Ohio's Systemic Initiative
Discovery

Rainy Lake, aka Mirror Lake

One-Page Overview

By Robert B. Brown, The Ohio State University

Topics:

Problem-solving strategies, Geometry, Measurement, Estimation

Levels:

Grades 6 – 12

Problem:

This activity involves a map of a geographical feature. A lake or river works well, especially a small lake or pond. The problem as initially posed has no unique solution because of the different possible surroundings of the feature. It is a good problem-solving activity because of the need to recognize and deal with such circumstances.

Getting Started:

Take a topographical map featuring a body of water, such as a lake, pond, or river. Pose the problem of figuring out how much the level of the water has risen the morning after a one-inch rainfall the previous night.

Ohio Academic Content Standards, 2002

5-7		8-10		11-12	
1. Number, Number Sense and Operations		1. Number, Number Sense and Operations		1. Number, Number Sense and Operations	
2. Measurement	X	2. Measurement	X	2. Measurement	X
3. Geometry and Spatial Sense	X	3. Geometry and Spatial Sense	X	3. Geometry and Spatial Sense	x
4. Patterns, Functions and Algebra		4. Patterns, Functions and Algebra		4. Patterns, Functions and Algebra	
5. Data Analysis and Probability		5. Data Analysis and Probability		5. Data Analysis and Probability	
Mathematical Processes Problem Solving Connections		**Mathematical Processes** Problem Solving Connections		**Mathematical Processes** Problem Solving	

NCTM Principles and Standards, 2000

6-8		9-12	
1. Number and Operations		1. Number and Operations	
2. Algebra		2. Algebra	
3. Geometry	X	3. Geometry	X
4. Measurement	X	4. Measurement	X
5. Data Analysis and Probability		5. Data Analysis and Probability	
6. Problem Solving	X	6. Problem Solving	X
7. Reasoning and Proof		7. Reasoning and Proof	
8. Communication		8. Communication	
9. Connections	X	9. Connections	X
10.Representation		10.Representation	

Note: Capital X denotes major emphasis; lower case x denotes minor emphasis.

Rainy Lake, aka Mirror Lake

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Topics: Problem-solving strategies, Geometry, Measurement, Estimation	
Levels: Grades 6–12	*Timing:* Two hours
Materials: Topographical maps that include the catchment basin for a lake or pond or the watershed of a stream or river Rulers and pencils Tracing paper	*Prerequisites:* Estimating areas of irregular figures Calculating volumes

Problem:

This activity involves a map of a geographical feature. A lake or river works well, especially a small lake or pond. The problem as initially posed has no unique solution because of the different possible surroundings of the feature. It is a good problem-solving activity because of the need to recognize and deal with such circumstances.

Goals:

- Practice problem solving
- Practice identifying important features of a problem
- See that reasonable people can come up with differing estimates of the same thing
- Experience the synergies that come from group work
- Practice using a topographical map

Procedure:

Take a topographical map featuring a body of water, such as a lake, pond, or river. Pose the problem of figuring out how much the level of the water has risen the morning after a one-inch rainfall the previous night.

1. Break the students into groups and give each a group a topographical map featuring a body of water, such as a lake, pond, or river. You will have to supply a professional map, because a map with topological features would be too elaborate for the students themselves to produce within a reasonable time. You might also provide each group of students with some tracing paper, so they do not mark up the original maps and render them unusable for the future.
2. Pose the problem of figuring out how much the level of the water has risen the morning after a one-inch rainfall. Ask the students to discuss within their groups the difficulties of such a problem.
3. Have each group report on the difficulties that it deems important.
4. Discuss in the class as a whole how to proceed with the problem. Have the class agree on further assumptions and simplifications they would like to make.
5. Have each group work together to make an estimate of the rise in water level, making note of further difficulties, assumptions, and simplifications.
6. Have each group report on its estimate and how they arrived at it. In the class as a whole discuss the important differences in the ways the estimates were made. Do they have confidence in their answers? Could they devise long-term studies to decide what are the important features of this problem? Do they think that after such studies they would have more confidence in their estimates? Would they have enough confidence to make public flood predictions and evacuation orders?

