Activity

Engage

This activity will take more than one class period. In fact, plan on one class period for the “Engage” section alone. Set the stage with the introduction:

Today we enter into a different dimension in mathematics—the third dimension. It is hardly new to you, since we live in the third dimension. But in class, we have been exploring shapes only in two dimensions. Two-dimensional shapes lie flat on a tabletop, and they can be drawn on a piece of paper. But three-dimensional shapes can stand up—they have height.

With the students’ input, make a list of two-dimensional (2-D) shapes (triangles, squares, rectangles, circles, pentagons, etc.). Show the students the set of solid shapes. Ask pairs of students to explore the following questions: How are these three-dimensional (3-D) shapes like the ones we have written down? How are they different? Make a list of the similarities and the differences. Bring the class together to discuss their findings. (See an example of one pair’s work in fig. 1.12.)

Next, distribute copies of “Two- and Three-Dimensional Shapes” and assign the following task to pairs of students:

Select one 3-D shape and compare it to one or more 2-D shapes.

Write down on the activity sheet all the things that are alike about the shapes and all the things that are different.

(One pair’s list of likenesses and differences is shown in fig. 1.13.) Again summarize the exploration with a class discussion of the task.

Fig. 1.12.

A list of similarities and differences between two- and three-dimensional shapes

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Differences</th>
</tr>
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<tbody>
<tr>
<td>They both have length</td>
<td>2-D is flat and 3-D isn’t</td>
</tr>
<tr>
<td>They both have width</td>
<td>More faces than a 2-D</td>
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<tr>
<td>They are both shapes</td>
<td>Different elements</td>
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<tr>
<td>There is a 2-D shape on a 3-D shape</td>
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<tr>
<td>Can draw them both</td>
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<tr>
<td>The both have edge</td>
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Fig. 1.13.

A comparison of a 3-D shape and a 2-D shape

The figures that are impossible to build with the materials available have a circular shape (cone, sphere, and cylinder). The figures that are possible to build are polyhedra.

**Explore**

Pass out to each pair of students a set of "sticks" and a supply of "fasteners." Ask the students to create as many of the solids as they possibly can. You might suggest to them that they may find some solids that cannot be created.

Remind the students to try to build at least a cube, a rectangular prism, a triangular prism, and a square pyramid and to turn and flip their constructions to make sure they are truly different. You can refresh the students' understanding of congruence by referring to two-dimensional shapes if needed. After the models have been completed, have the students create a display of those they were able to build, putting them next to the appropriate three-dimensional block. Put all
the blocks they could not model together. Ask, “How are the figures you were able to build different from the ones you could not build?”

Next introduce the terms faces, edges, and vertices by referring to the terms used for two-dimensional shapes (e.g., sides are called edges and corners are called vertices). The 2-D shape becomes a face of the 3-D shape. A good way to remember the term face is that it makes up the surface of the solid.

Have the students count the number of faces, edges, and vertices in each of the shapes they constructed. They can use the blackline master “Counting Parts of Solids” as a recording sheet.

Children at this age may have difficulty counting the parts, especially the edges, because they have a difficult time finding an organized method for doing so. Rather than give them a strategy for counting, suggest that they devise a way that helps them avoid counting an edge or a corner twice. If some pairs of students continue to have trouble counting, have others share their successful strategies with the class. For example, they might label each vertex with a letter or color each edge they count.

Assess

Ask the students to write a response to the following in their journals:

I am a square and have just been beamed into your very unusual world from my flat land of two dimensions. What a strange world you have here! There is a figure that sort of looks like me, but not really. It looks like the figure in the margin. Please tell me everything you know about this figure.

Similar scenarios can be created for cylinders and prisms.

As an alternative assessment, students can create pop-up books in which two-dimensional shapes pop off the page into three-dimensional shapes (a square becomes a cube, a rectangle becomes a rectangular prism, a circle becomes a cylinder, etc.). This can be a class project in which a story line is created and a “big book” is made. The students can read the book to children in grades 1 and 2.

Extend

On the accompanying CD-ROM or the NCTM Illuminations Web site (address: illuminations.nctm.org; click on i-Math Investigations, and scroll down to the section for grades 3–5), all students can enjoy Exploring Geometric Solids and Their Properties, a five-part interactive geometry investigation. The activities, designed for students in grades 3–5, offer experiences in analyzing properties of two- and three-dimensional shapes and in developing mathematical arguments about geometric relationships. They also provide excellent opportunities for visualizing.

Students who need a greater challenge can be encouraged to look at the relationships among the faces, edges, and vertices of three-dimensional shapes using “Counting Parts of Solids.” Looking for number patterns, they might discover Euler’s formula (faces + vertices = edges + 2).

Students need a variety of experiences with three-dimensional shapes. Teachers often introduce these shapes and fail to allow ample time for exploring them. Continue these investigations by asking students to build 3-D shapes from specific sets of instructions rather
Leonard Euler is credited with recognizing that the number of faces plus the number of vertices equals the number of edges.

2. A biography of Euler:
   worksheet to accompany the exploration with solids, and other activities related to Euler's contributions to mathematics can be found in Historical Connections in Mathematics (Reiner 1992).

than from actual models. For example, have the students build a shape that is made up of exactly six square faces, and ask the following questions:

1. Can you make more than one model that fits this description?
2. How many vertices and edges does the shape have?
3. Now try making a figure from four equilateral triangles and a square. What do we call this figure? Count the vertices, edges, and faces.
4. Given two rectangles, what kinds of other shapes can you add to make a three-dimensional figure? Make as many different figures as you can.
Two- and Three-Dimensional Shapes

Names ____________________________

The three-dimensional shape we chose is a ___________________.

The two-dimensional shape we chose is a ___________________.

Here is a picture of the two-dimensional shape:

List all the ways these two shapes are alike.

List all the ways these two shapes are different.
## Counting Parts of Solids

<table>
<thead>
<tr>
<th>Figure</th>
<th>Number of Faces</th>
<th>Number of Vertices</th>
<th>Number of Edges</th>
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CONGRUENT SHAPES

Getting Ready

What You'll Need
Pattern Blocks, about 40 per pair
Crayons
Scissors
Paste
Overhead Pattern Blocks (optional)

Overview
Children create a shape using four Pattern Blocks and then use other combinations or arrangements of blocks to build shapes that are congruent to the original. In this activity, children have the opportunity to:

- explore and use equivalences among shapes
- test shapes for congruence
- develop spatial visualization skills

The Activity

Introducing

- Show the class this arrangement of Pattern Blocks. Ask children to duplicate your design with their blocks.
- Now, ask children to make the same shape, but with a different combination or arrangement of blocks.
- Call on a few children to display their designs. Invite discussion about whether all the designs are the same size and shape.
- Explain that the designs form shapes that are congruent. Point out that this means they are the same size and same shape.
On Their Own

How many different ways can you build the same shape with Pattern Blocks?

- With a partner, choose 4 Pattern Blocks and make a design.
- Make sure that at least 1 complete side of each block touches 1 complete side of another block.
- Record your design by tracing it at the top of a piece of paper. Then color it in.
- Now try to make other designs that have the same shape as your original design. You may either use blocks that are different from the original design or use the same blocks in a different way.
- Find a way to check that the shape of each new design is congruent to the shape of your original design.
- Record each new design by tracing and coloring it on a separate sheet of paper.
- When you think you have found all the different ways to make your shape, cut out your designs and paste them below the original design.

The Bigger Picture

Thinking and Sharing

Post children’s work and invite them to share their observations.

Use prompts such as these to promote class discussion:

- What strategies did you use for making congruent shapes?
- How did you check that your shapes were really congruent?
- Do you think you have found all the possible ways to make your shape? Explain.
- What do you notice when you look at the posted designs?
- Which shapes were made in the greatest number of ways? Which shapes were made in the least number of ways? Why do you think this is so?

Writing

Ask children to explain how they knew that they had found all the different ways to make their shape.

Extending the Activity

1. Have children repeat the activity, this time using five Pattern Blocks to make a shape and five or less to make shapes congruent to the original.
2. Have children use six Pattern Blocks to make a shape and six or less to make shapes congruent to the original.
Where's the Mathematics?

In searching for different ways to make congruent shapes, children use spatial skills to find ways to make equivalent substitutions of the Pattern Blocks. Some children may start by decomposing the blocks in their original shape into two or more blocks that can be used to fill the same space filled by each original block. The sequence of shapes below shows one way that this might be done. Equivalences were used to make a substitution of two green for a blue, then a blue and green for red, then two greens for a blue, and two greens for the last blue.

At this point, children need to use equivalences that involve the replacement of several smaller blocks with larger blocks to find other ways to build the same shape. For example, children may see that two groups of three green triangles can be replaced by two red trapezoids, as shown in A below. Other children may notice that each pair of triangles can be replaced with a blue parallelogram, as in B, or that six of the triangles can be replaced by a yellow hexagon, as in C.

Some children may approach the problem by exploring all the different ways each set of four blocks can be arranged to make the same shape. The sequence below shows four ways to rearrange the same four blocks.

