

Graphing Dissolved Oxygen Lesson Plan

Students practice creating a best-fit trend line, and study the role of dissolved oxygen in water.

Lesson Summary: In this lesson, students learn to analyze real world data, generate line equations, and other graphing techniques. This will include learning how to best fit a line to data, calculate slope, and how to use spreadsheet software like Microsoft Excel to create graphs.

Grade Level: 8th Grade

Time Allotted: Two class periods (approximately 50 minutes each).

Performance Objectives

References are to the Next Generation Sunshine State Standards (2007).

Math

- MA.8.A.1.1: Create and interpret tables, graphs, and models to represent, analyze, and solve problems related to linear equations, including analysis of domain, range, and the difference between discrete and continuous data.
- MA.8.A.1.3: Use tables, graphs, and models to represent, analyze, and solve real-world problems related to systems of linear equations.
- MA.8.S.3.1: Select, organize and construct appropriate data displays, including box and whisker plots, scatter plots, and lines of best fit to convey information and make conjectures about possible relationships.

Science

- SC.8.N.1.6: Understand that scientific investigations involve the collection of relevant empirical evidence, the use of logical reasoning, and the application of imagination in devising hypotheses, predictions, explanations and models to make sense of the collected evidence.

Prior Knowledge

- Students must know how to perform addition, subtraction, multiplication, and division and have an understanding of basic algebra.
- Students should have a working knowledge of spreadsheet software, including how to insert formulas and sum rows and columns of numbers.

Topic Overview

The students will learn about simple data analysis (determining averages, identifying outliers, using Excel to graph, etc) by downloading data from the Water Atlas and manipulating it. In this module, the data will be focused on the amount of dissolved oxygen (DO) found in the Orange County lakes, and the students will learn to interpret this data in both graph and table form. They will identify trends in the data and interpret their meaning. They will learn about the ability of water to absorb oxygen at

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different temperatures and salinities, and use this information to make hypotheses about the effect climate change might have on dissolved oxygen levels in water resources.

Key Vocabulary

Climate change

A statistically-significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer).

Data

Information (either facts or figures), from which conclusions can be drawn.

Graph

A visual representation of data. A graph may represent data as points, lines, bars, or other easily distinguished characters along some kind of continuum in relation to other pieces of data. Graphs can represent data collected during a certain time period, over a certain distance, or during any other interval where the observer might wish to observe. The highly visual nature of graphs allows for easy recognition of trends and patterns in the data.

Milligram

One one-thousandth (0.001) of a gram, abbreviated mg.

Materials

- Computer with internet access
- Spreadsheet software (Microsoft Excel or equivalent)
- Dissolved oxygen test kit

References

These references are available in the [Orange County Water Atlas Digital Library](#):

[A Beginner's Guide to Water Management: Oxygen and Temperature](#). 2004. Florida LAKEWATCH, University of Florida Institute of Food and Agricultural Sciences.

[Learn More: Dissolved Oxygen](#). Orange County Water Atlas.

Other references:

[Water Science for Schools—Water Properties: Dissolved Oxygen](#). 2011. U.S. Geological Survey (Adapted from *A Primer on Water Quality*, by Swanson, H.A., and Baldwin, H.L., U.S. Geological Survey, 1965 and *A Hydrologic Primer for New Jersey Watershed Management*, WRIR 00-4140.)

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Procedure – Day 1

Engage/Elicit

Tell students that Earth’s lakes, rivers, and oceans are able to sustain life because the water in them contains oxygen, which the organisms that live in them depend on in order to breathe. Gases like oxygen can dissolve in water just as some solids can. Water’s ability to absorb oxygen is affected by atmospheric pressure, temperature, and salinity.

- Ask students which they think can hold more oxygen: warmer water, or colder? Take a vote and record the result.
- Ask students where they think atmospheric pressure is higher, in a boat on the ocean, or on the top of a mountain. Take a vote and record the result.
- Ask students which they think can hold more oxygen, fresh water or sea water (assuming that the two other factors, temperature and pressures, are the same). Take a vote and record the result.

