Recreational Water Quality Slides

Recreational Water Quality in Southern Lake Michigan

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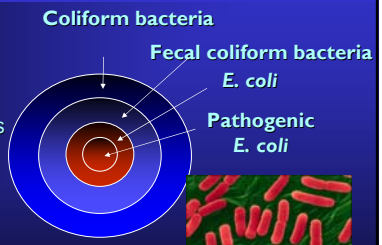
USGS

Recreational water quality standards: Fecal Indicator Bacteria

- 1900-1970: Total coliform bacteria
- 1972-1986: Fecal coliforms
  Epidemiological and water quality studies were conducted
- 1986-Present: *E. coli* or enterococci (freshwaters); enterococci (marine waters)



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Indicators should

1. Indicate human pollution
2. Not multiply in nature
3. Be short lived
4. Easy to count

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Problem: Other factors influence indicator bacteria

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Forest soils are a source of *E. coli*

Exclosures within Indiana Dunes State Park sampled for 10 months; *E. coli* was ubiquitous and persistent in Dunes Creek forest soils

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Dunes Creek impacts beach water quality

E. coli relationship	R Significance
East Side vs. West Side	0.291 <0.0001
East Side vs. Dunes Creek	0.403 <0.0001
West Side vs. Dunes Creek	0.319 <0.0001

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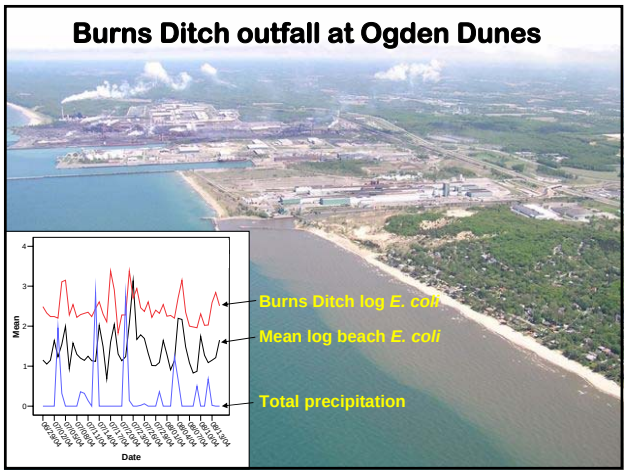
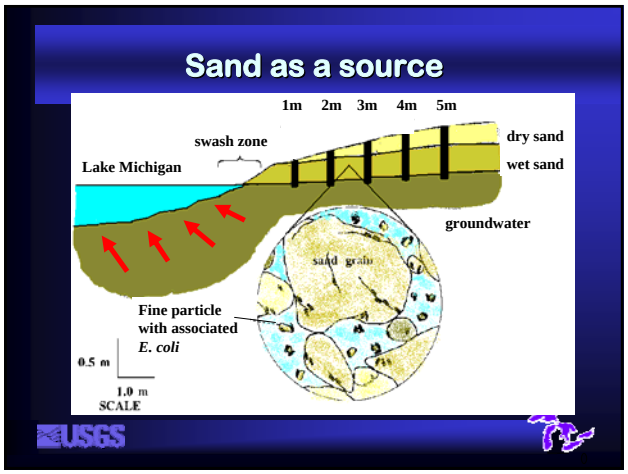
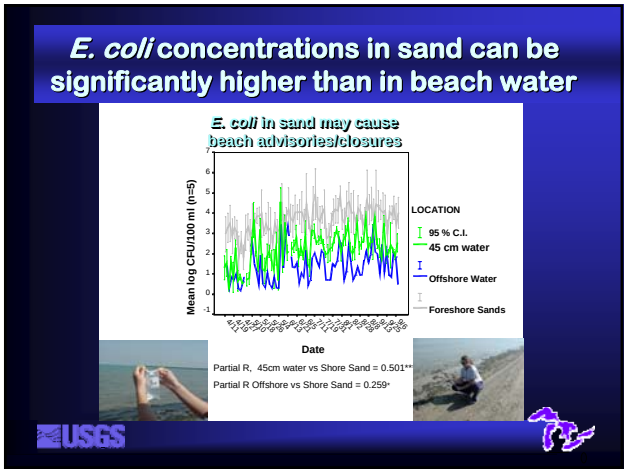
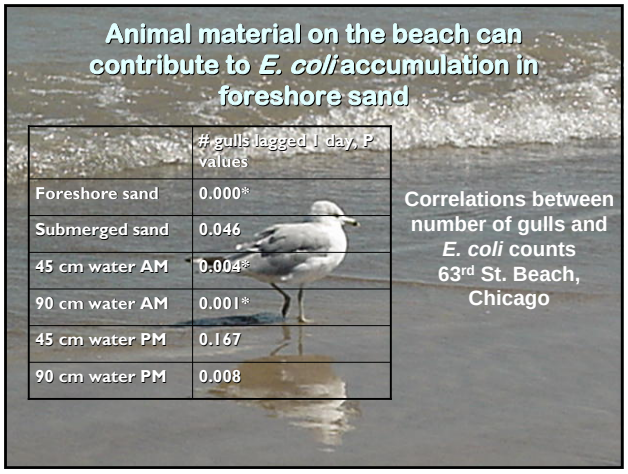
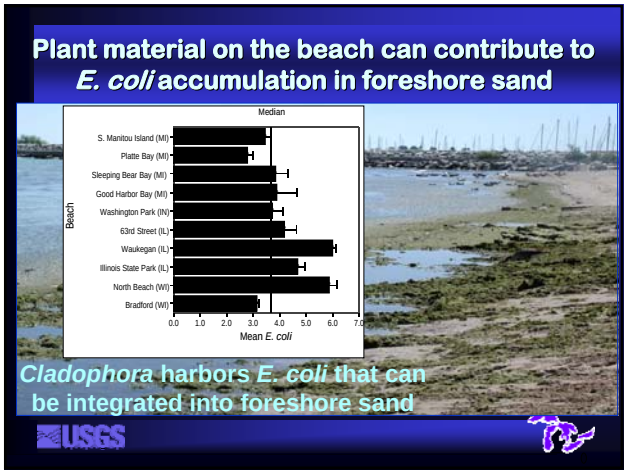








	# gulls lagged 1 day, P values
Foreshore sand	0.000*
Submerged sand	0.046
45 cm water AM	0.004*
90 cm water AM	0.001*
45 cm water PM	0.167
90 cm water PM	0.008

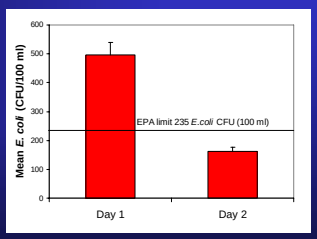


Recreational Water Quality Slides

Problems with *E. coli* monitoring protocols:

Sample results not available until 24 hours after sample collected

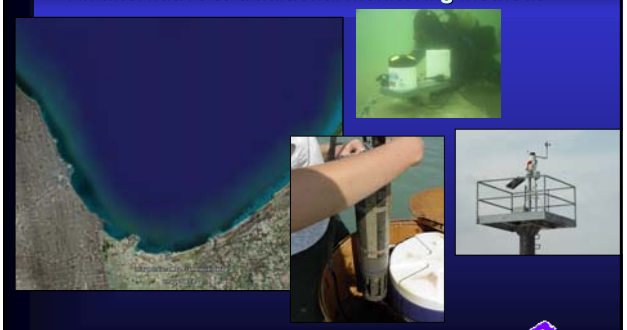
There is no relationship between day 1 and day 2 *E. coli*



USGS Indiana Dunes National Lakeshore beaches

Predictive Modeling:

An alternative to traditional monitoring methods



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Modeling Five Indiana Beaches: Usefulness as a Management Tool

Ogden Dunes (OD), West Beach (WB), Wells Street Beach (WS), Marquette Beach (MQ), and Lake Street Beach (LS)