Children who have worked with filling outlines with Pattern Blocks or Tangrams may not rely as much on the relationship among the Pattern Blocks. These children will create the first design and then trace just its
outline. This way they can try to fit different combinations of blocks within
the outline without being influenced by the blocks that were first used. For
example, the outline of the shape in the Introducing section would look
like this:

As they continue to make new designs, children need to check that each
new arrangement of blocks creates a shape that is indeed congruent to the
original shape and that the new design is not a duplication of a design
already made. Some children may not easily recognize duplication, espe-
cially in shapes that themselves have rotational symmetry. For example,
using a logical sequence of equivalent substitutions, a child may make the
following six designs, not realizing that shape H is the same arrangement as
shape E, and shape I is the same arrangement as shape F.

When children share their work, they may notice that some groups made
shapes that could be designed in many more ways than could those of other
groups. Children may realize that the number of different arrangements that
can be made depends a lot on the size of the blocks chosen for the original
shape. In general, the larger the blocks used, the greater the number of ways
to make congruent shapes. Children may reason that this is because there
are many more substitutions that can be made for a larger block, such as a
yellow hexagon, than for a smaller block, such as a blue parallelogram.

This activity is filled with opportunities for children to strengthen their
spatial reasoning and visualization ability. The skills needed to replace
larger blocks equivalently with smaller ones, to replace smaller blocks
equivalently with larger ones, to compare designs to check for duplication,
and to compare shapes to check for congruence require different kinds of
thought processes. These skills are important for children to develop and
maintain and to be able to apply to other mathematical contexts.
RECOVER THE SYMMETRY

Getting Ready

What You'll Need
Pattern Blocks, about 30 per pair
Mirrors, 1 per pair (optional)
Overhead Pattern Blocks (optional)

Overview
In this game for two players, children create symmetrical designs with Pattern Blocks, disturb the symmetry, and then challenge a partner to restore symmetry to their design. In this activity, children have the opportunity to:

- verify that a design has line symmetry
- develop spatial visualization skills

The Activity

Introducing

- Before working with the class, build two identical shapes symmetrical in both color and shape. Then move two blocks in one of the shapes to make it asymmetrical. For example:

- Display both shapes and identify them as being symmetrical and asymmetrical, respectively. Invite children to make observations about the symmetrical shape. Establish that it has line symmetry and point out the location of the line of symmetry.

- Have children suggest how they might move two blocks in the asymmetrical shape to make it symmetrical. Call on one or more volunteers to try this, and let children consider the results.
On Their Own

Play Recover the Symmetry!

Here are the rules.

1. This is a game for 2 players.

2. Together, players build a symmetrical design using 12 Pattern Blocks. The design should be symmetrical in both shape and color.

3. Players can use a mirror to check the symmetry of the design. They can look for other lines of symmetry by turning the mirror in different directions.

4. Next, one player looks away while the other player moves 3 blocks so that the design is not symmetrical.

5. The player who wasn't looking then tries to move 3 blocks to make the design symmetrical again.

6. After the symmetry has been recovered, players talk over these questions with each other: Is the new design symmetrical? Were the same blocks moved to recover the symmetry? Is the final design the same as the original one?

- Play several rounds of Recover the Symmetry.
- Be ready to talk about your games.

The Bigger Picture

Thinking and Sharing

Invite children to talk about their games.

Use prompts such as these to promote class discussion:

- What was easier, creating the original design or recovering the symmetry? Why?
- What did you notice during the game?
- Did you ever discover more than one line of symmetry in a design? If so, describe how this happened.
- What helped you decide how to move the blocks to recover the symmetry?
- When you made an asymmetrical shape symmetrical, did you recreate the original shape or did you find a new one? Why do you think this happened?
Extending the Activity

1. Have each pair of children make two identical symmetrical designs using Pattern Blocks, trace the outline of each, and draw in the line of symmetry. Then have children exchange outlines with another pair and use Pattern Blocks to fill one outline with a design that is symmetrical in color and the other with a design that is not. Have children compare the designs and discuss the differences.

Where's the Mathematics?

In this activity, children work with line symmetry, which is the exact correspondence of form and configuration on opposite sides of an imaginary line. A shape with form symmetry may or may not have color symmetry. The design on the left has form symmetry and color symmetry whereas the design on the right has form symmetry but not color symmetry.

Some children may form their designs by first drawing a line of symmetry and then placing blocks in reflection positions on each side of the line. For example, children might first place the red trapezoids as shown, then the blue parallelograms, then the orange squares, and so on.

Children who are able to visualize lines of symmetry within each of the Pattern Blocks may create designs similar to the one in the Introducing section of the activity. In these designs, the line of symmetry passes through the blocks.

After the discussion of symmetry in the Introducing section, most children will probably opt to create a design with a vertical line of symmetry, although some may decide to work with a horizontal line of symmetry.
2. Ask children to make a symmetrical design using 12 Pattern Blocks and then move four blocks from that design to make a new symmetrical design. Have them continue to create new symmetrical designs in this way, record each design, and see how many different symmetrical designs can be built.

Those children who look for additional lines of symmetry and feel motivated to adjust their symmetrical designs may be able to come up with designs that have both vertical and horizontal lines of symmetry. Still others who have had experience with analyzing figures for symmetry may form designs with more than two lines of symmetry.

![Symmetry Diagrams]

When children first play *Recover the Symmetry*, it is likely that the final design will be identical to their original design. As they become more comfortable with the idea of symmetry, they may look for ways to recover the symmetry by forming a new design. Here is an example of how such a game might play out. Figure A shows the original design, figure B shows an asymmetrical design that results from moving one red, one blue, and one green block, and figure C shows a symmetrical design, different from the first, that results from moving one red, one green, and one blue block.
SYMMETRY SEARCH

Getting Ready

What You'll Need
Cuisenaire Rods, 1 green and 1 orange per child
Mirrors, 1 per child
Glue stick or clear tape, 1 per child
Symmetry Search worksheet, 1 per child, page 101

Overview
Children figure out where to place a mirror on a given arrangement of Cuisenaire Rods to produce various symmetrical designs. In this activity, children have the opportunity to:

- work with reflective and rotational symmetry
- determine the effects of moving a line of symmetry
- use spatial reasoning

The Activity

Explain that the mirror should be held perpendicular to the light green rod so that it forms a right angle with the rod's top face.

Introducing

- Give each child a light green Cuisenaire Rod and a small mirror. Have children rest the mirror on top of the rod so that part of the rod is reflected in the mirror. Allow time for children to explore how changing the placement of the mirror creates different reflections.

- Sketch designs A and B on the chalkboard and challenge children to describe where the mirror could be placed on the light green rod in order to create each one.

- Demonstrate the ways to record how the designs are made and the placement of the mirror for each. Trace around the light green rod, then draw a dashed line to represent the position of the mirror. Add arrows to indicate which side of the mirror has the reflective surface.

- Verify that each design can be recorded in a number of ways.

Some solutions for design A

Some solutions for design B

GEOMETRY

- Spatial visualization
- Symmetry
On Their Own

Where should you place a mirror on an arrangement of Cuisenaire Rods to create a design?

- Work on your own. Glue a light green rod and an orange rod together as shown. Allow a few minutes for the glue to harden.

- Each design on the Symmetry Search worksheet can be made by laying your rod arrangement flat and placing a mirror on it. Find out where the mirror should be placed to make each design.

- Record your solution for each design by tracing around the light green and orange rods and then drawing a dashed line to show where you placed the mirror. Finally, add arrows to show which side of the mirror has the reflective surface. Here is the solution for a U-shaped design.

- With a partner, talk about how you decided where to put the mirror to re-create each design.

The Bigger Picture

Thinking and Sharing

Invite children to share their solutions and talk about what they learned.

Use prompts such as these to promote class discussion:

- How did you figure out where to place the mirror to create design number ————?

- What clues about mirror placement could you learn from the designs?

- Does knowing that a figure has symmetry help you know where to place the mirror? Explain.

- Were some designs harder to find solutions for than others? If so, which ones? Why?

- Did the solutions to some designs help you find the solutions to others? If so, what was alike about the two designs?

Extending the Activity

Have children find and draw additional designs based on the light-green-and-orange rod arrangement. Then have them exchange their drawings and challenge a partner to find out where the mirror was placed to create their designs.
Where’s the Mathematics?

In *Symmetry Search*, children work with congruence, symmetry, rotations, reflections, and visualization of angles and distances. The design that is produced by the mirror has to be exactly the same size and shape as (that is, congruent to) the pictured design. In order to exactly match each design, children may have to rotate the light-green-and-orange rod arrangement before placing the mirror.

The following solutions show the original rod arrangement rotated into position to agree with the orientations of the designs on the *Symmetry Search* worksheet.
Children intuitively learn that the mirror needs to be placed on the rods at the same angle as the line of symmetry in the design. For example, in Design 6, the line of symmetry makes a 25-degree angle with the side of the design; therefore, the mirror must be placed at a 25-degree angle along the orange rod in the original arrangement.

