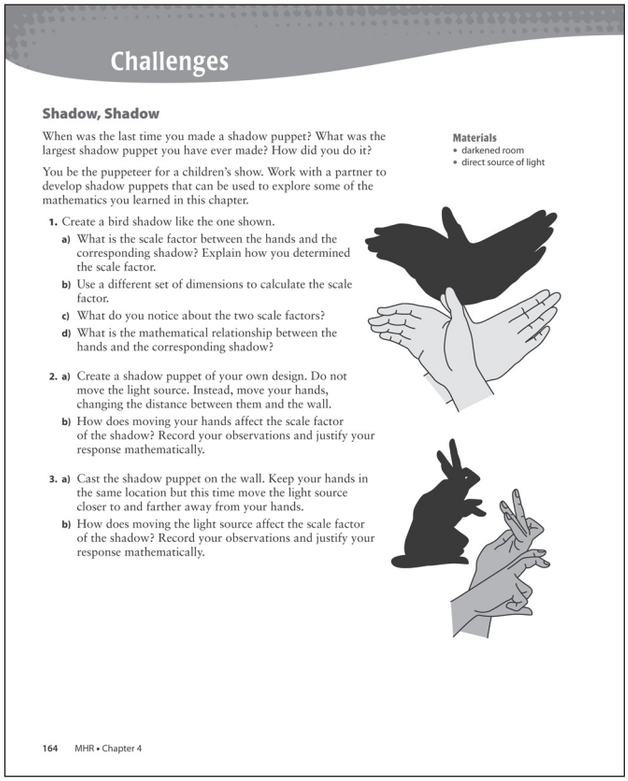

Challenges

Shadow, Shadow

When was the last time you made a shadow puppet? What was the largest shadow puppet you have ever made? How did you do it?

Materials
- darkened room
- direct source of light

You be the puppeteer for a children's show. Work with a partner to develop shadow puppets that can be used to explore some of the mathematics you learned in this chapter.

1. Create a bird shadow like the one shown.
- **a)** What is the scale factor between the hands and the corresponding shadow? Explain how you determined the scale factor.
- **b)** Use a different set of dimensions to calculate the scale factor.
- **c)** What do you notice about the two scale factors?
- **d)** What is the mathematical relationship between the hands and the corresponding shadow?

2. a) Create a shadow puppet of your own design. Do not move the light source. Instead, move your hands, changing the distance between them and the wall.
- **b)** How does moving your hands affect the scale factor of the shadow? Record your observations and justify your response mathematically.

3. a) Cast the shadow puppet on the wall. Keep your hands in the same location but this time move the light source closer to and farther away from your hands.
- **b)** How does moving the light source affect the scale factor of the shadow? Record your observations and justify your response mathematically.

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Suggested Timing
40–50 minutes

Materials
- direct source of light (e.g., flashlight, desk lamp)
- metre stick
- ruler

Blackline Masters
Master 1 Project Rubric

Mathematical Processes
- ☑ Communication (C)
- ☑ Connections (CN)
- ☑ Mental Mathematics and Estimation (ME)
- ☑ Problem Solving (PS)
- ☑ Reasoning (R)
- ☐ Technology (T)
- ☑ Visualization (V)

Specific Outcomes
SS3 Demonstrate an understanding of similarity of polygons.
SS4 Draw and interpret scale diagrams of 2-D shapes.

Planning Notes: Shadow, Shadow

This activity works best in pairs so that students can help each other measure hands and shadows.

You may wish to use the following steps to introduce and complete this Challenge:

1. Start the class either by using an overhead projector to project shadow puppets or by inviting students to demonstrate shadow puppets they are familiar with. Depending on your students, you may need to point out that shadow puppets need to be appropriate for math class. As students demonstrate examples of shadow puppets, ask how they might use their knowledge of scale factors and similar figures in working with shadow puppets.
2. During the class discussion, ask:
   - What parts of your hands and the shadow might you measure to identify the scale factor?
   - Would another part work as well? Explain.
   - What position should your hands be in when you are measuring them for a particular shadow puppet? Why?
   - What can you do if the shadow is fuzzy around the edges? Where could you measure from?
3. Read through the Challenge as a class and ensure that students understand what they are to do.
4. Clarify that the task is to
   - create shadow puppets and determine the scale factor between an object and the shadow it casts
   - discover what happens to the shadow when an object is moved closer to or farther away from the light source
   - discover what happens to the shadow when the light source is moved closer to or farther away from the object casting the shadow
   - record observations and justify responses mathematically
5. Review the **Master 1 Project Rubric** with students so that they will know what is expected.

