
PHOTOS COURTESY OF THE AUTHOR

The Merrimac River above flood stage in 2006 as it runs through the city of Lawrence, Massachusetts. Partially submerged trees and pedestrian railings are seen 10 meters from the bank of the river.

Making connections in Earth science using local data

In early May 2006, heavy rain pelted the Merrimack Valley in Massachusetts. Within one week, many areas received nearly a foot of rain, causing the Merrimack River to rise above flood stage. Homes were evacuated, schools were closed, and some places lost electricity for several days. Buried somewhere within this natural catastrophe was my sixth-grade rivers unit.

Before the Merrimack flooded, my Earth science class had been learning about rivers, watersheds, and weather. It was my first year teaching this course, and the students were disinterested in the standard read-and-regurgitate form of science they had been used to. Fearing the city would flood, I eagerly checked the United States Geological Survey (USGS) website for stream-flow data on the Merrimack. Soon after, the city had partially flooded, schools were closed, and I was left in awe of the power of the very topic we had been studying.

At home, I was left to ponder the fate of my rivers unit. As I snapped photos, reviewed rainfall totals, and monitored the stream-flow charts, I began to realize the potential for connecting real data to my unit. In the days that followed, the rivers unit evolved to incorporate activities that used these flood data to support inquiry and teach key Earth science concepts, while at the same time reinforcing the math skills of data analysis, graphing, and data interpretation. In this reworked unit, the lessons became less centered on the event of the flood and more about patterns in weather and rivers. Instead of learning general information about how the spring melt increased river-flow volume, students worked with actual temperatures and flow data. Timing the lesson with spring melt and pairing it with field trips allowed students to observe their focus of study, and the unit went from being lackluster to eagerly anticipated.

Designing units that use real data to bring practicality and relevance need not be catalyzed by a natural disaster such as the Merrimack flood of 2006. Earth science is filled with many topics for which an excellent variety of information can be obtained. Look to match available information resources with the topics you choose for such activities.

Choosing a topic

Topics such as precipitation, temperature trends, and stream flow can be found for nearly any region and make

they may need time
video clip.

excellent topics of study. Connecting data to local phenomena brings relevance to the activities and opens up opportunities for direct observation. The National Science Education Standards on science as inquiry state that middle school students can begin to conceptualize the relationship between explanation and evidence (NRC 1996, Science Content Standards: 5–8, Content Standard A). Choose the topics based on this consideration and generate inquiry-based activities that help bring understanding to the provided evidence.

Adding data interpretation into an existing unit need not be complicated. Many Earth science topics are studied by government agencies, such as the United States Geological Survey. Their website hosts data ranging from satellite photos of dust clouds to stream-flow data to volcanic activity logs. The National Oceanic and Atmospheric Administration is also an excellent resource for current water temperatures, precipitation data, and archived weather maps. Browsing these websites or e-mailing with requests for data should provide enough information to craft a lesson. Constructing lessons that allow students to search for the data themselves adds ownership to the activity and takes advantage of existing interest in technology use.

Creating objectives

Using data available from online resources (see sidebar) provides an excellent opportunity for teachers to realize a variety of objectives. Of course, specific objectives will depend on the nature of the data as well as available time frames and student levels. However, when choosing these topics, teachers should consider guiding their curriculum development with the following questions:

1. Can any local plant life, animal life, or landforms be brought into this unit for relevance?
2. Can graph interpretation or data analysis be used to provide more depth to the material?
3. Does this curriculum offer the opportunity for field investigation?

In addition to strengthening core material concepts, objectives should be crafted to highlight inquiry and approach learning from a cross-curricular standpoint. One such objective may be for students to work with rainfall data to generate a best-fit curve in a graph.

The process of inquiry is at the core of science education. Data can be used to promote inquiry by giving students practical information from which to draw conclusions. There is particular power in comparing

Online resources for local data

Looking for information to tie into your curriculum? Give these resources a look. To gather information on a local river to investigate seasonal flow differences, go to the United States real-time water data website located at *http://waterdata.usgs.gov/nwis.*

Doing a unit that involves habitats, forest types, or ecosystems? The National Forest Service has a resource called Treesearch, which provides Forest Service research articles broken down by region that pertain to invasive pests, ecosystem management, and other related topics! It can be found online at *www.treesearch.fs.fed.us.*

If you're into a weather unit and need to buff it up with some temperature analysis or rainfall-pattern analysis, check out the National Weather Service's website. Here you will not only find a great deal of information pertaining to weather, but also searchable data from local weather stations. Visit *www.nws.noaa.gov.*