Some children will use a trial-and-error approach all the way through this activity. On the other hand, after drawing the solution for each of the first few designs, some children will begin to see a resemblance between the line of symmetry in the designs and the placement of the mirror on the rods. They may consciously use this idea, rotating the original rod design so that the colors appear to be in the correct locations and then moving the mirror along the design at the same angle as the line of symmetry. In the example involving Design 6 on the preceding page, a child might think, “I need to rotate the rod arrangement until the light green is on the left side and the orange is on the right because that is how the light and dark shading appears above and below the line of symmetry in the design. Now I will slide the mirror along so that it’s at the same angle as the line of symmetry in the design until the rods and their reflection look just like the design.” The child may not use words like “line of symmetry” and “angle,” but these are likely to be the ideas he or she is using.
Each of these designs can be made by placing a mirror on your original green-and-orange rod arrangement.
Teaching the Standard (Geometry) With Children’s Literature

*Books dealing with this subject that could be incorporated into mathematics instruction.

- The Amazing Book of Shapes by Lydia Sharman (Dorling Kindersley, 1994).
- Arrow to the Sun: A Pueblo Indian Tale by Gerald McDermott (Viking, 1974).
- A Cloak for the Dreamer by Aileen Friedman (Scholastic Press, 1994).
- The Greedy Triangle by Marilyn Burns (Scholastic Press, 1994).
- Look at Annette by Marion Walter (M. Evans and Company, 1971).
- Make a Bigger Puddle, Make a Smaller Worm by Marion Walter (M. Evans and Company, 1971).
- Round Buildings, Square Building, Buildings That Wiggle Like a Fish by Philip Isaacson (Knopf, 188).
- Sir Cumference and the First Round Table by Cindy Neuschwander (Charlesbridge, 1997).
- The Tangram Magician by Lisa Campbell Ernst and Lee Ernst (Harry N. Abrams, Inc., 1990).
- The Village of Round and Square Houses by Ann Grifalconi (Little, Brown, 1986).
Standard 5 — Measurement

The study of measurement is essential because of its uses in many aspects of everyday life. Students measure length to the nearest half-inch, add units of length, and find the perimeters of shapes. They estimate area and volume in preparation for developing formulas for calculating them. They estimate, measure, and compare weights, capacities, and temperatures in standard units. They also learn about money: the value of any collection of coins and dollars, writing money using the $ symbol, and deciding whether they have enough money to make a purchase.
Standard 5
Measurement
Students choose and use appropriate units and measurement tools for length, capacity, weight, temperature, time, and money.

3.5.1 Measure line segments to the nearest half-inch.
   Example: Measure the length of a side of a triangle.

3.5.2 Add units of length that may require regrouping of inches to feet or centimeters to meters.
   Example: Add the lengths of three sheets of paper. Give your answer in feet and inches.

3.5.3 Find the perimeter of a polygon*.
   Example: Find the perimeter of a table in centimeters. Explain your method.

3.5.4 Estimate or find the area of shapes by covering them with squares.
   Example: How many square tiles do we need to cover this desk?

3.5.5 Estimate or find the volume of objects by counting the number of cubes that would fill them.
   Example: How many of these cubes will fill the box?

3.5.6 Estimate and measure capacity using quarts, gallons, and liters.
   Example: This bottle holds one liter. Estimate how many liters the sink holds.

3.5.7 Estimate and measure weight using pounds and kilograms.
   Example: Estimate the weight of your book bag in pounds.

3.5.8 Compare temperatures in Celsius and Fahrenheit.
   Example: Measure the room temperature using a thermometer that has both Celsius and Fahrenheit units. If the temperature in the room measures 70°F, will the Celsius measurement be higher or lower?

3.5.9 Tell time to the nearest minute and find how much time has elapsed.
   Example: You start a project at 9:10 a.m. and finish the project at 9:42 a.m. How much time has passed?

3.5.10 Find the value of any collection of coins and bills. Write amounts less than a dollar using the ¢ symbol and write larger amounts in decimal notation using the $ symbol.
   Example: You have 5 quarters and 2 dollar bills. How much money is that? Write the amount.
3.5.11 Use play or real money to decide whether there is enough money to make a purchase.
Example: You have $5. Can you buy two books that cost $2.15 each? What about three books that cost $1.70 each? Explain how you know.

3.5.12 Carry out simple unit conversions within a measurement system (e.g., centimeters to meters, hours to minutes).
Example: How many minutes are in 3 hours?

* polygon: two-dimensional shape with straight sides (e.g., triangle, rectangle, pentagon)
Example Measurement Lesson
Lesson Plan Content Page

Name: Abby Land
Lesson Topic: Measurement (Area)

INTASC Principle: The professional educator understands content. (#1)

IN State Standard: Standard 5 Measurement- Students choose and use appropriate units and measurement tools for length, capacity, weight, temperature, time, and money.

IN State Indicator: 3.5.4- Estimate or find the area of shapes by covering them with squares.

Annotated Bibliography:
Instructional:
This book provides many different area lessons involving covering figures with different size squares. It is from this book that the sea animal page and the area rule pages were copied. This book is available at Ball State University on the fourth floor of the Robert Bell Building in the Reading Room.

This book contains basic ideas for lessons that involve measuring the area of objects by using squares. It contains lessons that have students measure their book, their name, and their hand using square units. This book is part of Ms. Nancy Kitt's personal collection, and it can be found in her office on the fourth floor of the Robert Bell Building.

Informational:
This book provides several activities that help teachers explain to students the difference between perimeter and area. These activities could be used in the classroom with the student or for the teachers own personal reference. This book is also part of Ms. Nancy Kitt's own personal collection, and it too can be found in her office on the fourth floor of the Robert Bell building at Ball State University.
Lesson Plan

IN State Standard: Standard 5 Measurement- Students choose and use appropriate units and measurement tools for length, capacity, weight, temperature, time, and money.

IN State Indicator: 3.5.4- Estimate or find the area of shapes by covering them with squares.

Lesson Objective: The students will estimate and measure the area of different shapes and pictures using square tiles and square grid paper.

Materials/Media: Butcher paper grid, markers, square tile, Area Rule 1 worksheets (one for each student), enlarged copies of shapes 1-6 on Area Rule 1 worksheet for board, magnets to hold shapes on board, Area Rule 2 worksheets (one for each student), enlarged copies or Area Rule 2 shapes 2 and 6, Cube Covering worksheets (one for each student), cm cubes (about 20-30 for each student), double-sided tape, and grid paper (one sheet per student).

New Information:
- Area is the measure of space occupied by the surface of an object.
- Area is measured in square units.

Motivation: The teacher will lay the butcher paper (which has a six-inch by six-inch grid drawn on it) down on the floor. The teacher will then ask for a volunteer to assist the class. Once the teacher has selected a volunteer they will have the volunteer lay on the butcher paper while they trace the student's outline with a marker. Once the teacher is done tracing the student the student will stand up and the class will inspect the figure. "How could we find out how many squares ______'s area is? What do you think is the best method for counting the squares? What about the squares that are not whole?"

(Questions, Cues, Advance Organizers) Have the students estimate the area of the figure as a class. "Today we will be estimating and finding the area of different figures by using squares as measurement tools." Goal for Learner

Procedure:
1. New Information: "Area, the concept we will be learning about today, is the measurement of the space an objects surface occupies. Area is measured in square units such as square centimeters, inches, and feet. (Take out a square tile and explain why it is called a square inch, however, do not go into too much detail as this will be covered in later lessons.) this is why we will be finding the area of shapes using squares today."

2. Modeling: The teacher will explain to the students the best method to use in order to find the area of an object (like the student's figure) using squares. "When I am finding the area of something using a square grid, I think it is best to count off the squares as I go. (The teacher should begin checking off squares with the marker and counting them out loud.) For now I am only
going to check off the whole squares, I will come back to the partial ones later.” Once the teacher is done checking off the whole squares they should tell the students, “There were ___ whole squares in ______’s figure. However, I cannot forget about these pieces of squares because they make up part of the figure too. To get a measurement of about how many squares ______’s figure is I need to add these partial squares in too. I will do this by finding squares I could put together to make a square that is about one whole square.” The teacher should then find two squares that would almost equal one whole square if put together and check them both off. The teacher should continue putting partial squares together, checking them off, and counting as they go. Once the teacher comes up with the total number of squares in ______’s figure, they should ask the students, “Was our class estimate close to the measurement that was just found? Why or why not?” (Questions, Cues, Advance Organizers and Generating/Testing Hypotheses)

3. Guided Practice: The teacher will give each student a copy of the Area Rule 1 worksheet so they will have a visual in front of them. Then they will place an enlarged copy of shape 1 on the board in front of the class. The teacher will ask for a volunteer to find the area of this shape. Next, they will explain to the class that while this student is counting off the squares at the board, they should be following along at their desks to make sure the student gets the correct answer. Have the volunteer come up to the front and give them a marker, so they can mark out the squares as they count. If the student has problems finding the area, give suggestions so the entire class can benefit from the extra instruction. Once the student has come up with an answer, ask the class, “Is this the same answer you came up with?” If the students disagree, work as a class to find the correct area. If the students agree, move on to the next problem. Place shape number 2 on the board and allow another student to come up and find the area using a marker to cross off the squares as they go. Once they are done consult the class as you did before. Do this same procedure for shapes 3, 4, 5, and 6 so the class gets plenty of practice finding the area of the shapes.