USGS science for a changing world — Project SAFE

Monday, August 22, 2005

Swimming Advisory Forecast Estimate

A Pilot Experiment by USGS

In Cooperation with NOAA, Gary, IDEM, NPS

9:00 AM Weather Conditions	
Wind Speed (kts)	7-10
Wind Direction	NE
Air Temperature (°F)	66
Water Temperature (°F)	71
Wave Height (ft)	2-4
UV Index (forecast)	High
Burns Ditch Gage height (ft)	4.13

USGS science for a changing world — Project SAFE

Monday, August 22, 2005

Swimming Advisory Forecast Estimate

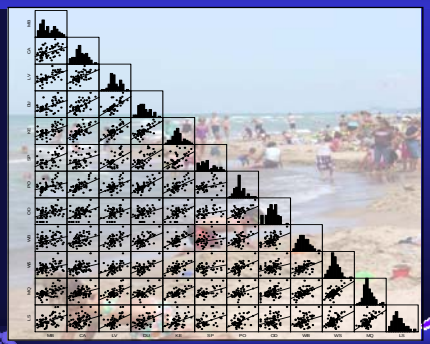
A Pilot Experiment by USGS

In Cooperation with NOAA, Gary, IDEM, NPS

Beach	Probability of EPA Advisory*
Lake St. Beach	25-50 %
Marquette Park	25-50 %
Ogden Dunes	50-75 %
West Beach	50-75 %
Wells St. Beach	25-50 %

Modeling across a longer shoreline

12 Indiana beaches, 35 km of shoreline



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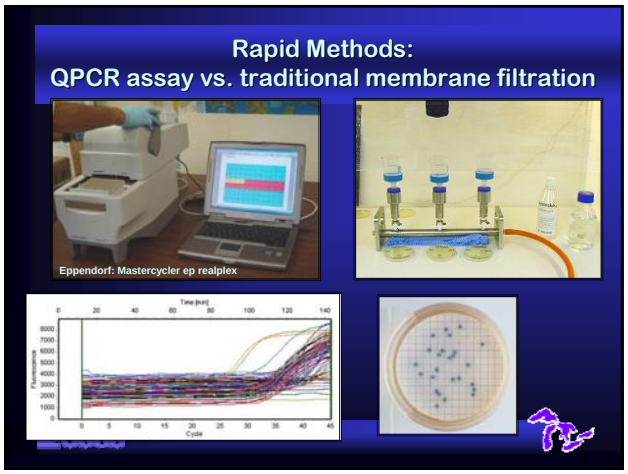
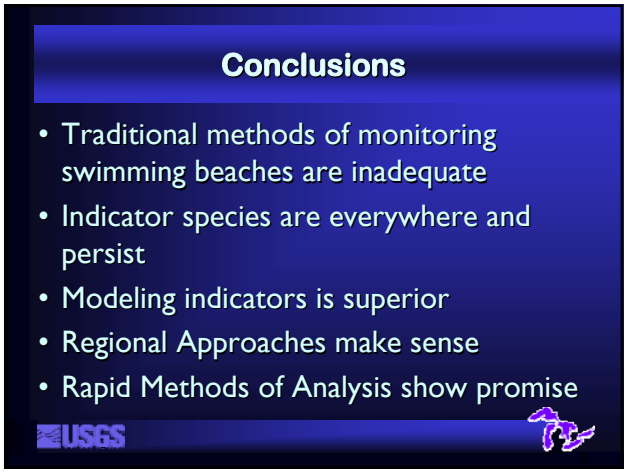
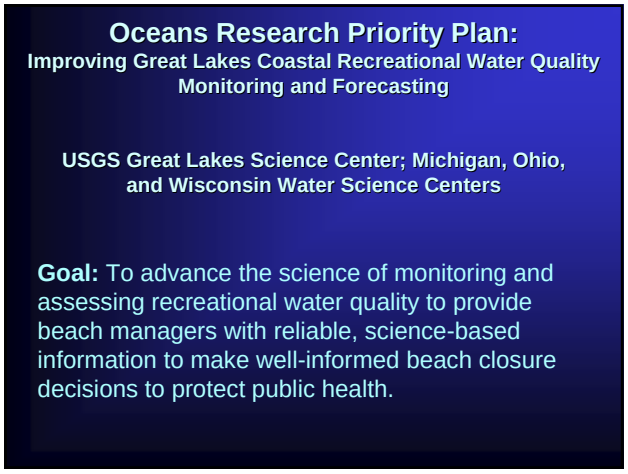
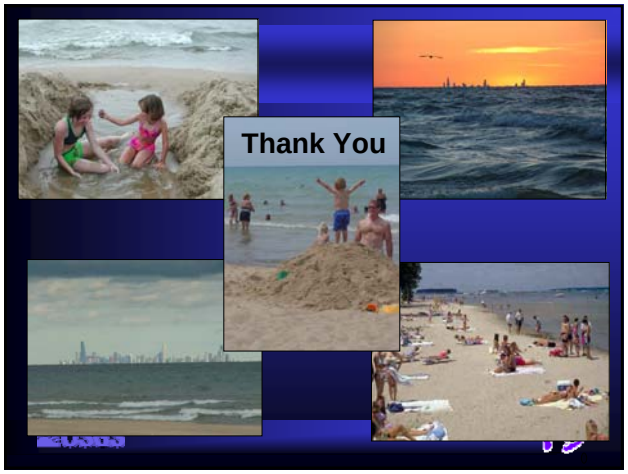
Recreational Water Quality Slides









Lead the Way...
to Cleaner Beaches & Healthier People

Millions of people swim and wade in Lake Michigan each year, and few get sick. Though low, the actual risk of waterborne disease is not known. Bacteria, viruses, and other microorganisms can be encountered in most water activities, but by following these easy steps, you can help protect your health and that of other beach-goers.

At the Beach

- Do not swim or play in streams or ditches flowing into Lake Michigan (they contain run-off that is more likely to be contaminated).
- Do not feed the seagulls, geese, or other animals on the beach. The feces from these animals as well as from dogs can increase the presence of microorganisms on the beach and in the water.
- Place all litter in trash cans provided (or properly dispose of it after leaving the beach). Trash left out on the beach is unsightly, can be hazardous, and will attract animals to the beach.
- Take young children on bathroom breaks and check diapers often. Waiting to hear "I have to go" may mean that it's too late.
- Do not swim when you have diarrhea and don't allow children in dirty diapers to swim. Micro-organisms can spread through the water and make other people sick.
- When going to the beach or for other outdoor activities, keep two items handy—a sunscreen lotion and a hand-sanitizing lotion (62% ethyl alcohol). Use an appropriate sun screen before going outside and use the hand-sanitizing lotion after swimming or playing in the sand. (Microorganisms are present in the water, sand, and soil.)

At Home

- Support wetland restoration. Wetlands help to clean and protect Lake Michigan and can reduce the level of microorganisms. Healthy wetlands will lead to open beaches.
- Keep your septic system properly maintained.
- Reduce your water use, especially during heavy rain events, when local sewage treatment plants get overloaded. Postpone your laundry chores when it is raining.
- Pick up pet waste, seal it in a plastic bag, and dispose of it in trash cans. Don't hose waste into storm drains. Pet waste contains microorganisms that can spread disease. Help keep your yard, neighborhood, and Lake Michigan, healthy and clean.

On the Water

- When boating, do not use the lake as a toilet. Use on-boat facilitates, portable potties, or make on-shore restroom breaks. Waste disposed overboard contaminates swimming beaches.
- Dispose of boat sewage in onshore sanitary facilities only. Maintain on-boat equipment and properly use marina pump-out equipment.