Studying plants? If so, a wealth of information on plants, searchable by region, can be found at the United States Department of Agriculture's PLANT Database website at *http://plants.usda.gov.*

Finally, if you need to find some information about local animal life in your area, check out eNature.com. This website allows you to search for wildlife in your area and even has a feature to send photos of local animals to you via e-mail! Check this website out at *www.enature.com.*

FIGURE 1 **Mourinho River data**

Date	Peak river flow	Daily high temperature
April	Cu. ft./sec.	Degrees Celsius
1	1,500	-2
2	1,503	0
3	1,502	2
4	1,510	3
5	1,512	4
6	1,530	4
7	1,550	5
8	1,576	5
9	1,601	6
10	1,650	6

sets of data to highlight the interrelation between Earth systems. For example, a series of data points highlighting a warming trend in May might be tied to data which may show reduced snowpack. Couple this with data for local stream flows, and students will be given the opportunity to develop the process skill of data interpretation as they strengthen their understanding of seasons, river flow, and weather changes.

Examining data provides a unique opportunity to have students work actively with various technologies, such as computers or graphing calculators. Students can import data into spreadsheet software, execute mathematical calculations, create data graphs, and use this material in reports to present the results of their inquiry. Reinforcing the use of technology in a classroom environment, as well as generating reports to communicate information, is another goal of the National Science Education Standards. Whether using computers, graphing utilities, or graphing by hand, students gain exposure to many core mathematical concepts such as graphing, data interpretation, and simple statistical analysis. Defining these objectives reinforces the link between science and math and brings relevance to both topics. Well-planned activities surrounding the manipulation and interpretation of data can encompass each of these areas of objectives effectively and efficiently. The following activity example details how students can explore and try to make sense of data.

FIGURE 2 Culminating activity rainfall data

	Merrimack River USGS data	National Weather Service data
Station	Lowell, MA	Newburyport, Ma
May 2006	Flow (cu. ft./sec.)	Rainfall (in.)
11	6,743	0.27
12	7,012	0.05
13	9,602	0.86
14	45,909	5.83
15	91,064	6.63
16	84,755	1.10
17	65,436	0.52
18	53,660	0.00
19	49,355	0.00
20	47,381	0.00
21	44,529	0.00
22	41,312	0.00
23	38,642	0.00
24	36,419	0.00

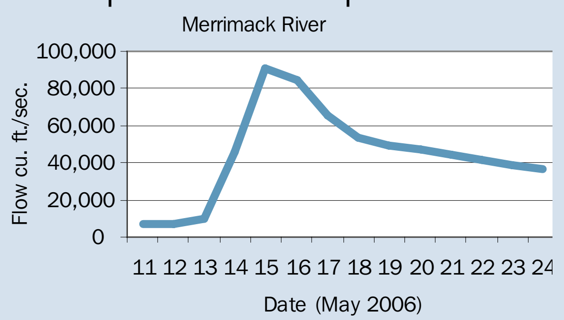

FIGURE 3 Rivers data student task sheet

Exploring some river data!

Now that you've had the opportunity to analyze data in class, it's time to roll up your sleeves and get your hands dirty with real data! You will use the provided data set, which details a 14-day stretch of river-flow data from the Merrimack River. Read over these data and become familiar with them before you begin.

Step 1: Rainfall graph: Generate a graph of rainfall versus date. Be sure to scale and label the axes appropriately.
Step 2: River-flow graph: Generate a river-flow-versus-date graph. Make it similar in size to the previous graph, but be sure to scale and label all axes appropriately.
Step 3. Comparison and interpretation of graphs: Once the graphs are complete, look at them and think about what might have been occurring. Use this information to answer the following questions.

1. Explain what the rainfall data show happening over the two week span.
2. Now look at the corresponding stream-flow information. If average stream flow for this time of year is about 10,000 cu. ft./sec., is the river "normal" over these two weeks? Explain.
3. Consider both of the graphs. Come up with a reasonable explanation of what might have happened to cause the river's behavior.
4. April and May often bring warmer temperatures to many areas, including snow-covered mountains. Might this spike in river flow have been caused only by melting snow?