4. Check for Understanding: Pass Area Rule 2 worksheets out to students. Ask students to estimate the size of objects number 2 and 6. Now tell the students to find the area of the two shapes. Give the students a couple minutes to count the squares and find the area. Then ask the class, “What did you get for the area of object 2? What about the area of object 6?” (Questions, Cues, Advance Organizers) If the students are all correct, you can assume they understand fairly well and move on. If some of the students do not get answers close to the correct answer, place the enlargements of these two shapes on the board. Then ask one of the students who got the correct answer if they can explain, using the shape on the board, how they got their answer. This way the class will get a quick refresher before moving on.
5. **Practice/Application:** Give each student a copy of the cube covering worksheet and about 20-30 cm cubes. Tell the students to make sure to write their name on the worksheet because it will be evaluated to determine how well they understood the lesson. Since the problems on this worksheet are slightly different than those on the others (because the student are placing the cubes on top of the animals instead of working with shapes on a grid) do the first problem as a class. Tell the students to begin placing cubes on top of the starfish to make a grid like we saw under the last set of shapes. Remind the students that the cubes will not exactly cover the starfish so they may have to add some of the parts that are not covered together to use another cube. Give the students time to find an answer and then check this answer as a class. Once you have done this, allow the students time to complete the next four problems on their own using the cm cubes. Make sure the students turn the worksheet in when they are finished.

6. **Closure:** “Who can tell me what area is? What type of units are used to measure area? When do you think you might need to find the area of something in your everyday life? (Examples: painting a room, seeing if a huge new TV will fit in your entertainment center, etc.)” *(Questions, Cues, Advance Organizers)* Discuss these questions with the students to finish up the lesson.

**Evaluation of Student Learning:** The teacher will grade the last four problems on the Cube Covering worksheet to evaluate the students’ level of learning. Each question will be worth two points, one for filling in an estimate and one for the correct answer. Since it is hard to be exact when using cm cubes to measure objects; the teacher will count the students’ answers correct if they are with in one or two cubes of the answer either way.

**Lesson Extension:** If there is time left over the teacher will give each student a piece of grid paper. Then the students will estimate who has the longest name in the class. At that point the teacher will show the students how to write their names on the grid paper so that they are all writing them about the same size (one grid row wide for the sticks on R’s, T’s, J’s, etc.). Then the teacher will give the students time to color their names onto the grid using markers and to count the squares in order to find the area of their names. After all the students have found the area of their name, they will check to see if their estimation about whose name would have the biggest area was correct. *(Generating/Testing Hypotheses)*
Area Rule 1

Find the areas of the shapes below by counting the number of squares each shape covers. Before you start counting you must make up a rule for the counting of part squares.

My rule is ...

The areas of the shapes are:

Shape 1
Shape 2
Shape 3
Shape 4
Shape 5
Shape 6
Area Rule 2

Use the rule that you made up on Area Rule 1 to find the areas of the circles and ovals in the grid below. Estimate the area before you count the squares. Record your answers below.

The areas of the shapes are:

Shape 1 Est. _____ Actual _____ Shape 4 Est. _____ Actual _____
Shape 2 Est. _____ Actual _____ Shape 5 Est. _____ Actual _____
Shape 3 Est. _____ Actual _____ Shape 6 Est. _____ Actual _____

World Teachers Press Exploring Measurement, Grades 3-4
Cube Covering

Cover the pictures below using cubes. Estimate the number of cubes it will take to cover each picture before you cover them. Record your answers and estimates.

1. Estimate ____________
   Actual ____________

2. Estimate ____________
   Actual ____________

3. Estimate ____________
   Actual ____________

4. Estimate ____________
   Actual ____________

5. Estimate ____________
   Actual ____________

Order the drawings from greatest number of cubes to the least number of cubes.
More Teaching Ideas for Measurement
Teaching Ideas Bibliography (Measurement)

*Contains the “How Many Cubes” idea on page 27.

*Contains the “How Many to a Pound?” and “Follow the Liter” activities on pages 27 and 34.

*Contains the “Picture Perimeter”, “Container Capacity”, and “Way to Weigh” ideas on pages 7, 30, and 33*
Picture Perimeters

Use
- photograph
- centimeter cubes
- small poster
- centimeter ruler

Explore

1. Estimate the distance around the photograph in cubes. Then measure.
   
   Estimate: ______ cubes
   Measure: ______ cubes

2. Estimate the distance around the photograph in centimeters. Then measure.
   
   Estimate: ______ centimeters
   Measure: ______ centimeters

3. Estimate and measure the perimeter of the poster in cubes. The perimeter is the distance around an object.
   
   Estimate: ______ cubes
   Measure: ______ cubes

4. Estimate the perimeter of the poster in centimeters. Then measure.
   
   Estimate: ______ centimeters
   Measure: ______ centimeters

Explore Some More

Estimate and measure the perimeter of an object on the poster. Try to find an object in your desk that has a perimeter of about 100 centimeters.
How Many Cubes?

Find the capacity of the containers listed below. Do this by filling them with cubes. Estimate the number of cubes you will need for each before you start filling and counting.

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Your hand</td>
<td></td>
</tr>
<tr>
<td>2. Two hands</td>
<td></td>
</tr>
<tr>
<td>3. A pencil case</td>
<td></td>
</tr>
<tr>
<td>4. A cup</td>
<td></td>
</tr>
<tr>
<td>5. A milk carton</td>
<td></td>
</tr>
<tr>
<td>6. A shoe</td>
<td></td>
</tr>
<tr>
<td>7. An ice-cream container</td>
<td></td>
</tr>
<tr>
<td>8. A plastic bag</td>
<td></td>
</tr>
<tr>
<td>9. A margarine container</td>
<td></td>
</tr>
<tr>
<td>10. A plastic bowl</td>
<td></td>
</tr>
<tr>
<td>11. A shoe box</td>
<td></td>
</tr>
<tr>
<td>12. Own choice</td>
<td></td>
</tr>
</tbody>
</table>

Order your containers from largest to smallest capacity.
Follow the Liter

Can you tell how big a liter is?

Although Americans continue to use customary rather than metric units for most measures, the liter has become a familiar size in the U.S. marketplace. This activity helps children get a sense of the capacity of a liter.

The Plan

1. Display a 1-liter bottle. Ask children what kinds of things usually come in containers like this (liquids such as soda, milk, or juice).
2. Display an assortment of unlabeled bottles. Ask volunteers to try to select bottles that hold less than 1 liter, more than 1 liter, and about 1 liter.
3. Divide the class into groups. Give each group a 1-liter bottle, some unlabeled bottles (some greater, some less than 1 liter), and a catch basin. Have children pour water from the 1-liter bottle into the other containers to determine which ones hold more than 1 liter and which hold less than 1 liter. Provide funnels, if needed.
4. Then have children pour water from the 1-liter bottle into a paper cup to determine about how many servings of that size a 1-liter bottle would provide.

MATERIALS

- labeled 1-liter bottles
- various unlabeled bottles that hold more and less than 1 liter
- catch basins
- water
- funnels (optional)
- paper cups
- paper towels or sponges

Follow-Up

☆ Knowing about how many servings are in a liter is a useful real-life fact. Plan a class party that involves beverages sold in 1-liter containers. Help children figure out how many liters to buy so that everyone in the class can have a paper cup serving.

☆ Conduct a similar investigation using quarts or gallons.
**Container Capacity**

**Use**
- large containers labeled W, X, Y, and Z
- water
- one-liter measure or bottle

**Explore**

1. Put the containers in order from smallest to largest, based on how much you think they hold. Use the letters to record.

<table>
<thead>
<tr>
<th></th>
<th>______</th>
<th>______</th>
<th>______</th>
<th>______</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smallest</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td></td>
</tr>
<tr>
<td>Largest</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

2. The capacity of a container is how much it holds.

   How many liters of water does each container hold? Estimate. Then measure. Record your data in the chart.

<table>
<thead>
<tr>
<th>Container</th>
<th>Capacity in Liters</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Estimate</td>
</tr>
<tr>
<td>X</td>
<td>Measure</td>
</tr>
<tr>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td></td>
</tr>
</tbody>
</table>

3. Put the containers in order, based on their capacity.

<table>
<thead>
<tr>
<th></th>
<th>______</th>
<th>______</th>
<th>______</th>
<th>______</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smallest</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td></td>
</tr>
<tr>
<td>Largest</td>
<td>______</td>
<td>______</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

**Explore Some More**

Use a one-quart measure. Measure the capacity of each container in quarts. Make a chart on the back of this paper. Explain how you think a quart and a liter are similar and how they are different.
How Many to a Pound?

What does a pound look like?

Well, that depends on the object! If a sign says that apples are 45¢ a pound, how many apples do you get for 45¢? Children can start to become smart shoppers by getting a sense of how many fruits or veggies make 1 pound.

The Plan

1. Have children hold a 1-pound weight and get a sense of how heavy it feels. Then ask them to estimate how many apples weigh 1 pound. Record their guesses. Then bring out some real apples and have a volunteer use the balance scale to answer the question.

2. Repeat with other items. Have children first guess and then verify their guesses using the balance scale and actual objects. Provide each child with a recording chart such as this one:

<table>
<thead>
<tr>
<th>Item</th>
<th>GUESS How Many to a Pound?</th>
<th>ACTUAL Number to a Pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>apples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bananas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Follow-Up

☆ Encourage children to make generalizations about the number of items to the pound. Some may say that the heavier the item, the fewer you get in a pound. Others may notice that if items come in varied sizes, you might be able to mix and match them to get closer to exactly 1 pound.

