

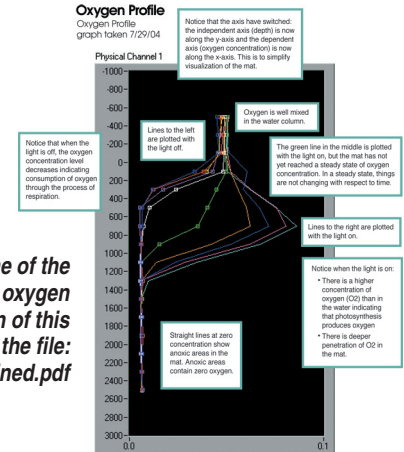
# Math Lesson Plan: Graphing Oxygen Concentration Profiles

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## Main Concept

Data gathered using remotely operable instrumentation can be visualized using a common spreadsheet program. The process of generating and analyzing graphs helps interpret the results of scientific experiments.

*An interpretation of some of the information contained in an oxygen profile. A full size version of this figure is contained in the file: [Oxygen\\_Profile\\_Explained.pdf](#)*



## Scientific Question

*How can one use a mathematical model (graph) to evaluate the results of scientific investigations?*

## Objectives

- 1 The student will learn how to use a spreadsheet application to enter data and general graphical representations.
- 2 The student will pick an appropriate graph to represent data.
- 3 The student will determine an appropriate scale for the graph.
- 4 The student will use graphical representations to make predictions and inferences about the results of a scientific experiment.

## Abstract of Lesson

Students will input oxygen profile data generated from lab view in the spreadsheet application and generate graphical representations. Students will analyze the spreadsheet graphical representations to draw conclusions about the experiment.

The Web Lab is located in the Microbiology Ecology/Biogeochemistry Research Lab at NASA Ames Research center in Mountain View, California and is classroom accessible through an internet connection to the Microbes @ NASA website: <http://microbes.arc.nasa.gov/>.

A microsensor within the lab can be remotely controlled by users to collect data on oxygen concentrations within a microbial mat. In order to participate in Web Lab experiments, remote sites will need to download LabVIEW run time engine (version 6.1) at <http://ni.com>. Users will need to register with National Instruments in order to download the LabVIEW run time engine. In order to ensure that users can access the Web Lab for classroom experiments at specific times, please email Dr. Brad Bebout at [Brad.M.Bebout@nasa.gov](mailto:Brad.M.Bebout@nasa.gov) to reserve a run time.

## Main Concept

This lesson can be modified for a variety of learners. For advanced learners, students may want to design their own experiment to conduct on Lab View and graph data generated from that experiment. Contact Dr. Brad Bebout at NASA Ames Research Center (Brad.M.Bebout@nasa.gov) to make arrangements to use the Web Lab for a student designed experiment. Refer to the design your own experiment lesson in this unit for experimental design guidelines. For English language learners and resource students: pair students with another learner. Use picture cues to help guide instruction. The use of an LCD Projector to demonstrate how to use the spreadsheet application will help students learn the program.

## Prerequisite Concepts

1. Understanding of the use of scatter plots to represent data.
2. Basic Technological literacy: Opening a program, saving files, using a mouse, etc.

## Major Concepts

1. Gathering Data
2. Using a spreadsheet workbook to organize data and plot results
3. Analyzing Results using graphical representations of Data

## Misconceptions

1. The conclusions of an experiment can change just because the graph is plotted in a different way.
2. The data from the experiment does not change and the results do not change when the graph is plotted in a different way. However, the interpretation of the data can change because of the picture shown by the graph. It is important that students learn to look at the graph and the scale of the graph to interpret the graph correctly.

## National Standards

NCTM Mathematics Standards

National Science Education Standards

International Society for Technology in Education (ISTE) Standards for Students

## National Education Standards

Fully Met	Partially Met	Addressed
<p><b>NCTM 2C (6-8): #1</b>  <b>NCTM 5C (6-8): #1, #2</b>  <b>NCTM 6A (6-8): #1, #2, #3, #4</b>  <b>NCTM 6C (6-8): #1, #2</b>  <b>NCTM 6E (6-8): #1</b>  <b>ISTE 3: a</b>  <b>ISTE 5: b</b>  <b>ISTE 6: a, b</b>  <b>NSES A1 (5-8):</b> Abilities Necessary to do Science Inquiry c, d, h  <b>NSES A2 (5-8):</b> Understandings about Science Inquiry c,d</p>	<p><b>NCTM 2D (6-8): #1</b>  <b>NCTM 5A (6-8): #2</b>  <b>NCTM 5B (6-8): #2</b>  <b>NCTM 6D (6-8): #3</b>  <b>ISTE 3: b</b>  <b>NSES A1 (5-8):</b> Abilities Necessary to do Science Inquiry e  <b>NSES C7(5-8):</b> Populations and Ecosystems c</p>	<p><b>NCTM 5A (6-8): #1</b>  <b>NCTM 6E (6-8): #2</b>  <b>NSES B6 (5-8):</b> Transfer of Energy a, f  <b>NSES C6 (5-8):</b> Regulation and Behavior d  <b>NSES C7(5-8):</b> Populations and Ecosystems a, b</p>
<p><b>2061: 1C (6-8) #6</b>  <b>2061: 3A (6-8) #2</b>  <b>2061: 8E(6-8) #2</b>  <b>2061: 5D (6-8) #1</b>  <b>2061: 9B(6-8) #2</b>  <b>2061: 12D(6-8) #1, #2</b></p>	<p><b>2061: 9B(6-8) #3</b>  <b>2061: 9C(6-8) #4</b>  <b>2061: 11C(6-8) #1, #2</b></p>	<p><b>2061: 5D (6-8) #1</b>  <b>2061: 5E(6-8) #1, #2, #3</b>  <b>2061: 9C(6-8) #6</b>  <b>2061: 11A(6-8) #1, #2</b>  <b>2061: 11B(6-8) #1, #2</b></p>