Tell students that you will be revisiting these questions later.

Tell students that when scientists evaluate water resources—lakes and rivers—to find out how healthy they are, they usually measure the amount of dissolved oxygen, or DO, in the water. Tell them that they are going to look at some the data that has been collected by these scientists.

Explore

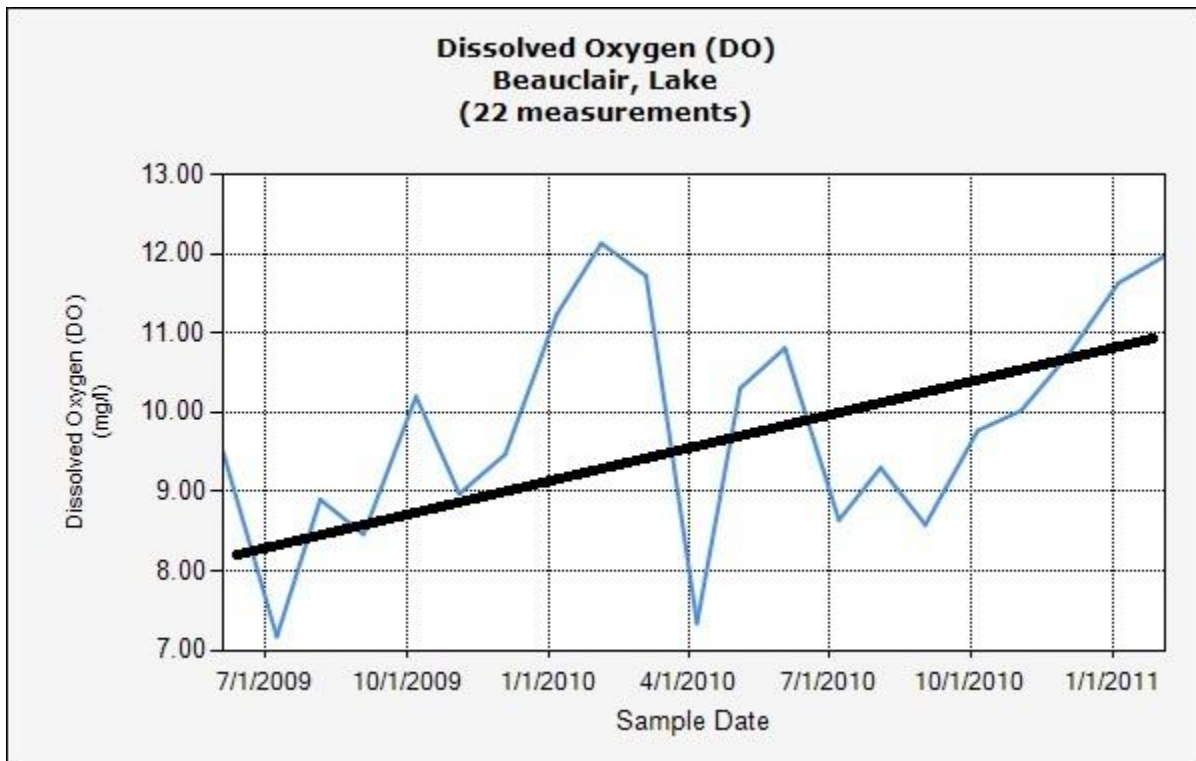
Note: You may elect to have students work in pairs or small groups to complete the following exercise. Prior to class, preview the steps you will demonstrate in calculating the trend-line, using data you have downloaded.

1. Guide students to the [Orange County Water Atlas](#) website, and instruct them to locate a lake with dissolved oxygen sampling data by doing the following:
 - a. Choose **Water Quality** from the **Topics** drop-down menu on the navigation bar.
 - b. Click on the **Dissolved Oxygen** link.
 - c. Choose a lake from the list that appears.
 - d. When the lake’s **Water Quality** page comes up, verify that it has fairly recent dissolved oxygen data, and that there are at least about a dozen data points. If not, go back to the previous page and choose a different lake.
2. Once students have settled on a lake, instruct them to download the dissolved oxygen data to a file on their computer, as follows:
 - a. Click the **Download this Data** link in the Dissolved Oxygen component.
 - b. Review the list of stations that appears. Choose one or more, then click **Give me all station data** or **Give me selected station data**, as desired.