☆ Talk with children about what happens in a store when someone wants to buy more or less than an exact pound. If possible, bring in grocery store receipts that show produce weighed by the pound and its price calculated accordingly.

MATERIALS

☆ balance scale
☆ 1-pound weights
☆ various foods (peanuts in the shell, apples, potatoes, onions, and so on)
☆ recording chart (see below)
☆ pencils
Way to Weigh

Use

- objects in your classroom
- calculator
- bathroom scale (showing pounds or kilograms)

Explore

1. How many pounds (or kilograms) do you weigh? Estimate. Then weigh yourself on the scale. Record your weight. Circle pounds or kilograms.

   Estimate: _____ pounds or kilograms
   Measure: _____ pounds or kilograms

2. Find objects in your classroom that are heavy, but not so heavy that they are hard to lift. Hold each object and stand on the scale. Record the total weight. Then subtract your weight from the total weight to get the weight of the object. Example:

   Total weight: 80 pounds
   Your weight: 76 pounds
   The object’s weight: 4 pounds

   Record your work in the chart.

<table>
<thead>
<tr>
<th>Object</th>
<th>Weight in Pounds</th>
<th>Weight in Kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Measure</td>
</tr>
<tr>
<td></td>
<td>Estimate</td>
<td>Measure</td>
</tr>
</tbody>
</table>

Explore Some More

Find something that weighs about 5 pounds. Find something that weighs about 10 pounds. Explain to your partner what you thought about as you lifted objects and tried to estimate their weight.
Teaching the Standard (Measurement) With Children’s Literature
*Books dealing with this subject that could be incorporated into mathematics instruction.

America’s Champion Swimmer: Gertrude Ederle by David Adler (Harcourt, 2000).


How Big Is a Foot? by Rolf Myller (Dell, 1962).

If You Hopped Like a Frog by David M. Schwartz (Scholastic Press, 1999).


Is a Blue Whale the Biggest Thing There Is? by Robert E. Wells (Albert Whitman, 1993).

Jam by Margaret May (Little, Brown, 1986).


Measuring Penny by Loreen Leedy (Holiday House, 1997).


Pigs Will Be Pigs by Amy Axelrod (Simon & Schuster, 1994).

Thunder Cake by Patricia Polacco (Philomel, 1990).

Twitch by Pat Hutchins (Aladdin Books, 1971).


What’s Faster Than a Speeding Cheetah? by Robert Wells (Albert Whitman, 1997).
Standard 6 — Problem Solving
In a general sense, mathematics is problem solving. In all mathematics, students use problem-solving skills: they choose how to approach a problem, they explain their reasoning, and they check their results. As they develop their skills with numbers, geometry, or measurement, for example, students move from simple ideas to more complex ones by taking logical steps that build a better understanding of mathematics.
Standard 6
Problem Solving
Students make decisions about how to approach problems and communicate their ideas.

3.6.1 Analyze problems by identifying relationships, telling relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
   Example: Solve the problem: “Start with any number. If it is even, halve it. If it is odd, add 1. Do the same with the result and keep doing that. Find what happens by trying different numbers.” Try two or three numbers and look for patterns.

3.6.2 Decide when and how to break a problem into simpler parts.
   Example: In the first example, find what happens to all the numbers up to 10.

Students use strategies, skills, and concepts in finding and communicating solutions to problems.

3.6.3 Apply strategies and results from simpler problems to solve more complex problems.
   Example: In the first example, use your results for the numbers up to 10 to find what happens to all the numbers up to 20.

3.6.4 Express solutions clearly and logically by using the appropriate mathematical terms and notation. Support solutions with evidence in both verbal and symbolic work.
   Example: In the first example, explain what happens to all the numbers that you tried.

3.6.5 Recognize the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.
   Example: Measure the length and width of a room to the nearest meter to find how many student desks will fit in it. Would this be an accurate enough method if you were carpeting the room?

3.6.6 Know and use strategies for estimating results of whole-number addition and subtraction.
   Example: You buy 2 bags of candy for $1.05 each. The cashier tells you that will be $1.70. Does that surprise you? Why or why not?

3.6.7 Make precise calculations and check the validity of the results in the context of the problem.
   Example: In the first example, notice that the result of adding 1 to an odd number is always even. Use this to check your calculations.

Students determine when a solution is complete and reasonable and move beyond a particular problem by generalizing to other situations.

3.6.8 Decide whether a solution is reasonable in the context of the original situation.
Example Problem Solving Lesson
Lesson Plan Content Page

Name: Abby Land
Lesson Topic: Problem Solving

INTASC Principle: The professional educator understands content. (#1)

IN State Standard: Standard 6 Problem Solving- Students determine when a solution is complete and reasonable and move beyond a particular problem by generalizing to other situations.

IN State Indicator: 3.6.9- Note the method of finding the solution and show a conceptual understanding of the method by solving similar problems. Example: Change the first example so that you multiply odd numbers by 2 or 3 or 4 or 5, before adding 1. Describe the pattern you see.

Annotated Bibliography:
Instructional:
   This book contains math stories that help teach certain problem-solving methods. The laughing machine story, found in this book, helps teach students how to work backwards. This book is part of Ms. Nancy Kitt’s own personal collection, and can be found in her office on the fourth floor of the Robert Bell Building at Ball State University.

   This book provides many different ideas for teaching problem-solving. It contains lessons that focus on many different areas of problems-solving. However, for this lesson, it was the “Backward Burglar” idea that was used out of the book. This book is also part of Ms. Nancy Kitt’s own personal collection, and it too can be found in her office.

Informational:
   This book can also be used as an informational resource by the teacher because it provides information on how to teach the problem-solving skill, which is covered in the chapter, to the students. This book is part of Ms. Nancy Kitt’s own personal collection, and can be found in her office on the fourth floor of the Robert Bell Building at Ball State University.
Lesson Plan

IN State Standard: Standard 6 Problem Solving- Students determine when a solution is complete and reasonable and move beyond a particular problem by generalizing to other situations.

IN State Indicator: 3.6.9- Note the method of finding the solution and show a conceptual understanding of the method by solving similar problems. Example: Change the first example so that you multiply odd numbers by 2 or 3 or 4 or 5, before adding 1. Describe the pattern you see.

Lesson Objective: The students will use the working backward method of problem-solving to find solutions to similar problems.

Materials/Media: Blackboard, chalk, square tiles, Toby and The Laugh Machine Worksheets pages 77 and 78 (one set for each student), The Backward Burglar worksheets pages 75-78 (one set for each student), and answer keys for both worksheets.

New Information:
- Many different methods can be used to solve problems. One of these methods is known as working backwards.
- Working backwards is best for problems containing a step-by-step process or a complicated chain of information.
- Work backwards when you know the answer and are trying to figure out the question.
- Begin working backwards by making a list of what you know, what you don’t know, and what you need to find out.
- Work back step by step and keep track of what you find out.
- Evaluate what you find out and make sure you are getting closer to the goal.

Motivation: “I got to school at the perfect time today, so I am going to leave my house at the exact same time tomorrow. However, I do not remember what time I left my house today, so I need to try and figure it out with your help. I know I got to school at 7:30, and I stopped for 7 minutes at the gas station to fill up my car and get a cup of coffee. I also know it takes me exactly 12 minutes to get to school when I don’t make any stops. If I plan on stopping at the gas station every morning like I did today, and still getting here at 7:30, what time should I leave my house?” Allow students time to think about this question. Once the students get the correct answer (7:11) ask them, “How did you come up with that answer? Why did you use that method?” (Questions, Cues, Advance Organizers) Tell the students, “You found the answer by using a problem-solving strategy known as working backwards. Today we will be learning more about this problem-solving strategy and the times it should be used.” Goal for Learner

Procedure:
1. New Information: There are many different strategies that can be used to solve problems. Working backwards is one of these strategies. Working backwards is best for problems containing a step-by-step process or a
complicated chain of information. Working backwards should also be used when you know the answer to the problem. For example: you knew the answer to my problem, I got to school at 7:30, you just needed to find out when I left. Working backwards is easiest to do if you start out by making a list of what you already know (that I got school at 7:30, took 7 minutes at the gas station, and 12 minutes to drive from my house to school without stopping), what you don’t know (how long it took me total to get from my house to school), and what you need to find out (what time I left). When working backwards, remember to take things slow and work backwards step by step. Also, remember to pay attention as you go to make sure you are still headed in the right direction.