Nurturing Young Scientists Educator Institute
June 17 -19, 2008

June 17: Focus on Prior Knowledge, Questioning, and Hypothesizing

- Introductions and Icebreaker (Buzzword Bingo)
- Using Research as an Educational Tool
- Journaling as a Tool for Research and Education
- Research in "The Pit"
- I'm Going on an Investigation – Want to Come?
- Lunch
- Free Exploration at the Beach: Observation, Questioning, Hypothesizing
- Introduction to Alliance for the Great Lakes' "Adopt-A-Beach" Program
- Dinner
- Values on the Line (Adapted from Project Learning Tree)
- Beach Mysteries (from Alliance for the Great Lakes' Great Lakes In My World Curriculum Guide
- *E.coli* – The Questions Involved with Research By Dr. Richard Whitman
- Skyscraper Thinking

June 18 Focus on Developing Methods, Data Collection, and Interpretation

- Breakfast with the Scientists
- Designing an Investigation on the Little Calumet River
- Lunch

- Water Quality Monitoring in Rivers
  By Joe Ext, Hoosier River Watch

- Data Collection Along the Little Calumet River

- Data Sharing

- Dinner

- Presentation on Henry Chandler Cowles by Cowles Biographer Victor Cassidy

June 19 Focus on Data Interpretation, Conclusions, and Presentations

- Data Interpretation, Developing Conclusions and Presentations

- Lunch

- Presentations

- Closing and Evaluations

Instructions for "Research in the Pit" Game

This activity is an adaptation of a commonly played environmental education activity called "The Pit":. The adaptation was developed by John Hayes, Director, Dunes Learning Center. The activity can be conducted either indoors or out.

1) Divide the group or class into "x" number of smaller groups of 3 – 4 people each.

2) Cut out "x" sets of cards, with each card having one of the following words:
   Prior knowledge
   Question
   Hypothesis
   Methods
   Data Collection
   Data Analysis
   Conclusion
   Presentation

3) Distribute the cards created in #2 above randomly to each of the "x" groups. Each group should then have an incomplete set of eight cards. Several will be duplicates of each other.

4) Designate a portion of the room or area as the "trading pit". You are going to simulate an exchange area similar to that in the New York Stock Exchange, or the Chicago Board of Trade. Instruct the participants that one person of each team can come into the pit with one card and yell "Trading one! Trading one!" A person in the pit from another team may trade cards with them sight unseen and both parties then return to their team. Team members can look at the word cards they have collected. Another member of the team can then go into the pit to trade. "Trading one, trading one!"

5) The object of the game is to acquire one each of the eight cards mentioned in #2 above, and to put them in the appropriate order (also in #2 above).

6) The first team to get all eight cards in the appropriate order and show them to the pit boss (generally the teacher or the ranger) is the winner.

Viewpoints on the Line

Activity 19

This activity is designed to get students thinking about and expressing their views and to listen to those of their classmates. It helps students explore the underlying assumptions that shape our opinions. You may wish to use this activity on a regular basis to give students a chance to evaluate their opinions as they learn more about environmental issues.

Levels
Grades 6-8

Subjects
Social Studies, Science

Concept
Cultural and societal perspectives influence the attitudes, beliefs, and biases of people toward the use of resources and environmental protection. (2.10)

Skills
Evaluating, Establishing Criteria, Discussing, Principle Forming

Technology Connections
Graphics Software

Materials
Copies of student page, and pens or pencils, Variation: chalk, string, or masking tape

Time Considerations
Preparation: 15 minutes
Activity: 50 minutes

Related Activities
People of the Forest, A Look at Lifestyles

OBJECTIVES

- Students will share their views and opinions with others and gain awareness on the range of opinions related to environmental issues.
- Students will identify the need for balanced information when forming opinions.

ASSESSMENT OPPORTUNITIES

- Have students as individuals or in small groups select and research a local environmental issue. After selecting an issue, have them prepare background information or a summary, and state arguments for and against it. End the assessment by having the students support their own position.
- Have the students think about the following questions and write down their responses. Then have the group discuss each question.
  - What problems, if any, might there be in forming an opinion about an issue without knowing all the facts, related issues, and consequences of various actions?
  - How can people become better informed about all sides of an issue?
  - When people with different opinions end up on different sides of an issue, conflicts can arise. How can people on different sides of an issue reach a settlement?

BACKGROUND

Students should learn to respect the processes of searching for truth. These processes involve identifying and assessing facts; distinguishing substantial from insubstantial evidence; separating the search for truth from the acceptance of propaganda; and examining in a constructive and unbiased manner controversial subjects such as politics, ethics, science, and religion.

Many people never take the time to explore the underlying assumptions they have concerning the environment. They may even form an opinion without understanding all the sides of an issue. To make decisions, students need to resolve ambiguities, balance the advantages and drawbacks of alternative solutions, and project the likely consequences of a particular choice. By combining such a decision-making procedure with pertinent scientific and technological information, students move toward achieving environmental literacy.

GETTING READY

Read over the opinion statements on the student page and add one or two statements pertinent to your group's studies. Make a copy for each student.

DOING THE ACTIVITY

1. Give students copies of the student page, and ask them to rank how much they agree or disagree with each statement. For each statement, they should circle a number, with "10" signifying strongest agreement and "1" signifying strongest disagreement.

2. Find an open space and have the students stand in line. Tell them that the line represents the scale of 1 to 10 that they used to rank the opinion statements (one end of the line being "strongly agree" and the other end "strongly disagree").

3. Read aloud one of the opinion statements and have students reposition themselves in line according to how they ranked that statement. They will need to communi-

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cate with each other to make sure everyone is in the right place. Once they are settled, point out how the line reflects the range of opinions in the class.

4. Next, break the line at its midpoint, and have half the students stay in place while the other half moves down so that each student has a partner. (See diagram below).

5. Give each person in each pair one minute to explain to his or her partner the ranking he or she chose. Then give the other partner half a minute to paraphrase what the partner said. Have the partners switch roles, giving the other person a minute to explain his or her ranking and the partner half a minute to paraphrase.

6. Repeat Steps 3 through 5 for as many of the opinion statements as you like.

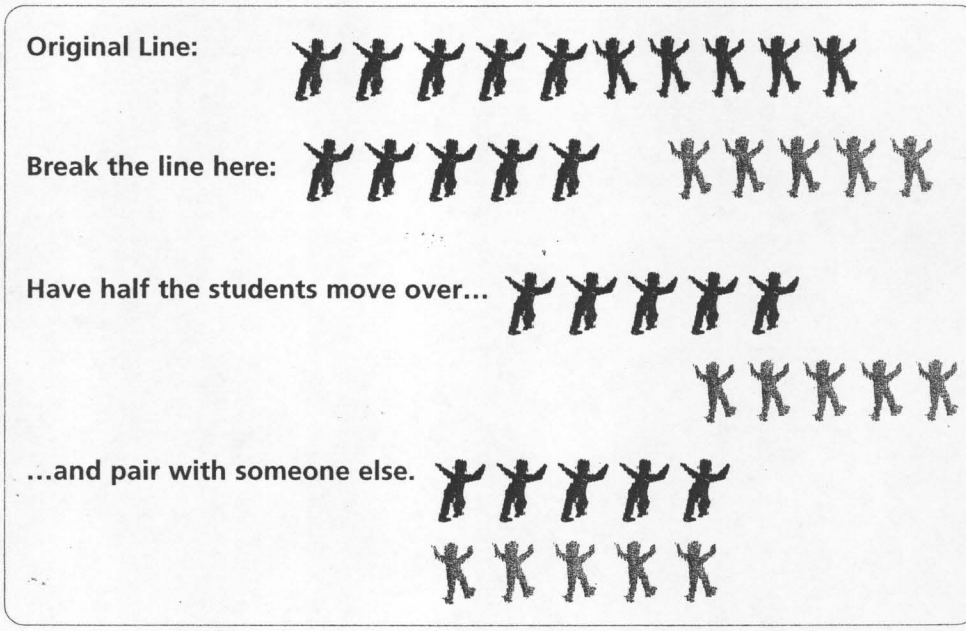
7. Discuss each opinion statement with the students, using the following questions as a guide:

- What reasons did they have for the rankings they chose?
- What reasons did their partners give for the rankings they chose?
- Did any of them support their rankings using examples or specific information from real-life situations?
- Did anyone feel like changing their ranking on a particular statement after pairing with someone else and hearing their opinion?
- Did students feel they needed additional information to judge an issue? If so, what did they need?
- What assumptions underlie each person's opinion?
- Where do people's opinions come from? What kinds of experiences change or strengthen people's opinions?