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- c. Choose **Excel** for file type, and **Row** for format. Click **Generate File to Download**, then **Download File**.
- d. Save the file on your computer.
3. Tell the students to examine the data in the file, and to notice:
 - a. What units are used to measure dissolved oxygen.
 - b. What other information is included with each data point, besides the date and the sampling value.
 - c. Whether any of the data points look suspicious, either abnormally high or low, or have missing values.
 - d. Whether there are any big gaps between sampling dates, or dates when multiple samples were taken.
4. Tell students they will be graphing their data, and using linear regression to find a best-fit trend line for it. Show them an example of a graph with a trend line, like this one taken from the Orange County Water Atlas.



The slope of the trend line is positive, indicating that, in general, the amount of DO in the water has increased over time. A *negative* slope would indicate a trend of *decreasing* DO over time.

5. Tell the students you are going to demonstrate for them how to calculate the slope of a best-fit trend line for the data they just downloaded.

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- Open your data file using Microsoft Excel. Create a new worksheet. Copy two of the columns to the new worksheet: SampleDate (column A) and Result_Value (column B). Change the Column headers to SampleDate (x) and Sample_Value (y).
- Write the formula below on the board. Tell students that you will be using it to calculate the slope of the trend line that best fits the data, where x is the sample date and y is the sample value:

The best fit line associated with the n points $(x_1, y_1), (x_2, y_2), \dots (x_n, y_n)$ has the form

$$y = mx + b$$

where

$$\text{slope} = m = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

$$\text{intercept} = b = \frac{\sum y - m(\sum x)}{n}$$

Here, \sum means “the sum of.” Thus:

$$\sum xy = \text{sum of products} = x_1y_1 + x_2y_2 + \dots + x_ny_n$$

$$\sum x = \text{sum of x-values} = x_1 + x_2 + \dots + x_n$$

$$\sum y = \text{sum of y-values} = y_1 + y_2 + \dots + y_n$$

$$\sum x^2 = \text{sum of squares of x-values} = x_1^2 + x_2^2 + \dots + x_n^2$$

- Add another column to your data (column C), with a column heading “xy”. In each cell, place a formula that multiplies the corresponding date by the sample value (e.g., =A2*B2). The sum of the values in this column corresponds to $\sum xy$.
- Add another column to your data (column D), with a column heading “x²”. In each cell place a formula that multiplies the date by itself (e.g., =A2*A2). The sum of the values in this column corresponds to $\sum x^2$.
- At the bottom of each column of data, add a formula to sum all the values in that column (e.g., =SUM(A2:A101)). The sum of values in the sample date column is $\sum x$ and the sum of values in the sample value column is $\sum y$.
- In a cell off to the right of your data columns, write a formula to calculate the slope, substituting the number of your data points for n , and the column totals you created for the other constituents of the formula. If you have 100 data points, it will look something like this: =((100*C101)-(A101*B101))/((100*D101)-(A101*A101))
- Is your result positive or negative? Does this indicate increasing, or decreasing, DO?
- Select the data in the sample date and sample value columns, omitting the “total cells” at the bottom. Use Microsoft Excel’s **Insert Charts** command to create a line graph of the data. With the graph selected, use the Excel command to add a linear trend line, choosing the box that

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displays the trend line's equation on the chart. Check your work: Does its slope agree with your calculation?