2. **Modeling:** Read this out loud to the students while writing the information you know on the board. “Toby wants to add three new laughs to her repertoire- the SNICKER, SNORT, and CACKLE. The Laugh-Meter rates a CACKLE as 5 times as funny as a SNORT. It rates a SNORT as 3 times as funny as a SNICKER. And it rates as SNICKER as 5 points less funny than a CHUCKLE. If a CHUCKLE registers 10 points on the Laugh-Meter how many points are the SNICKER, SNORT, and CACKLE?” At this point all the information you know should be written on the board. So the board should say:

- CACKLE = 5 x SNORT
- SNORT = 3 x SNICKER
- SNICKER = CHUCKLE - 5 points
- CHUCKLE = 10 points

Tell the students it is very important to always write down the information you know. **(Summarizing/Notetaking)** Ask the students, “What do we need to find (the value of a CACKLE, SNORT, and SNICKER)? Now model for the students how one would go about solving these problems using square tiles. “I already know a CHUCKLE is 10 points (tiles) so if I put 10 points (tiles) in for the CHUCKLE I can find out a SNICKER is 5 (tiles) by subtracting the 5 points (tile difference) from the original 10 points (tiles). If I plug 5 points (tiles) in for the SNICKER, I can find a SNORT is worth 15 points (tiles) by multiplying the 5 points (tiles) by the 3 points (tiles). Finally, I plug those 15 points (tiles) in the top equation; I then learn that a CACKLE is 75 points (tiles) by multiplying the 15 points (tiles) by the 5 points (tiles).”

The tiles should help students visualize this from a concrete level.

3. **Guided Practice:** Give each student a copy of the Toby and The Laugh Machine worksheet pages. Allow the student time to read the two pages. Now work through the problems on the pages as a class. First, show the students how the information they already know is written down in the box. Begin by telling the students it will be easiest to answer the questions if they know the values of all the laughs. Ask the students if they would like to use square tiles for these questions, or if they fell comfortable working them out on their own. Ask the students, “Which laugh should we start with? Why? (The GIGGLE is the only laugh you already know the value to.)” As the
students find the correct answer to a problem ask them, “Which laugh should we do next? Why?” (Questions, Cues, Advance Organizers) This way the students have to rationalize why they are doing what they are doing. Continue working through the laughs in this manner as a whole class. Once the class knows the value of all 6 laughs, it is time to work your way through problems 1-8 by calling on students in the class.

4. Check for Understanding: “When is it a good idea to solve a problem by working backwards? What is an important thing to remember when working backwards? Why do you think working backwards is helpful when solving problems like these?” (Questions, Cues, Advance Organizers) Allow the class time to discuss each question after it is asked.

5. Practice/Application: The teacher will pass out The Backward Burglar worksheets (pages 75-78) to the students. The teacher will tell the students that this worksheet will be used to evaluate them, so they should be sure to fill it out completely and take their time. The students will then be given time to read the story (which is an example problem) and answer the five problems. The teacher will walk around the room while the students are working to make sure everybody understands the assignment. Once the students are done, or the teacher has decided enough time has passed, the teacher will collect the assignments from those students that are done and tell the others to make sure it is turned in by tomorrow morning.

6. Closure: The teacher will ask the students, “What did you learn during today’s lesson?” The teacher and the students will discuss the answers. “Sometimes I solve problems like the one this morning, when I was trying to figure out when to leave, without even realizing that I am using a problem-solving strategy, working backwards! Did you ever solve problems before by working backwards without even realizing what you were doing?” Again the teacher and the students will discuss their answers. (Questions, Cues, Advance Organizers)

**Evaluation of Student Learning:** The teacher will grade the 5 questions on the Backward Burglar worksheet. Each question will be worth a total of 2 points for a worksheet total of 10 points.

**Lesson Extension:** If there is time left over, or if the students catch on to the lesson very quickly and need more of a challenge, the teacher will have the students each write their own problems that could be solved by working backward and then have them exchange these problems with the person next to them.
Toby had always wanted to be the best at something. But she wasn’t terribly good at sports (too dull) or music (too picky-picky), and while she liked to dance, she would probably never be the “best” at it (too lanky).

The one thing she was good at was laughing. Her mother said it was a natural gift. It got to the point that folks would end up laughing because of Toby instead of whoever or whatever was supposed to be funny. She was that good.

From there it was only a short step to Hollywood. It seems that the Big Time Television Network needed a professional “laugher” for its audience. Toby tried out and won the job outright from 60 other contestants. From there it was on to all those hilarious Big TV shows, such as “Barney Pigg” and “I Married a Horse,” where Toby was expected to laugh up a storm.

Which she did, and quite well, thank you, until the network bosses came up with a Laughter Machine.

The buttons on the machine are shown below.

Toby knew that she could beat the machine at its own game if she could

<table>
<thead>
<tr>
<th>Button</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIGGLE</td>
<td>3 times as funny as a CHUCKLE, scores 30 on a Laugh-Meter</td>
</tr>
<tr>
<td>GUFFAW</td>
<td>3 times as funny as a CHORTLE</td>
</tr>
<tr>
<td>CHORTLE</td>
<td>Twice as funny as a CHUCKLE</td>
</tr>
<tr>
<td>HOWL</td>
<td>20 points more than a GUFFAW on a Laugh-Meter</td>
</tr>
<tr>
<td>ROAR</td>
<td>10 times as funny as a CHUCKLE, 20 more than a HOWL on a Laugh-Meter</td>
</tr>
<tr>
<td>CHUCKLE</td>
<td>See GIGGLE, CHORTLE, ROAR</td>
</tr>
</tbody>
</table>
only get a hold of a Laugh-Meter. With a Laugh-Meter, she could measure the precise power of each laugh. But then she realized that she could figure out the value of each laugh even without a meter.

1. Which has the greater laugh value, a GIGGLE or a CHUCKLE?

8. Give the value of each laugh.

It came down to this. Toby would have a “Laugh-Off” against the Laugh Machine. Whoever laughed more accurately would get the job as Chief Laughter for Big TV’s new fall shows. The two battled it out for hours and hours. Whenever Toby laughed, the delighted audience roared along with her, while during the machine’s laugh there was an eerie silence in the room. But the machine’s laughing was more accurate. In the end, the machine was ahead, not by a lot, mind you, but just by a few snickers, which were almost too small to detect on a Laugh-Meter.

As the Big Boss came out to announce the winner, Toby hung her head. She had laughed her best, but she just couldn’t quite compete with a machine.

“And the winner is—TOBY FRANKLIN!” the Big Boss announced. Toby was stunned.

“Why me?” she asked.

“Simple,” said the Big Boss. “When the Machine laughs, it laughs by itself. But when you laugh, everyone laughs with you.”

2. Which laugh has the largest value?

3. Which laugh has the smallest value?

4. List the laughs in the order of how funny they are.

5. What is the value of a CHUCKLE?

6. A HOWL is how many times as funny as a CHUCKLE?

7. What laughs combined equal the power of a ROAR?
the secret doesn’t exceed 510 until 6 hours pass.

<table>
<thead>
<tr>
<th>Hour</th>
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<th>Total People</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>i</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>14</td>
</tr>
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<td>3</td>
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<td>5</td>
<td>243</td>
<td>365</td>
</tr>
<tr>
<td>6</td>
<td>729</td>
<td>1094</td>
</tr>
</tbody>
</table>

7. 6 hours.

TOBY AND THE LAUGH MACHINE (PAGE 77)

1. GIGGLE.
2. ROAR.
3. CHUCKLE.
4. CHUCKLE, CHORTLE, GIGGLE, GUFFAW, HOWL, ROAR.
5. 10.
6. 8.
7. 2 Answers: CHUCKLE, GIGGLE, GUFFAW or CHORTLE, HOWL.

THE INCREDIBLE DO-NOTHING MACHINE (PAGE 79)

1. Because it does nothing.
2. Step F.
3. After Step D.

TRIVIAL COURT (PAGE 83)

1. ON.
2. ON, ON, ON, ON.
3. Every answer would be the opposite—OFF.
4. Timmy did not leave it ON.
5. Yes. Any even number would change the answer.
6. OFF.
4. A: FAN/LIGHT.
   B: ON.
   C: FAN/LIGHT.
   D: ON.

BURGER BATTLES (PAGE 86)

1. 4 mayo to 1 mustard. Use Easier Numbers. Suppose there were 2 ounces of mustard to every 6 ounces of mayo. The ratio of mayo to mustard would be 6/2, or 6 divided by 2, which equals 3. Now you know to divide ounces of mayo, 1 1/2, by the ounces of mustard, 3/8. 1 1/2 divided by 3/8 = 4.
I got a call from the First National State Federal Trust Savings and Loan Bank of America. There had been a robbery. It wasn’t just any robbery, though. The bank had been a victim of the Backward Burglar.

"Tommy, I’m glad you’re here," said the bank manager when I arrived.

"Tell me exactly what happened," I said.

"It was very strange," said the manager. "A man came in the bank. He went up to teller number three, Doris. He gave Doris an envelope of money. Then he went to teller number two, Cloris. He gave her an envelope of money, too. Then he gave an envelope of money to Boris, who is teller number one."

"Sounds like the Backward Burglar to me," I said. "What happened next?"

"He went behind the counter, and emptied the three envelopes of money," the manager said. "He mixed it all up with our other money. Then he walked out of the bank."
It was a classic job by the Backward Burglar. He doesn't steal money from banks. He gives money to banks. That's because he's committing the robbery in reverse. No one understands him, but no one really minds.

"The burglar gave you extra money," I said. "So why do you need a detective?"

"We are a bank," the manager said. "We need to know exactly how much money we have. Now we have too much. And it's all mixed up, so we don't know how much extra money we have."