Seasonal and abnormal changes in rivers

Overview

For this activity, students begin by exploring seasonal changes in the fictitious Mourinho River. They are given flow and precipitation data from the United States Geological Survey to analyze abnormal changes in rivers. The data for the second activity are actual Merrimack River flood data from May 2006. Both activities reinforce the concept that rivers change seasonally in regular ways in response to many factors but that they also change in abnormal ways. It also provides students an opportunity to apply real-world data to the concept of river flow.

Objectives

1. Students will graphically represent river-flow and air-temperature data using either a computer, graphing utility, or paper and pencil.
2. Students will explore the relationship between air temperature and stream flow during the spring melt.
3. Students will interpret stream-flow data of flooding and draw conclusions based on their interpretations.

Introductory activity

First, the entire class explores the fictitious air temperature and stream-flow data from the Mourinho River (see Figure 1). Students create graphs for each of the data sets and observe how as the daily air temperatures climb above 0°C, the flow of the Mourinho River also increases. The teacher needs to mention that the area has had a hard winter and there is a great deal of snow on the ground. The class then tries to determine the relationship between the air temperature and the river flow.

Sometimes it can be difficult for students to conceptualize the relationship between Earth systems. While all of my students were able to see the relationship between warming weather and snow melt, few of them understood the end result of increased flow in rivers. Challenging them to think about these as interrelated systems is part of the excitement of the experience.

Independent reinforcement activity

Present the class with an independent activity to graph the same type of data for the Mourinho River for the hot,

FIGURE 4 Rivers data scoring rubric

Use this rubric to assign points for each of the graphs and the student questions.

	Point values				
	1	2	3	4	5
Graphs 1 and 2	Graph exists, but information is not complete, axes are not scaled properly, large amounts of information are not present or are graphed incorrectly.	Graph may not be complete, there are many issues with data, graph setup, or labeling.	Graph is complete and much of the information is provided, yet there are some issues with data, graph setup, or labeling.	Graph is complete and well done, there are only a few minor issues with setup, data, or labeling.	Graph is complete, axes are scaled and labeled properly, units are included, and the graph is simple to read and understand.
Questions 1–4	Explanation is incomplete, is not backed up by the information provided in the activity, or is well below ability-appropriate language and grammar use.	Explanation is either a little incomplete, missing data to reinforce answer, or does not demonstrate ability-appropriate language and grammar use.	Explanation is complete and lucid. Student backs up observations with facts, answer has ability-appropriate grammar and language use.		

dry month of August. It is important to spend some time checking students' work at the beginning to ensure that they are graphing properly and picking up on trends in the data and the flow.

Culminating activity

As the lesson comes to an end, supply one last set of river data (see Figure 2). These are actual data from the USGS for the Merrimack River. Students graph the data and write a brief one-paragraph discussion about what they infer from the activity. Challenge students to determine what event the data represent and when it happened.

At the onset, students found that working with data was a bit challenging. I could see that scaling the graphs was a struggle for them because many had lines running off the sheet. However, once they moved past this, many immediately made the connection between the rain amounts and the flood conditions. In this way the activity proved to be a valuable learning experience because while they connected to the topic of rivers and gained skills in mathematics and inquiry, they were engaged and excited to learn more about the "100-year flood."

A traffic sign in Lawrence, Massachusetts, engulfed by the Merrimac River. The river crested 2.4 meters above flood stage on May 15th, 2006.

Possible extensions

- More complex data analysis could be performed by requiring analysis of averages, maximum and minimums, etc.
- Field trip to local body of water to observe the flow (especially useful if coordinated with spring runoff, or after rain).

Conclusions

Incorporating data into investigations in Earth science is a powerful way to increase student understanding of science, reinforce math concepts, and promote inquiry. Data are collected by various government science agencies and made easily available through the web. Accessing these data with students also provides the opportunity for discussing what sources of data are credible and what sources are not. By crafting objectives around activities that involve data use, teachers provide engaging curricula that will stick with students far longer than the standard textbook approach.

The Merrimack River nearly flooded again in 2007. Due to water-management lessons learned the previous year as well as some more moderate precipitation, the schools remained open and the cities safe. During this time, a seventh grader who had taken Earth science the previous year approached me after school and asked, "Did you know the Merrimack almost flooded again? I was looking online to see if it was going to reach that level again. Remember making us do all that graph work last year?" Making an impact in the classroom can be a difficult task at times, but including relevant data to tie students' personal lives into the curriculum is an excellent way to provide lasting impact.

Reference

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

Resources

NOAA's National Weather Service,—*www.weather.gov/climate*

USGS real-time water data for the nation—*http://waterdata.usgs.gov/nwis/rt*

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