14. Tell students that the intercept can be calculated similarly, but is of less interest in this case.

Explain

1. Tell students that they should now perform a similar operation on their own data, and calculate the slope of the trend line. Display the formula you used on the board for them to refer to. Walk around the room and provide assistance where needed. When they have finished, have them generate a graph with trend line for the data, print it, and save the file.
2. Have students make a copy of their data file. Have them open the copy and use it for experimentation:
 - a. What happens to the graph if they delete duplicate data points, or get rid of outliers? How does the slope of the trend line change?
 - b. Ask students to think about the units used in calculating the slope. Each sample date is represented as an integer—the number of days since an arbitrary date—and the sample value is given as milligrams (mg) per liter of dissolved oxygen. Can they figure out a way to normalize the date values so that the resulting slope value represents the overall change in DO per year, in mg/L?
 - c. How would they use the trend line formula to estimate the expected value of a DO sample take at a future date?

If your students have limited experience using Microsoft Excel, this exercise could take quite a bit of time. Allot at least 30 minutes for your students to accomplish the task. If any students/pairs/groups finish early, they can compute the intercept, help their classmates, or start on the homework described below.

Extend

As homework, ask students to:

1. Read pages 1-5 of Part I of *A Beginner's Guide to Water Management: Oxygen and Temperature* (see Resources).
2. Use the reading and/or other resources to find out the answers to the questions about temperature, atmospheric pressure, and salinity posed at the beginning of the class period.

Exchange/Evaluate

1. Check students' graphs and data tables for correctness. Double check that the graphs are properly labeled and that students calculated the slopes properly.
2. Evaluate students' participation in class discussion.



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Procedure – Day 2

Engage/Elicit

1. Remind your students of the questions you asked them on Day 1. Did they find the answers in the reading assignment? Were their original answers right, or wrong?
2. Show the students the chart below and ask them to summarize what it means in one sentence. (Answer: As temperature and/or salinity increase, oxygen saturation decreases.)

Oxygen Saturation (mg/L) Based on Temperature and Salinity

Temperature (deg. C)	Salinity (parts per thousand)					
	0	9	18.1	27.1	36.1	45.2
0	14.62	13.73	12.89	12.10	11.36	10.66
10	11.29	10.66	10.06	9.49	8.96	8.45
20	9.09	8.62	8.17	7.75	7.35	6.96
25	8.26	7.85	7.46	7.08	6.72	6.39
30	7.56	7.19	6.85	6.51	6.20	5.90
40	6.41	6.12	5.84	5.58	5.32	5.08

3. Ask students whether they think atmospheric pressure differs much throughout Florida due to altitude. (It doesn't; most of Florida is at, or very close to, sea level.) Ask students whether they think atmospheric pressure in Florida changes seasonally. (It does, somewhat. High-pressure systems tend to occur in winter and spring, low-pressure in summer and fall.)

Explore

1. Direct students to once again visit the Orange County Water Atlas, and to view the seasonal graphs for dissolved oxygen for several lakes (found on the Water Quality page for each lake). At what time of year are DO rates highest? Lowest? Why do they think this is so?
2. Ask students (a) to come up with a proposed question/hypothesis related to the presence/absence of dissolved oxygen in water bodies under specific conditions, and (b) to propose an experiment that would test the hypothesis. Example questions: How much, if at all, do aeration fountains increase dissolved oxygen in a pond? Does rainfall increase, or decrease, dissolved oxygen in a water body? How does decaying matter affect the level of dissolved oxygen in a water body?

Explain

1. Ask students whether they would expect dissolved oxygen rates to be higher at night, or during the daytime. What two factors could account for differences between daytime and nighttime DO rates? Would this day/night difference be greater in winter or summer? Why?

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2. Scientists are concerned that climate change could threaten aquatic ecosystems. What specific effects could result that would be detrimental to aquatic organisms?

Extend

Visit a local pond or lake. Take two identical water samples in glass jars, including some submerged plants and algae. Back in the classroom, place one in a sunlit window, the other in a darkened area. After about a day, use a test kit to measure the levels of dissolved oxygen in the water. Which is higher? Repeat the experiment using other conditions, for example, with one jar in a cool place and the other in a warm place, in similar lighting. What is the result?

Exchange/Evaluate

Have students share their hypotheses and proposed experiments with the class. Allow other students to ask questions and make suggestions for improvements.

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