"The Backward Burglar usually leaves some backward clues," I said. "Did he say anything?"

"He told me he gave me $5 less than he gave teller number two," said teller number three, Doris.

"Well, he told me he gave me $10 more than he gave teller number one," said teller number two, Cloris.

"He told me he was giving me $6," said Boris, teller number one.

"Oh, it's all so confusing!" cried the bank manager. "How will we ever figure it out?"

I said it was simple to solve the problem. All we had to do was work backward. The last thing the burglar did was give Boris $6. Before that, he gave Cloris $10 more than he gave Boris. That means he gave Cloris $16, because $6 plus $10 equals $16.

The first thing he did was give Doris $5 less than Cloris. That means he gave Doris $11, because $16 minus $5 equals $11.
To find out the total amount of money the burglar gave to the bank, I just had to add up the three amounts he gave to Boris, Cloris, and Doris. So the Backward Burglar gave the bank $33, because $6 plus $16 plus $11 equals $33.

"You have $33 in extra money," I told the manager.
"You're welcome," said the manager.
"Ah-ha," I said. "A backward thank you."
The manager smiled. "You can bank on it."

NOW IT'S YOUR TURN...

Now work backward to solve the following problems. Do the math from the end to the beginning, just like Tommy did.

1. The Backward Burglar eats lunch in the middle of the day, just like everybody else. But he eats dinner in the morning and breakfast at night! Today, he ate 3 more Burglar Burgers than tuna fish sandwiches. He ate 4 less tuna fish sandwiches than bowls of cereal. The Burglar ate 6 bowls of cereal for dinner. How many Burglar Burgers did the Backward Burglar eat?

2. The Backward Burglar loves to sleep during the daytime. He snored for 4 hours longer than he talked in his sleep. He talked in his sleep for twice as long as he walked in his sleep. He walked in his sleep for 1 hour. For how many hours did the Backward Burglar snore?
3. The Backward Burglar has a backward backyard. That's because it's in his front yard! He has 3 times as many apple trees as shrubs. He has 5 more shrubs than swimming pools. He only has one swimming pool, right in the middle of his front yard. How many apple trees does the Backward Burglar have in his yard?

4. The Backward Burglar doesn't enjoy books very much. He always reads the endings first! He read 3 less pages in his cowboy book than he did in his science fiction book. The number of pages he read in his science fiction book was the number of pages he read in his detective novel. He only read the last 20 pages of his detective novel. How many pages did the Backward Burglar read in his cowboy book?

5. The Backward Burglar was on a backward diet this week. He tried to gain weight! He gained 5 more pounds on Thursday than he did on Wednesday. He gained 5 times more pounds on Wednesday than he did on Tuesday. The pounds he gained on Tuesday were the number of pounds he gained on Monday. On Monday, he gained 8 pounds. What is the total number of pounds the Backward Burglar gained on those 4 days?
2. a. Bonnie  b. Connie

<table>
<thead>
<tr>
<th></th>
<th>skates</th>
<th>hair dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonnie</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Connie</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3. a. Old Man Nichols  b. Vanna  c. Ronny

<table>
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<tr>
<th></th>
<th>ape</th>
<th>giant banana</th>
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<tr>
<td>Vanna</td>
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</tr>
<tr>
<td>Nichols</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Ronny</td>
<td>No</td>
<td>No</td>
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</tbody>
</table>


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</tr>
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<td>No</td>
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<tr>
<td>Fran</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Nan</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

The Backward Burglar (page 74)
1. 5 Burglar Burgers
2. 6 hours
3. 18 apple trees
4. 7 pages
5. 35 pounds

The Cafeteria Caper (page 79)
Answers will vary.
More Teaching Ideas for Problem Solving
Teaching Ideas Bibliography (Problem Solving)

*Contains the “Nose Job” story on pages 34 and 35 with answers provided on pages 96 and 97.

*Contains the “Too Much Talking” story on pages 39, 40, 41, 42, 43, and 44 with answers provided on page 123.
Too Much Talking!

Story Summary
Detective Gina Jasper questions a person who's giving her too much information.

The Questions
Students pick out the necessary facts in word problems and then solve them.

Teaching Notes
Understanding a word problem and solving it can be difficult enough. The following problems raise the stakes a bit by providing too much information. The questions are loaded with numbers that have nothing to do with the problem. Students must read carefully, decide what information is crucial, and correctly solve the problem. This is an important real-world skill, especially in a time where we are often bombarded with information. Knowing what is relevant can make all the difference. Before students read the story, discuss with them the importance of looking for necessary information whenever they read.

SKILL/STRATEGY
"Too Much Information" problems

Additional Skills:
- Reading for detail
- Whole number +, −, ×, ÷
- Money +
- Computing with time
- Critical thinking
Gina Jasper here. Being a detective is tough for some of the other kids, but not for me. Sometimes I think I can read minds or something. It makes my work a snap. For example, I walked into our office the other day. A girl was pacing back and forth. She looked nervous. Somehow I knew that she had been the victim of a robbery.

"Let me guess," I said to the girl. "Someone stole something from you."

"That's right," said the girl. "How did you know that?"

"It's hard to explain," I explained. "When you're a top-notch detective like me, you just know. So who are you?"

The girl stopped pacing. "My name is Gabby Tock. I'm 10 years old. Actually, I'm 9 years, 11 months old. But I tell people that I'm 10. Because soon I will be 10,
and I don’t want them to think I’m 9. We’re going to have a big birthday party. We’ll have a chocolate cake. Chocolate is my favorite flavor. Strawberry is good, too, but not as good as chocolate. The party will be on a Saturday. My birthday is really on the Thursday before that. My mom thinks more people will come if it’s on Saturday. On Saturday I’ll be 10 years and 2 days old. We might have a special dinner on Thursday, with chicken and potatoes and—"

“Yes, yes, that’s very interesting,” I said, before Gabby could say another word. “But what I really want to know about is the robbery. What was stolen?”

“Oh, you want to know about the robbery. I’ll tell you all about it,” Gabby said. “Is it okay if I sit down?” Gabby sat down. “Sometimes I like to stand, but other times I like to sit. We might play musical chairs at my party! This is a nice chair. I like chairs made out of wood. They’re better than metal chairs or plastic chairs. My dad has a favorite chair. He likes to read the newspaper in his favorite chair when he comes home from work. Sometimes, Ralph is in the chair when Dad gets home. Ralph is our dog. Here’s a picture of my family and Ralph.” Gabby held up a picture. “Ralph’s funny! If he sees another dog across the street, he’ll bark and bark and bark! But if the dog comes close to
Ralph, then Ralph gets real scared. Anyway, if Dad finds Ralph in his chair, Dad yells at Ralph. Dad’s face gets red when he yells. One time Ralph was chewing Dad’s newspaper, and my mom came into the—"

I stopped Gabby again. “Gabby, I’m sure this is a great story. But you were about to tell me what was stolen.”

Gabby held her hands to her cheeks. “How silly of me! I’m sorry. My diary was stolen. It’s a really nice diary. It has a big lock on it. There are pictures of horses and stars all over the front and back of the diary. Horses are my most favorite kind of animal. I asked my dad if we could get a horse. He told me Ralph wouldn’t like that. But he said someday, if I’m good, we can go ride horses. It would probably hurt if you fell off a horse. But I would be really careful. I would ride it slowly, so I wouldn’t—”

This girl could really talk! “Gabby, I love horses, too. But you’re giving me too much information. You need to tell me about the robbery. I need to know about the stolen diary.”

“Oh, that? My little brother stole the diary. But he gave it back.”

Now I was mad. “Gabby, you know who took the diary? And you got it back? Then why did you come to a detective agency for help?”

Gabby gave me a strange look. “I didn’t come for help. I just need to use the bathroom. Where is it?”

I pointed down the hall. “Third door on the left.”

Gabby walked down the hall. I guess my mind-reading powers aren’t perfect yet. That’s okay. I’m still young.
NOW IT'S YOUR TURN...

Just like Gabby, sometimes math problems give you too much information. Read the following problems, and the question for each one. Underline the facts you'll need to answer the question. Solve the problem and write the answer in the blank.

1. Gabby was in the bathroom for 14 minutes. She left the faucet on for 8 minutes, but the plug was in the drain. So 15 gallons of water spilled onto the floor! Gabby pulled 38 paper towels off the rack to wipe up the spill. Gabby tried to sneak out the back door before anyone noticed. It took her 11 minutes to find the exit. How many minutes was Gabby in the bathroom with the faucet off?

2. Gabby wrote about her day in her diary. She started writing at 4:33 P.M. By 5:10 she had written 36 pages. On half the pages, she drew pictures of horses. On 13 other pages, she drew 11 pictures of cats, and 6 pictures of flowers. Gabby’s dad called her down for dinner at 5:47. How many pages had pictures of horses?