Extensions:

Discuss the problem that the people living in the Nile valley had to contend with several thousand years ago. Every year the Nile would flood. But the increased water in the Nile was the result of rainfall in the mountains of Ethiopia, several thousand miles to the South and East and unobservable to the Egyptians.

Closure:

The problem is a very serious one. Rises in water levels can have severe consequences for agriculture, urban life, and transportation and communication.

The Mathematics:

To make any headway you will probably have to explicitly assume that the rainfall was uniformly one inch over the entire watershed or catchment basin. One of the most important features would be the area of the catchment basin versus the area of the body of water. More difficult, perhaps impossible, to deal with is how porous is the land over which the water flows to get into the body of water. It is worthwhile to observe that even on dry and porous land such as some deserts, dangerous flash floods are fairly common and extremely dangerous to those caught in them.

Another very important feature is whether by morning all of the water captured by the basin will have found its way into the body of water. As is well known, there are often delays, sometimes quite predictable, between rainfall and floods. Every spring the highest water in major river systems can be predicted and traced as it propagates downstream.

Relevant as well is whether there is an outlet for the body of water. Artificial lakes generally have an outlet dam. Rivers and streams provide their own natural outlet. A great simplification can be made by assuming that there is no outlet. Natural bodies of water without outlets, exemplified by the Great Salt Lake, occur in the Great Basin of the United States and elsewhere around the world.

Relationships to the Ohio Academic Content Standards, 2002:

Grades 5-7:

Measurement Standard
The student will be able to…

- Select appropriate units to measure angles, circumference, surface area, mass and volume, using:
  - U.S. customary units; e.g., degrees, square feet, pounds, and other units as appropriate;
  - Metric units; e.g., square meters, kilograms and other units as appropriate.
- Select a tool and measure accurately to a specified level of precision.
- Identify appropriate tools and apply appropriate techniques for measuring angles, perimeter or circumference and area of triangles, quadrilaterals, circles and composite shapes, and surface area and volume of prisms and cylinders.

Mathematical Processes Standard
The student will be able to…

- Clarify problem-solving situation and identify potential solution processes; e.g., consider different strategies and approaches to a problem, restate problem from various perspectives.
- Relate mathematical ideas to one another and to other content areas; e.g., use area models for adding fractions, interpret graphs in reading, science and social studies

Grades 8-10:

Measurement Standard
The student will be able to…

- Apply indirect measurement techniques, tools and formulas, as appropriate, to find perimeter, circumference and area of circles, triangles, quadrilaterals and composite shapes, and to find volume of prisms, cylinders, and pyramids.
- Estimate and compute various attributes, including length, angle measure, area, surface area and volume, to a specified level of precision.
- Use formulas to find surface area and volume for specified three-dimensional objects accurate to a specified level of precision.

Mathematical Processes Standard
The student will be able to…

- Formulate a problem or mathematical model in response to a specific need or situation, determine information required to solve the problem, choose a method for obtaining this information, and set limits for acceptable solution.
- Apply mathematical knowledge and skills routinely in other content areas and practical situations.

Grades 11-12:

Measurement Standard
The student will be able to…
- Apply various measurement scales to describe phenomena and solve problems.
- Estimate and compute areas and volume in increasingly complex problem situations.

Mathematical Processes Standard
The student will be able to…
- Construct algorithms for multi-step and non-routine problems.

Relationships to the NCTM Principles and Standards, 2000:

Grades 6-8 and Grades 9-12:

Measurement Standard
Instructional programs from pre-kindergarten through grade 12 should enable all students to…
- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.

Problem Solving Standard
Instructional programs from pre-kindergarten through grade 12 should enable all students to…
- Solve problems that arise in mathematics and in other contexts.
- Apply and adapt a variety of appropriate strategies to solve problems.

Connections Standard
Instructional programs from pre-kindergarten through grade 12 should enable all students to…
- Recognize and apply mathematics in contexts outside of mathematics.