Variations

Using chalk, string, or tape, create a scale of 1 to 10 on the floor or ground. Make the scale 10 yards or meters long with the numbers one yard or meter apart. For a particular opinion statement, have the students place themselves as close as possible to the ranking they chose. When everyone is settled, make a diagram on the board or easel paper of how students are distributed on the scale. Have them do the exercises in Steps 3 to 5, and allow them to change their ranking based on what they learn. Have students once again position themselves on the scale. Draw another diagram showing their revised positions. Compare the diagrams and discuss the changes with the entire group.

Use graphics software to record the students' viewpoints on each statement. After all the students add their viewpoints to the graph, show them the overall class view on each statement.



READING CONNECTIONS

Baylor, Byrd. *The Table Where Rich People Sit.* Atheneum. 1994. A girl discovers that her impoverished family is rich in things that matter in life, especially being outdoors and experiencing nature. Grades K-4. ISBN: 0689820089.

George, Jean Craighead. *Cry of the Crow.* Harper Collins. 1982. While caring for a baby crow, Mandy begins to look at her family and herself in a different light. Grades 3-7. ISBN: 0064401316.

Klass, David. *California Blue.* Scholastic. 1994. When 17 year old John Rodgers discovers a new sub-species of butterfly which may necessitate closing the mill where his dying father works, they find themselves on opposite sides of the environmental conflict. Grade 6+. ISBN: 0590466895.

Leopold, Aldo. *A Sand County Almanac.* Oxford University Press. 1989. A Sand Country Almanac combines some of the finest nature writing since Thoreau with an outspoken and highly ethical regard for America's relationship to the land. Grade 6+. ISBN: 019505928X.

Sussman, Art. Dr. *Art's Guide to Planet Earth: For Earthlings Ages 12 and Up.* Chelsea Green Publishing. 2000. The book provides a simple yet powerful way to understand how our planet works, and what we can do about today's global and local environmental issues. Grades 6-8. ISBN: 189013273X.

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Opinion Statements

1. It is important for people to preserve wilderness areas.

1 2 3 4 5 6 7 8 9 10

2. The world's natural resources exist for people to use.

1 2 3 4 5 6 7 8 9 10

3. Environmental degradation is the biggest problem facing humanity today.

1 2 3 4 5 6 7 8 9 10

4. People will eventually develop new technologies to cope with environmental problems.

1 2 3 4 5 6 7 8 9 10

5. People have a responsibility to protect all life forms on Earth.

1 2 3 4 5 6 7 8 9 10

6. Protecting a country's natural resources and natural heritage is primarily the government's responsibility.

1 2 3 4 5 6 7 8 9 10

7. The government is doing a good job of protecting the country's natural environment.

1 2 3 4 5 6 7 8 9 10

8. Recycling is the most important thing people can do to help improve the environment.

1 2 3 4 5 6 7 8 9 10

9. People should be able to use their own land in whatever way they see fit (for farming, housing, logging, wildlife habitat, and so on).

1 2 3 4 5 6 7 8 9 10

10. All people have a right to clean air and water.

1 2 3 4 5 6 7 8 9 10

11. Human consumption is the greatest factor contributing to Earth's environmental problems.

1 2 3 4 5 6 7 8 9 10

12. Use of compact fluorescent light bulbs, which use less energy than incandescent bulbs, should be required in all public buildings.

1 2 3 4 5 6 7 8 9 10

13. Global treaties are needed to address the earth's changing climate.

1 2 3 4 5 6 7 8 9 10

14. New energy production on the planet should be limited to only renewable energy sources.

1 2 3 4 5 6 7 8 9 10

15. There should be laws restricting development on farmland or forestland outside cities or towns.

1 2 3 4 5 6 7 8 9 10

16. Zoning laws should prevent people from living in places with a history of major forest fires.

1 2 3 4 5 6 7 8 9 10

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INVESTIGATE

8 | Beach Mysteries

GRADE LEVEL

4-8

90 minutes

summary

Students learn about bacteria as an indicator of beach water quality for swimming. In groups they solve hypothetical problems associated with beaches. Then students write persuasive essays on the issue.

objectives

- Discuss the effect of harmful bacteria on swimming conditions at beaches.
- Diagram three reasons for beach contamination.
- Explain solutions for beach health problems.
- Write a persuasive essay about beach health.

prerequisite

Garbage Investigation, Litter Tag

vocabulary

Bacteria: single-celled organisms, free-living or parasitic, that break down the wastes and bodies of dead organisms, making their components available for reuse by other organisms
Sewage overflow: sewage that is discharged into waterways
Stormwater: water that accumulates on the ground during a rain event

subjects

Environmental Science, Human Health, Social Studies, Language Arts

standards

IL
Science: 12.B.2a, 13.B.2a, 13.B.2f
Social Studies: 17.B.3b, 17.C.2c
Language Arts: 3.C.2a, 3.C.3a

IN
Science: 6.3.8, 7.4.14, 8.3.6
Language Arts: 4.5.6, 5.5.4, 6.5.5, 7.5.4, 8.5.4

MI
Science: SCI.III.5.E.4, SCI.III.5.MS.6
Social Studies: SOC.II.4.LE.5
Language Arts: ELA.2.MS.1

WI
Language Arts: B.8.1, C.4.2, C.8.1

setting

INDOORS

OUTDOORS

Classroom or beach

materials

- Prescription for Healthy Beaches (on cd)
- Journals
- Pencils
- Clipboards (if outside)

background

Beaches can bring great advantages to shoreline communities, providing recreation, gathering places and beauty. It is important to keep them clean and healthy. Although this activity is about beach closings, emphasize to students that the Great Lakes beaches can be wonderful places for swimming and recreation. However, based on the rise of beach closings due to bacteria issues, it is important that communities become informed about beach closings. The information in this activity should not stop students and their families from enjoying Great Lakes beaches when they are open and healthy. On the contrary, this information should enable students and their families to better understand how to appreciate their beaches and keep them healthy so they can be enjoyed.

Beach Closings: Local health departments are forced to close beaches or declare "swimming bans" when bacteria levels are high. As monitoring programs start in communities, beach closings happen with increasing frequency.

Closures are prompted because of the health risks posed by the bacteria which comes from sewage overflows, untreated stormwater runoff, animal waste, boating wastes and malfunctioning septic systems. Sewage treatment plants in some large cities were not originally built for the increased number of people that now live there. Each day a beach is closed, according to a 2004 study, The Economic Costs of *E. coli* Beach Closings, communities can lose thousands of dollars in revenue. In 2003 for example, Lake Michigan beaches that were monitored for bacterial pollution experienced 1473 closings due to high bacteria counts.

Recreational water quality monitoring: Beaches are run by governmental agencies that try to keep the shoreline safe for human use. In many cases these agencies monitor the water quality by testing bacteria levels. When levels are too high, areas that have monitoring programs will close the beaches.

Health Issues: When a beach is closed, everyone who uses nearshore areas for recreation – including divers and swimmers – is at risk when bacteria are present. Bacteria and other germs in contaminated sand and water can cause vomiting, diarrhea, stomachaches, nausea, headaches, fever, giardiasis, rashes, and pink eye.

E. coli: *E. coli* is the bacteria used to determine if a beach should be closed. It is found in human and animal feces. *E. coli* is a common bacteria used for science experiments in thousands of schools and laboratories around the world. You have it living inside your intestines right now, as does every other human, and many other organisms. *E. coli* has hundreds of genetic variants; only a very few of these can make humans sick. The *E. coli* agencies search for in beach testing is not necessarily what makes humans sick, but it indicates the presence of fecal contamination (and possibly other pathogens that ARE harmful).