3. Gina was tired after Gabby’s visit. She tried to take a nap. Gina put 6 pillows under her head. Four of the pillows were blue, and 2 were yellow. Gina slept for 26 minutes. She had a dream that was 9 minutes long. In the dream, Gina was chased by 12 girls who looked like Gabby, 8 men who looked like Gabby’s dad, and 14 boys who looked like Gabby’s brother. They were all talking nonstop! They chased Gina for 37 miles. How many people were chasing Gina?
4. Gabby’s dog Ralph is 6 years old. He dug 14 holes in the backyard. He dropped 3 bones into each hole. Ralph chewed up Gabby’s dad’s newspaper and dropped it in 8 of the holes. Gabby’s dad walked down the 4 steps into the backyard. He saw what Ralph did and yelled for 16 minutes. What is the total number of bones Ralph dropped into the holes?

5. It takes Gabby’s dad 32 minutes to get home on bus number 17. Before he gets on the bus, Gabby’s dad buys 6 copies of the newspaper. He plans to give 5 papers to Ralph, and still have one to read. The total cost of the newspapers is $3.00. When Gabby’s dad walks in the front door, he trips on 46 marbles. Half of the marbles are black. While Dad is on the floor, Ralph chews up all 6 newspapers. How much does one newspaper cost?

**YOU CAN DO IT** Write your own “too much information” problem starring Gabby and her family. Exchange problems with your classmates and solve the problems.

**THINK IT OVER** Why do think it’s a good idea to underline the important facts in each problem?
**Diving Into Mystery (page 28)**
1. Mark Spritz, Wade Weeder, and C. P. Arr
2. Cloris Chlorine
3. Mark Spritz, Frank N. Mustard, Doreen Dryer, and Cloris Chlorine
4. Mark Spritz and Doreen Dryer
5. a. Wade Weeder, Doreen Dryer, or Cloris Chlorine  
   b. Wade Weeder and Doreen Dryer  
   c. Doreen Dryer

You Can Do It: Answers will vary.

**Estimation Celebration (page 34)**
1. a. 60 cans  
   b. 10 packages
2. 50 hamburgers
3. a–e. Answers will vary, depending on individual estimates.
4. Answers will vary. Cesar could guess about how much packages of each item will cost. Then he could add all the costs together. Cesar should probably bring more money than he estimates, in case his estimate is too low.
5. Answers will vary.

Think It Over: Answers will vary. You might need to know an exact number of something if you were selling items and wanted to keep track of how many you sold, or if you had a collection of items and wanted to make sure you hadn't lost any, or if you were counting money.

**Too Much Talking! (page 39)**
1. 6 minutes
2. 18 pages
3. 34 people
4. 42 bones
5. $.50

You Can Do It: Answers will vary.

Think It Over: Answers will vary. When you underline the important facts in a problem, you know what information to look at to solve the problem.

**Watch Your Step! (page 45)**
1. Two Steps: + and – Answer: 35 sets of footprints
2. Two Steps: × and + Answer: 30 pies
3. Two Steps: + or × and + Answer: 37 minutes
4. Two Steps: – and –, or + and – Answer: $1.11
5. Two Steps: + or × and – Answer: 6 slices
It was a cold night in the town of Two-Ply. So cold that the waterfall in the Two-Ply River froze over. And the clock at the Two-Ply State Bank froze and stopped at exactly 12 midnight.

Then the unthinkable happened.

Sheriff Philamina Two-Ply didn't learn about it until the next morning. There was a rap on her door. It was her cousin Bill. He was a Two-Ply, too. In fact, most everyone in the whole town was a Two-Ply of one sort or another.

"Philamina!" he cried. "Come quick! Moses Two-Ply’s nose just froze solid and fell off!"

Philamina put on her sheriff’s hat and sheriff’s badge and ran into town. And there it was—the statue of her great grandfather, Moses Two-Ply, the town founder and original Two-Ply—completely NOSELESS!

Underneath the statue were the remains of the nose—a pile of rubble.

"This just won’t do," Philamina cried.

It wouldn't do because noses were important to the town of Two-Ply. Moses Two-Ply had made his fortune from noses. First he invented nose plugs. Then nose cream. Then nose drops. Then came his masterpiece—the two-ply tissue. Because of Moses Two-Ply, noses all over the world were happier, healthier, and better taken care of.

"What now?" Bill asked.

"Make a new nose," Philamina said.

"How?" Bill asked. "The old nose is totally shattered. How do we know what it should look like or how big it should be?"

"Hmm," Philamina said. "Turn sideways, Bill. Folks always did say you looked a lot like Grampa Moses. Especially your nose. Meet me at the statue in a half hour."

"What for?" Bill asked.

"You'll see," Philamina said.

A half hour later they stood under the statue. Philamina had a tape measure.

"It won't work," Bill said. "The statue's too tall to measure with a tape measure."

"We're not going to measure the
statue,” Philamina said. “We’re going to measure three things: your shadow, the statue’s shadow, and the size of your nose.”

Bill grabbed onto his nose.

“I can understand your wanting to measure my nose,” Bill said. “But what does my shadow have to do with it?”

“Hold still,” Philamina said, as she measured Bill’s nose. It was two inches in length, by one inch wide, by one inch deep.

The 6-foot-tall, 200-pound Bill had a 2 1/2-foot shadow. The statue had a 15-foot shadow.

“I sure hope you know what you’re doing,” Bill said.

Philamina just smiled. “Don’t I always?” she said.

1. “First we need to find the height of the statue,” Philamina said. How can they do that?

2. Bill is how many times as large as his shadow?

3. The statue should be how many times as large as its shadow?

4. How tall is the statue?

5. What is the length of the statue’s nose?

6. How many 1-inch cubes of clay would be needed to make a nose the size of Bill’s nose?

7. About how many cubes would be needed to make a nose for the statue?

8. If each cube of clay weighs 1/4 of a pound, how much would the statue’s nose weigh?

The new nose was unveiled just in time for that year’s Nose Festival. Everyone thought it was just perfect, so much like the old one that you couldn’t tell the difference.

As for Bill—he walked around saying “That’s my nose up there!” and turning to the side so people could see it.

Of course, most of the people at the festival were Two-Plys, and they didn’t see anything at all special in Bill’s nose—because they had the same nose themselves! But Bill was proud anyway. Philamina was proud too. In fact, even the old statue seemed to have a new twinkle in its eye.

And the next morning in the newspaper there was a big picture of the nose. The headline read: MOSES’S NOSE’S OKAY!

And it never fell off again.
0000, then 9,999, then 9,998, etc. So 9,900 is 99 units, or about 4 months before Sylvester was born.

**NOSE JOB (PAGE 34)**

**NOTE:** Ratios and proportions are especially helpful for this story.

1. Find the ratio in height of Bill to his shadow. The ratio of the statue to its shadow should be the same.
2. 2 2/5.
3. 2 2/5.
4. 36 feet. Use Easier Numbers lets you see what is happening in this problem. Suppose Bill’s shadow was 3 feet instead of 2 1/2 feet. That would mean the he would be twice as tall as his shadow. That would also mean that the statue would be twice as tall as its shadow. The actual numbers show that the ratio between Bill and his shadow is 2.4 to 1. The ratio for the statue should be the same. Multiplying 15 (the length of the statue’s shadow) by 2.4 gives you an answer of 36 feet.
5. 1 foot.
6. About 2 cubes.
7. 432 cubes. Drawing a Diagram helps you see the relationship between heights and nose sizes. Bill is 6 feet tall; the statue is 36 feet tall (Problem 4). This means in every dimension—height, width, and length, the statue should be 6 times

the size of Bill. Bill’s nose is 2 inches by 1 inch by 1 inch. The statue’s nose, therefore, should be 12 by 6 by 6 inches. In volume this comes out to $12 \times 6 \times 6 = 432$ square inches.

8. 108 lbs.

**THE EXAGGERATED NEWS (PAGE 36)**

**NOTE:** Kids need to know that presidential elections occur every four years and the Declaration of Independence was written in 1776. They should also be familiar with the film *20,000 Leagues Under the Sea*.

1. Channels on which EXAGGERATED NEWS is seen: 5.
2. Pinky’s actual weight: 22 lbs.
3. Hours Pinky spent in the tree: 168.
4. Last time Pinky was seen: 4 years earlier.
5. Number of mice: 39.
6. Pinky’s IQ: 86.
7. Number of pounds of catnip Pinky has: 346.
8. Cat population: 65,000.
10. Votes received: 11.
11. Actual provision: 1222.
12. Declaration of Independence year 1776.
13. Time spent sniffing: 60 percent.
Teaching the Standard (Problem Solving) With Children’s Literature
*Books dealing with this subject that could be incorporated into mathematics instruction.

17 Kings and 42 Elephants by Margaret Mahy (Dial, 1987).

Anno’s Hat Tricks by Akihiro Nozaki (Philomel, 1985).

Betcha! by Stuart Murphy (HarperCollins, 1997).


Easy Math Puzzles by David Adler (Holiday House, 1997).


The Emperor’s New Clothes by Janet Stevens (Holiday House, 1985).

The I Hate Mathematics! Book by Marilyn Burns (Little, Brown, 1975).

The Jelly Bean Contest by Kathy Darling (Garrard, 1972).


Math Curse by Jon Scieszka and Lane Smith (Viking, 1995).

Mental Math Challenges by Michael Lobosco (Sterling, 1999).

Number Mysteries by Cyril Hayes and Dympna Hayes (Penworthy Publishing, 1987).

The Principal’s New Clothes by Stephanie Calmenson (Scholastic Press, 1989).