Meeting Student Needs

- Students who have difficulties making shadows could use objects you provide. For best results, select objects that have clear dimensions and angles.

- It may be acceptable for some students to describe the situation using phrases like "the shadow becomes bigger when the light is moved closer to the object" and "the shadow becomes smaller when the light is moved away from the object."

ELL

- Ensure that students understand the term *puppeteer*.

Gifted and Enrichment

- Challenge students to create a children's shadow puppet show. Provide the following guidelines:
  – Consider forming several images at the same time to tell a short story for a duration of several minutes.
  – Collaborate to write a narrative script involving two or more characters.
  – Choose a story line appropriate for the age group.
  Prompt students to consider objects that might be used for the background and setting.

Answers

Shadow, Shadow

1. a), b) Make sure that students measure the same part of their hands and the shadow. The two scale factors are the same.

c) Example: The hands and the corresponding shadow are similar to each another.

d) Example: The shape is the same and the size is proportional.

2. b) Example: As the hands move closer to the wall, the shadow becomes smaller. In terms of scale factor, the scale factor decreases as the distance between the hands and the shadow decreases. When the hands touch the wall, the two sizes become the same size.

3. b) As the light moves closer to the hands, the shadow becomes larger. As the light is moved away from the hands, the shadow becomes smaller. In terms of scale factor, as the distance between the hands and light decreases, the scale factor increases. As the distance between the hands and the light increases, the scale factor decreases.

This Challenge can be used for either Assessment *for* Learning or Assessment *of* Learning.

Assessment	Supporting Learning
Assessment *for* Learning	
Shadow, Shadow Discuss the Challenge as a class. Have students provide individual responses.	• Consider allowing students to work with a partner and then to write individual responses.
Assessment *of* Learning	
Shadow, Shadow Introduce the Challenge to the class. Have students provide individual responses.	• **Master 1 Project Rubric** provides a holistic descriptor that will assist you in assessing student work on this Challenge. Page 225 provides notes on how to use this rubric for the Challenge. • To view student exemplars, go to www.mathlinks9.ca, access the Teacher Centre on the Online Learning Centre, go to Assessment, and then follow the links.

The chart below shows the **Master 1 Project Rubric** for tasks such as this Challenge, Shadow, Shadow, and provides notes that specify how to identify the level of specific answers for this project.

Score/Level	Holistic Descriptor	Specific Question Notes
5 (Standard of Excellence)	❑ Applies/develops **thorough** strategies and mathematical processes making **significant** comparisons/connections that demonstrate a **comprehensive** understanding of how to develop a complete solution ❑ Procedures are **efficient and effective** and may contain a **minor mathematical error** that does not affect understanding ❑ Uses **significant** mathematical language to explain their understanding and provides **in-depth** support for their conclusion	• provides a complete and correct solution
4 (Above Acceptable)	❑ Applies/develops **thorough** strategies and mathematical processes for making **reasonable** comparisons/connections that demonstrate a **clear** understanding ❑ Procedures are **reasonable** and may contain a **minor mathematical error** that may hinder the understanding in one part of a complete solution ❑ Uses **appropriate** mathematical language to explain their understanding and provides **clear** support for their conclusion	Demonstrates one of the following: • provides a complete response to all parts of the problem, with a weak justification for at most two calculations • provides a complete and correct response based on an incorrect #1a)
3 (Meets Acceptable)	❑ Applies/develops **relevant** strategies and mathematical processes making **some** comparisons/connections that demonstrate a **basic** understanding ❑ Procedures are **basic** and may contain a **major error or omission** ❑ Uses **common** language to explain their understanding and provides **minimal** support for their conclusion	Demonstrates one of the following: • correctly completes any two questions • provides partially correct solutions to all parts of the problem but communication may be weak
2 (Below Acceptable)	❑ Applies/develops **some relevant** mathematical processes making **minimal** comparisons/connections that lead to a **partial solution** ❑ Procedures are **basic** and may contain **several major mathematical errors** ❑ Communication is **weak**	Demonstrates one of the following: • correctly completes all parts of #1 but communication may be weak • correctly completes #2 but there may be minor errors in communication or inaccuracies in recording data • correctly completes #3 but there may be minor errors in communication or inaccuracies in the mathematical justification
1 (Beginning)	❑ Applies/develops an **initial start** that may be **partially correct** or could have led to a correct solution ❑ Communication is **weak or absent**	Demonstrates one of the following: • provides a correct #1a) • makes a correct initial start to any part of the problem

For student exemplars, go to www.mathlinks9.ca and follow the links.