There is only one particular strain of *E. coli* harmful to human health, and it is relatively uncommon. However, *E. coli* is easy to test for and is an indicator of other potentially harmful bacteria that can exist under the same conditions. When *E. coli* is found in high levels, beaches are closed because bacteria harmful to human health may be present.

procedure

1. Ask for a show of hands to find out how many students in your group swim regularly at a Great Lakes beach. Discuss as a class: Can beaches be dirty if there is no garbage to be seen? How? Take a few responses.
2. Are beaches in your area ever closed or do they have *swimming bans? This depends on whether or not your area has a recreational water quality monitoring program. Beaches in some areas are closed when bacteria levels exceed Environmental Protection Agency standards.*
3. Why does this happen? Create a list of ideas to assess students' prior knowledge about why beaches close. *Note: If beaches are not monitored or closed in your area due to high bacteria levels, let students know that this happens in other areas of the Great Lakes.*
4. Use the background information to explain bacteria in general and *E. coli* in particular, and the health issues they present.
5. Have students work in small groups to solve beach mysteries on journal pages. Students may use the Alliance for the Great Lakes' Prescription for a Healthy Beaches: http://www.greatlakes.org/beach_center/prescription.pdf (or see copy on compact disc).

Answers to Beach Mysteries

#1. How did the bacteria get there? *After the gulls have eaten, they may leave droppings behind on the beach.* E. coli *bacteria is found in human and animal waste.*
How can we help solve this problem? *Don't leave litter behind. Any litter can cause harm. Food-related litter can attract wildlife in greater numbers than might normally live at or near the beach. Wildlife waste may contribute to high bacteria levels at the beach.*

#2. How did the bacteria get there? *When a lot of precipitation (rain or snow) falls, the water treatment plant may not be able to process and clean all the water as quickly as it accumulates. If this happens, water treatment plants may release untreated sewage into the lake.* E. coli *may be found in the untreated sewage. This can cause elevated bacteria levels. As for the phone call, beach managers are often notified of sewage overflows.*
How can we help solve this problem? *Encourage your local municipality to make sure your water treatment facility is big enough to handle all of the water from your community. Do not contribute extra water to the system during a heavy rain. This may mean waiting to run your dishwasher or do your laundry.*

procedure continued

#3. How did the bacteria get there? *Dog waste may be contributing to E. coli or other bacteria in the water if the dog owners do not responsibly pick up after their pets. How can we help solve this problem? Always pick up after your pet. Encourage other animal owners to do the same.*

#4. How did the bacteria get there? *When rain reaches the ground during a rain event, it is called stormwater. As it accumulates, stormwater flows to the lowest point. In a Great Lakes community, this is often the lake. Stormwater carries bacteria and other pollutants from a variety of sources including animal waste from domestic and wild animals, as well as fertilizers. Stormwater flows from the surrounding surfaces (streets, parking lots, lawns, agricultural areas) over sand and into the lake. This can cause elevated levels of bacteria to be detected. Some communities funnel stormwater into the Great Lakes through pipes called outfalls, which can contribute to the bacteria levels. Nationally, stormwater is the most frequent cause of beach closings.*
How can we help solve this problem? *Encourage your community to incorporate "green spaces" such as rain gardens, wetlands, or a pond system near hard surfaces so the rain runoff can be absorbed and filtered instead of flowing directly into the Great Lakes. Other ideas include using hard surfaces that allow water to pass through (permeable paving) and planting native grasses in "green borders" around parking lots.*

6. Discuss the mysteries in a large group. Have students present their answers to each other.
7. Create! After students have solved the Beach Mysteries, have them create and label a diagram that shows at least three to four ways bacterial pollution can get to the beach. Students should include solutions to the problems in their diagrams
8. Discuss as a class: What are solutions to beach health issues? Have students share the responses in their diagrams. Remember that while monitoring can indicate that there is a problem, it doesn't identify or eliminate the source. Source elimination is the ultimate solution.
   How will students' knowledge of beach health issues change their future behavior at the beach?
9. As a follow-up, have students write a persuasive essay about human responsibility with regard to beach health. This can include the following:

   a. Your area may or may not have a program for monitoring the recreational water quality for beach health purposes. Why should such a program exist in your community?
   b. Humans can change their behaviors to improve water quality. What should or shouldn't people do to help improve water quality?

wrap-up

1. Play Mysterious Bacteria to finish the activity.
2. Students sit in a circle with their eyes closed. Choose one student to be the "beach bacteria." Tap this student on the shoulder and have everyone re-open his or her eyes. The student uses the knowledge from the activity to decide what source s/he is from *(sewage overflow, seagull waste, stormwater runoff)*
3. Have the students walk around the room, shaking hands with each other. When the "bacteria" student shakes hands, s/he squeezes the other students' hand, indicating the spread of the bacteria.
4. When a student is "contaminated," s/he dramatically falls to the ground, indicating sickness.
5. Other students can guess who the "bacteria" student is. If they are wrong, they are out of the game.
6. Once the student is identified, the other students can ask yes or no questions to determine the student's selected source of contamination.
7. After the game, explain that it is currently very difficult to determine the source of bacteria in the water, much like it was difficult to determine which student was the harmful bacteria and what their source was.

extension

1. Research the status of recreational water quality in your area by inviting a beach manager as a guest speaker to your classroom.

2. Have the students decide if they would like to take action to improve beach health in their community. If so, have them choose one or more of the following options:

   - Participate in the Alliance for the Great Lakes's Adopt-a-Beach program, which enables students to create positive change for their beaches through litter clean-up and monitoring and water quality monitoring.
   - Turn the persuasive essays regarding beach health into a class "letter to the editor" for your local paper.

assessment

Rubric on page 311

8 | Beach Mysteries

GRADE LEVEL
4-8

journal pages

FIRST NAME																				
LAST NAME																				

[1] Facts: A high level of bacteria is not detected at the beach. A flock of seagulls spot some food and wrappers left behind by humans. They land on the beach to eat and inspect the garbage. A boat sails by in the distance. Two kayakers paddle up to the shore, which startles the birds. They fly away. Several hours after the seagulls arrived, water samples are taken. When they come back from the lab, results show there is a high level of bacteria in the water near the beach.

Questions: How did the bacteria get there?

How can we help solve this problem?

[2] Facts: The beach is clean. A high level of bacteria is not detected. That night a huge rainstorm takes place. It rains hard all night long. You think it is a great night to stay in and do laundry and your dishes, so your family runs both the washing machine and the dishwasher. You listen to music while doing homework, then go to bed. The next day, the beach is closed because the beach managers have received a call from the water treatment plant. Based on the call, the beach managers know there will be high levels of bacteria in the water.

Questions: How did the bacteria get there?

What did the mysterious phone call tell the beach managers about why the beaches should be closed?

How can we help solve this problem?

APPROVED BY	

8 | Beach Mysteries

GRADE LEVEL
4-8

journal pages

FIRST NAME																				
LAST NAME																				

[3] Facts: A few friends meet on the beach in the morning to walk their dogs. The dogs run along the shoreline and into the water, fetching sticks for an hour. A jet-ski zooms by in the distance and several motor boats pass by at high speeds. When the group with the dogs leaves, there is dog waste visible along the water's edge. The next day, the beach is closed because the beach managers have detected high levels of bacteria at the beach.

Questions: How did the bacteria get there?

How can we help solve this problem?

[4] Facts: During a walk around your neighborhood, you see dog waste on the ground, ants walking on the sidewalk and into the grass and hear birds singing in the trees. After it rains that night, the beaches are closed. You remember that the dog waste was not close to the beach, but in the grass across the street from it. It was not really a heavy rain, and you know that there was not a "sewage overflow," but there are still high levels of bacteria when the beach managers get the results back from a water sample they take after the rainy night.

Questions: How did the bacteria get there?

How can we help solve this problem?

APPROVED BY	

8 | Beach Mysteries

GRADE LEVEL
4-8

journal pages

FIRST NAME																				
LAST NAME																				

[5] Create and label a diagram that shows at least three ways bacterial pollution can get to the beach. Include solutions to the problems you indicate in the diagram.

APPROVED BY	

8 | Beach Mysteries

GRADE LEVEL
4-8

journal pages

FIRST NAME																				
LAST NAME																				

[6] Write a persuasive essay or letter to the editor about human responsibility with regard to beach health. You may include the following ideas:

a. Your area may or may not have a program for monitoring the recreational water quality for beach health purposes. Why should such a program exist in your community?

b. Humans can change their behaviors to improve water quality. What should or shouldn't people do to help improve water quality?

APPROVED BY	

Hooked on thinking

ANN PAZIOTOPOULOS
MARIANNE KROLL

All of us work hard to motivate our students to think because they must become analytical and creative thinkers if they are going to meet the tremendous needs of the 21st-century workforce. According to *The Kiplinger Letter* ("Forecasts," 2003), "The first of seventy-eight million boomers can start retiring in five years. And far fewer younger workers have the know-how to replace the retirees. Also, 20 million jobs will be created by 2010, exacerbating the problem" (p. 2).

This revelation presents an awesome challenge for educators—we must teach all children to read and think. We cannot afford to leave any of them behind. To meet this challenge, we have created the Skyscraper—a graphic organizer based on Bloom's Taxonomy (see Figure 1) as a concrete model to help all students achieve higher order thinking. The skyscraper analogy relates to a quote from Oliver Wendell Holmes:

> There are one-story intellects, two-story intellects, and three-story intellects with skylights. All fact collectors, who have no aim beyond their facts, are one-story men. Two-story men compare, reason, generalize, using the labors of the fact collectors as well as their own. Three-story men idealize, imagine, predict—their best illumination comes from above, through the skylight.

Several years ago, when we created the Skyscraper, we knew students were capable of more rigorous thinking and discussions of text than they were demonstrating in our classrooms. However, we had difficulty finding an instructional model that would enable us to help students develop thinking skills. As we struggled to find a solution, the analogy of a skyscraper came to mind with its feature of ascending floors. The floors symbolize the effort needed to reach the next level. This graphic also conveys an enhanced view or broadened perspective from the top floor, making the Skyscraper the perfect visual to symbolize higher order thinking.

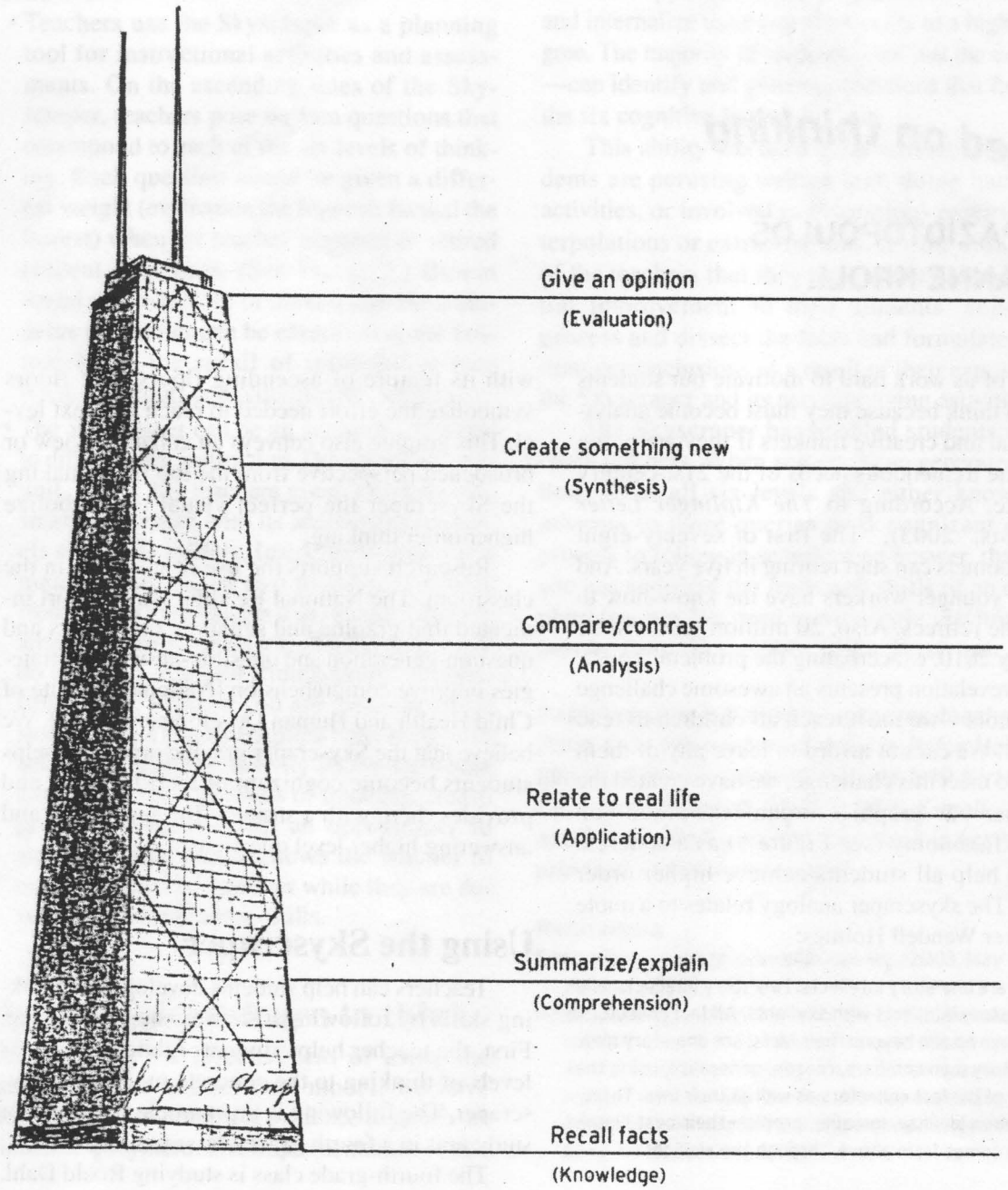
Research supports the use of graphics in the classroom. The National Reading Panel report indicated that graphic and semantic organizers and question-generation and question-answering strategies improve comprehension (National Institute of Child Health and Human Development, 2000). We believe that the Skyscraper graphic organizer helps students become cognizant of their thinking and provides them with a strategy for generating and answering higher level questions.

Using the Skyscraper

Teachers can help students develop their thinking skills by following a step-by-step procedure. First, the teacher helps students relate the various levels of thinking to the concrete model of a skyscraper. The following is an example of an author study unit in a fourth-grade classroom.

The fourth-grade class is studying Roald Dahl, and the teacher reads *The Witches* (Puffin, 2002) orally to the students. They discuss vocabulary, characters, and events to ensure basic comprehension before the teacher is ready to introduce the Skyscraper to her students. By presenting and referring to the Skyscraper model, as shown in Figure 1, the teacher helps students visualize how moving up the stairs of a skyscraper is similar to mov-

FIGURE 1
Bloom's Taxonomy adapted for use with literature



ing up to higher levels of thinking. She begins by telling her students that walking into a skyscraper is easy and takes little effort. However, getting to the top floor is a more difficult task. Pointing to different locations on a poster of the Skyscraper, the teacher says that climbing each new set of stairs to the next floor takes more effort than the one before. As you stop to look out the window on each ascending floor, you notice that your view begins to change. You're no longer focused on the details of

objects on the ground. Though the details are still present, they no longer restrict your view. You are now able to notice all that's around you. Finally, due to the increased altitude of the top floor, you acquire a greater understanding of where you are because you see the "big picture."

Next, the teacher connects the Skyscraper scenario to thinking. She explains to her students that the facts in a story or textbook are easy to find. They're right there in the print before your eyes. (Here the teacher points to the bottom of the Skyscraper.) However, discovering new findings, making judgments, and expressing opinions are higher levels of thinking that take more effort and processing by the student than identifying bare facts. (The teacher points to higher levels on the Skyscraper.) Just as your view changed as you went up the floors of the Skyscraper, your thinking changes as you move to higher levels. Though the details are still present in the text, they no longer restrict your thinking. You are now able to think about the "big idea" of the text. The big idea is the meaning, beyond the literal level, that you formulate for the text.

At this point, the students can visualize the connection between thinking levels. Thus, the teacher moves on to explain each of the six levels of Bloom's Taxonomy, pointing to its location on the Skyscraper. The teacher's objective is to help students understand that moving their thinking from the knowledge level to the evaluation level results in more meaningful or expanded thinking, just as moving from the bottom floor of the skyscraper to the top floor results in a more meaningful or expanded view. Following is the language that teachers in our school use to explain to their students the levels of Bloom's Taxonomy and the prompts related to each level.

- Knowledge/get the facts: What is_____? Can you recall_____? How would you explain_____?
- Comprehension/understand the facts: What is the main idea of_____? How would you summarize_____? What facts or ideas show_____?
- Application/make a connection: What examples can you find to_____? How would you show your understanding of_____?
- Analysis/take apart: How would you classify _____? What conclusions can you draw? Why do you think_____?
- Synthesis/create something new: What would happen if_____? Suppose you could _____. What would you do?
- Evaluation/give an opinion: What is your opinion of_____? Why was it better than _____? What judgment would you make about_____?

The teacher in the earlier example noted that with practice her students can identify a low-, middle- and high-level question because they understand the meaning of each level and can identify its location on the Skyscraper. This activity is much more than an exercise in memorization. If students identify a question at the knowledge level, they become aware that they are at the bottom of the Skyscraper and must move up to create a more meaningful question. As the students' thinking ascends the Skyscraper, they begin to make connections with life experiences, draw conclusions, and formulate opinions.

While reading orally to the students, the teacher models the different levels of questions by thinking aloud. We crafted the following classroom scenario, including dialogue between teacher and students, to demonstrate how to use this approach.

The teacher positions herself near the poster of the Skyscraper while reading the book *The Witches* to her students, pausing at designated points in the story to ask questions.

Teacher: How was the boy changed in the story?

Mari: He was turned into a mouse.

Teacher: How do you know that the boy turned into a mouse?

Mari: Because it tells us in the book.

Teacher: Can you find the page that tells us that the boy changed?

Mari: Yes, it tells us on page 32 that the little boy turned into a mouse.

Teacher: Is that a knowledge question or an evaluation question? Is that question at the bottom of the Skyscraper or the top?

Jacob: That's a bottom-floor question.

Teacher: Why is it a bottom-floor/knowledge question?

Jacob: Because you can find the answer in the book on page 32.

Teacher: That's right! Facts are written in the book. You can easily find the facts in a story. Why are facts important?

Mari: Facts tell you what's going on in the story.

Teacher: Excellent! We need to keep thinking about the facts in the story and stringing them along in our minds.

The teacher now takes a strip of paper and writes the question "How was the boy changed?" She asks Mari to write the answer under the question and adhere the strip of paper to the first floor of the Skyscraper. The teacher continues this model of reading and questioning while interspersing higher order questions as well.

Teacher: Who can tell us how to take a fact, like the boy turned into a mouse, and ascend the Skyscraper to create high-order questions?

Tim: If my answer to a question is in the book, I know I'm thinking at the bottom of the Skyscraper. So, I have to go up the Skyscraper to ask a question that can't be answered by just looking in the book, like trying to make a connection with my own life.

Teacher: Tim, can you think of a question at a higher level on the Skyscraper?

Tim: What if you were turned into a mouse? How would you feel?

Greta: I'd feel scared because no one would know me.

Teacher: Can Greta's answer be found in the book?

Jacob: No, she had to use the facts from the book and think about her own feelings.

Teacher: Let's think about another question. What is Roald Dahl's message? What is he trying to tell the boys and girls who read his book?

Tim: I think he's telling us to make the best of your life.

Teacher: Did you find your answer in the book?

Tim: No.

Teacher: How did you decide that this was the author's message?

Tim: I thought about the little boy who was turned into a mouse and how he handled the change in his life. He really wasn't upset. He was a mouse person and had fun.

Teacher: Where does Tim's answer belong on the Skyscraper?

Greta: It belongs on the top floor.

Teacher: Why?

Greta: Because he's giving us his (informed) opinion. You can't find Tim's answer in the book.

Teacher: That's right. Tim had to think about all the events and facts in the story before he could decide what the author's message was.

The teacher asks Tim to write his question and the answer on a strip of paper. She asks Tim to place it on the top floor of the skyscraper.

Teacher: Why is Skyscraper thinking important?

Marc: Because it makes you think.

Teacher: How does it make you think?

Marc: Because you have to think about all the facts that happened in the story.

Teacher: What do you do with the facts after you think about them?

Marc: You can come up with your own ideas about the book.

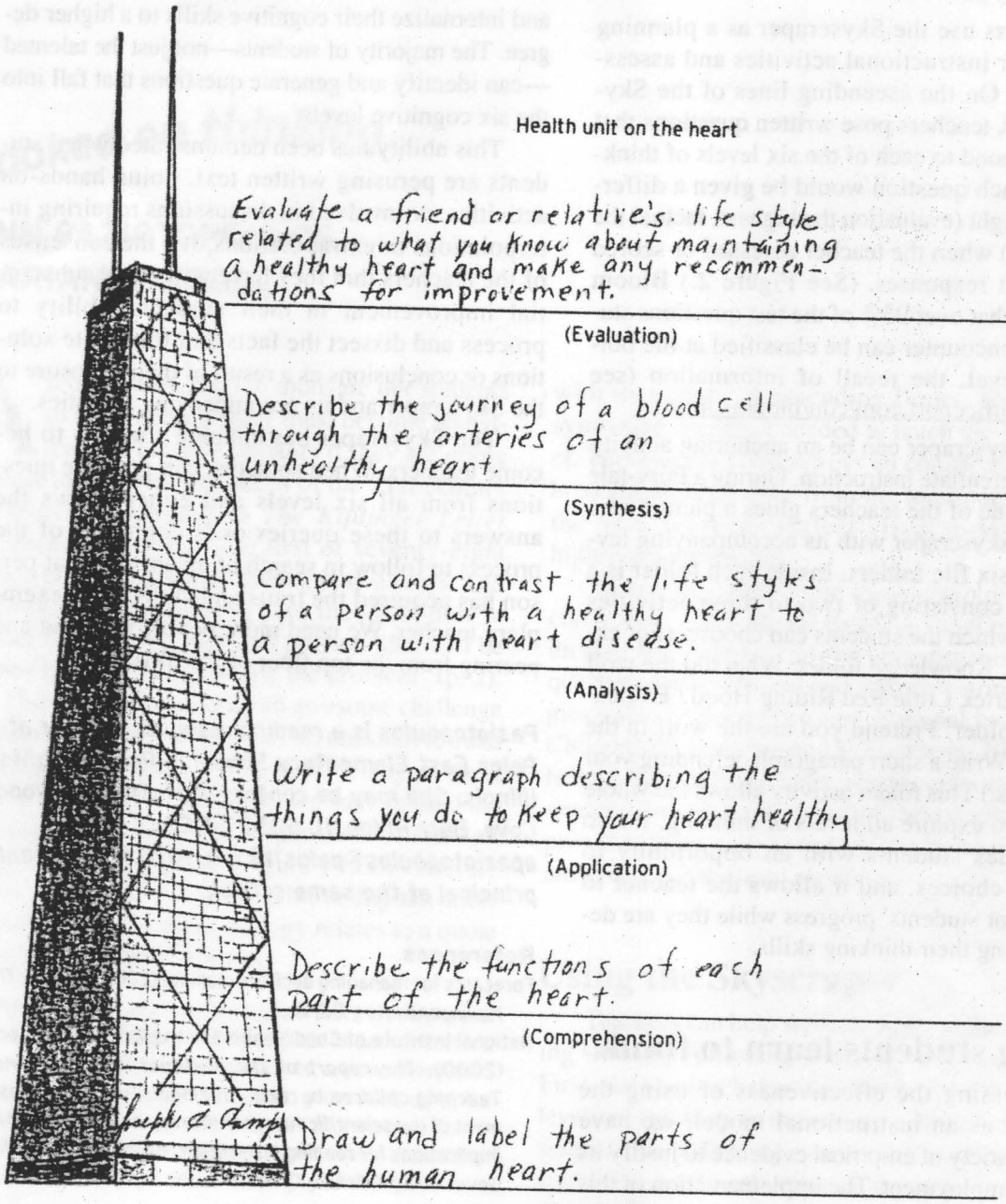
Teacher: Why is it important to have your own ideas about a book?

Marc: Because it's about what you're thinking while you're reading the book (metacognition).

In the third step of this procedure, the students, individually and in groups, practice generating different levels of questions. After the teacher has modeled the procedure for using the Skyscraper, the students are ready to read books by Roald Dahl at their instructional reading level. *Charlie and the Chocolate Factory* (Puffin, 2002), *Minpins* (Puffin, 1994), *The Enormous Crocodile* (Puffin, 2001), and *The Twits* (Puffin, 2002) are chosen for reading. Literature circles are designed by the teacher, and all students have a copy of the Skyscraper with them while they read their books. Each day the teacher assigns a number of pages to read. She also asks students to create questions reflecting levels of the Skyscraper. After the readings are completed, students share their questions and answers in their literature circles. The students are instructed by the teacher to always justify their answers by telling the group why and how they respond to certain prompts and how that helps their thinking.

This classroom example illustrates one way a teacher used the Skyscraper. Here are ideas from other teachers in our school:

FIGURE 2
Skyscraper for use as an assessment (planning tool for teachers)



- Students refer to the Skyscraper posted in the classroom as they respond to questions from the teacher either orally or in writing.
- As a quick check of comprehension, the teacher gives students the Skyscraper with a question at each level of thinking after reading a story or piece of nonfiction text.
- Students are given a copy of the Skyscraper. As they read, they formulate questions or responses. They place them on the appropriate

levels of the skyscraper to help them monitor their thinking while reading. Later they use them for discussion.

- Teachers use the Skyscraper as a planning tool for instructional activities and assessments. On the ascending lines of the Skyscraper, teachers pose written questions that correspond to each of the six levels of thinking. Each question would be given a different weight (evaluation the highest; factual the lowest) when the teacher assessed or scored student responses. (See Figure 2.) Bloom found that over 95% of the test questions students encounter can be classified at the bottom level, the recall of information (see www.officeport.com/edu/blooms.html).
- The Skyscraper can be an anchoring activity to differentiate instruction. During a fairy-tale unit, one of the teachers glues a picture of a small skyscraper with its accompanying levels to six file folders. Inside each folder is a menu consisting of two to three activities from which the students can choose. (For example, Knowledge folder: What did the wolf do to trick Little Red Riding Hood? Evaluation folder: Pretend you are the wolf in the story. Write a short paragraph defending your actions.) This folder activity allows the whole class to explore all levels of thinking. It also provides students with an opportunity to make choices, and it allows the teacher to monitor students' progress while they are developing their thinking skills.

Helping students learn to think

In assessing the effectiveness of using the Skyscraper as an instructional model, we have gleaned a variety of empirical evidence to justify its continued employment. The implementation of this concrete model by all staff members within all grade levels has created a sequential, cohesive, and universal approach in assisting students to develop and internalize their cognitive skills to a higher degree. The majority of students—not just the talented—can identify and generate questions that fall into the six cognitive levels.

This ability has been demonstrated when students are perusing written text, doing hands-on activities, or involved in discussions requiring interpolations or extrapolations. It's the consensus of the teachers that they have witnessed substantial improvement in their students' ability to process and dissect the facts and formulate solutions or conclusions as a result of their exposure to the Skyscraper and its accompanying activities.

The Skyscraper has enabled students to become teachers. When someone can generate questions from all six levels and either knows the answers to these queries or is cognizant of the process to follow in search of an answer, that person has acquired the traits and skills of an exemplary teacher. We need more people reaching and peering from the top floor of the Skyscraper.

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Evaluation

Synthesis

Analysis

Application

Comprehension

Knowledge

Questions Linked to Bloom's Taxonomy

LEVEL I
KNOWLEDGE

¬ *Exhibit memory of previously – learned materials by recalling facts, terms, basic concepts and answers*

Questions

What is ...?
Where is ...?
How did _____ happen?
Why did ...?
When did ...?
How would you show ...?
Who were the main ...?
Which one?
How is ...?
When did _____ happen?
How would you explain ...?
How would you describe ...?
Can you recall ...?
Can you select ...?
Can you list the three ...?
Who was ...?

LEVEL II
COMPREHENSION

¬ *Demonstrate understanding of facts and ideas of organizing, comparing, translating, interpreting, giving descriptions and stating main ideas*

Questions

How would you classify the type of ...?
How would you compare ...? Contrast?
Will you state or interpret in your own words ...?
How would you rephrase the meaning?
What facts or ideas show...?
What is the main idea of ...?
Which statements support?
Can you explain what is happening..what is meant?
What can you say about ...?
Which is the best answer...?
How would you summarize?

LEVEL III
APPLICATION

¬ *Solve problems to new situations by applying acquired knowledge, facts, techniques, and rules in a different way*

Questions

How would you use?
What examples can you find to ...?
How would you solve___ using what you have learned...?
How would you show your understanding of ...?
What approach would you use to ...?
How would you apply what you learned to develop ...?
What other way would you plan to...?
Can you make use of the facts to ...?
What elements would you choose to change ...?
What facts would you select to show ...?
What questions would you ask in an interview with...?

LEVEL IV
ANALYSIS

¬ *Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.*

Questions

What are the parts or features of ...?
How is ____related to...?
Why do you think...?
What is the theme...?
What motive is there...?
Can you list the parts of ...?
What inference can you make...?
What conclusions can you draw...?
How would you classify...?
How would you categorize ..?
Can you identify the different parts...?
What is the relationship between...?
Can you make the distinction between...?
What is the function of...?
What ideas justify...?

LEVEL V
SYNTHESIS

¬ *Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions*

Questions

What changes would you make to solve ...?
How would you improve...?
What would happen if ...?
Can you elaborate on the reason...?
Can you propose an alternative...?
Can you invent...?
How would you adapt_____to to create a different...?
How could you change (modify) the plot (plan) ...?
What could be done to minimize (maximize) ...?
What could be combined to improve (change) ...?
Suppose you could ___ what would you do...?
How would you test...?
Can you predict the outcome if...?
How would you estimate the results for...?
What facts can you compile...?
Can you construct a model that would change...?
Can you think of an original way for the...?
What way would you design...?

LEVEL VI
EVALUATION

¬ *Present and defend opinions by making judgments about information, validity of ideas or quality of work based on a set of criteria*

Questions

Do you agree with the actions...? with the outcome...?
What is your opinion of...?
How would you prove...?disprove...?
Can you assess the value or importance of...?
Would it be better if...?
Why did they (character) choose...?
What would you recommend...?
How would you rate the ...?
What would you cite to defend the actions...?
How would you evaluate...?
How would you determine...?
What choice would you have made...?
What would you select...?
How would you prioritize...?
What judgement would you make about...?
Based on what you know, how would you explain...?
What information would you use to support the view...?
How would you justify...?
What data was used to make the conclusion...?
Why was it better that...?
How would you compare the ideas? people...?

Objectives in the Cognitive Domain

Thinking, learning, and knowing are **cognitive** skills (the cognitive domain) that can be taught in an educational program. Objectives in the cognitive domain describe specific, measurable actions that the learner will achieve from the project.

The following table provides some action words that are helpful when writing objectives in the cognitive domain.

SMART (specific action) Words for Writing Objectives in the Cognitive Domain

Level	Know	Comprehend	Apply	Analyze	Synthesize	Evaluate
Words to use when writing cognitive object-tives	Define Memorize Repeat Record List Recall Name Relate	Restate Discuss Describe Recognize Explain Express Identify Locate Report Review Tell	Translate Interpret Apply Employ Use Demonstrate Dramatize Practice Illustrate Operate Schedule Shop Sketch	Distinguish Analyze Differentiate Appraise Calculate Experiment Test Compare Contrast Criticize Diagram Inspect Debate Inventory Question Relate Solve Examine	Compose Plan Propose Design Formulate Arrange Assemble Collect Construct Create Set up Organize Manage Prepare	Judge Appraise Evaluate Rate Compare Value Revise Score Select Choose Assess Estimate Measure