## California Science Standards

Fully Met	Partially Met	Addressed
<p>Math Grade 7: Algebra and functions 1.5            Math Grade 7: Statistics, Data Analysis and Probability 1.2            Science Grade 6: Investigation and Experimentation #7 c, e            Science Grade 8: Investigation and Experimentation #9 e</p>	<p>Math Grade 6: Statistics, Data Analysis and Probability 2.3            Math Grade 7: Mathematical Reasoning 2.5            Math Grades 8-12: Probability and Statistics 8.0            Science Grade 6: Investigation and Experimentation #7 b            Science Grade 7: Investigation and Experimentation #7 a</p>	<p>Science Grade 6: Ecology (Life Science) #5 a, b</p>

## Materials List

1. Access to data on the Web Lab through LabVIEW (<http://microsensor.arc.nasa.gov>), or raw data from the Profiles of Oxygen Concentration experiment in the For Educator's section of the Microbes @ NASA website <http://microbes.arc.nasa.gov>
2. Spreadsheet application
3. Computers
4. LCD projector

## Handouts

1. Copies of raw data to graph from: <http://microbes.arc.nasa.gov>
2. Rubric: Oxygen Concentration Profile—Scatter plot and Graph Interpretation Summary

## Reading on Topic Related to Study

Details of the experiments conducted at NASA are listed on the Microbes @ NASA website: Profiles of Oxygen Concentration experiment. Raw data is available at: <http://microbes.arc.nasa.gov>

LabVIEW Directions (link to lesson plans)

Scatter plot math lesson plan (link to lesson plans)

Oxygen Concentration Profile Model and Explanation (link to lesson plans)

## Preparation

1. Read the lab procedure in this lesson plan and details of oxygen profile concentration experiments at <http://microbes.arc.nasa.gov/>.
2. Decide whether to use the raw data from the above web site or to use remote access to Lab View to generate new data.
3. If Lab View is used to generate new data:
  - Download LabVIEW run time engine version 6.1 <http://ni.com>
  - Arrange for a live Internet connection to the Web Lab. Make certain that you will be able to show data sampling at the time of your class. Contact Dr. Brad Bebout at ([Brad.M.Bebout@nasa.gov](mailto:Brad.M.Bebout@nasa.gov)) one week before you want to use the Web Lab in your classroom to request a specific run time.
  - Download LabVIEW run time engine version 6.1 from <http://ni.com>. Users will need to register with National Instruments in order to download the free LabVIEW run time engine. Only one computer will be able to control the microsensor. Other computers may view the screen.
  - Arrange for a LCD projector to display the web cam and oxygen concentration profiles live from the web site.
  - Have copies of scatter plot data from an oxygen concentrate profile in case you are not able to run the experiment live or you have technical difficulties. Raw data is available at <http://learn.arc.nasa.gov/microbe/>.
4. Practice using your spreadsheet application to make a scatter plot of oxygen profile data.

## Procedure

1. Obtain data to use for the spreadsheet exercise. Either use raw data available online at <http://microbes.arc.nasa.gov> or generate new data in LabVIEW using the Web Lab.
2. If data is generated in LabVIEW, use the procedures in the Oxygen Concentration Profile and LabVIEW directions outlined in the on-line lesson plans.

## Engage

**Discuss:** Have you ever plotted the results of an experiment by hand? How would you describe the process? What could make the process easier?

(Allow for student response.)

Today we are going to use a spreadsheet application as a tool to help us graph the results of an experiment.

## Explore: Spreadsheet Instruction

1. Open a spreadsheet workbook file by selecting file → new. You can enter words or data in the cells.
2. Make certain that you include a description of your data at the top of your spreadsheet workbook. This description should include the date the data was collected, what the data is, a description of the variation in trials, etc. For each trial, the profile number, time of day, light level, and whether the mat was at a steady state should be indicated. A side heading is a good way to indicate this information.
3. Organize your data by adding a title and column headings to describe each trial.
4. Input data from the oxygen concentration profile experiment into the appropriate columns. Check to make certain that your data entry is correct.
5. Select chart wizard by choosing the chart wizard icon on the tool bar or select Insert → Picture → chart.
6. Select the appropriate graph. The standard types of charts on the chart wizard are a column, bar, line, pie, XY (scatter), area, doughnut, radar, surface, and bubble. Remember each type of chart has a particular purpose with which you will need to match to your data.
  - Column charts display data that changes over time when each column represents data for a particular amount of time. Columns on these charts are generally vertical.
  - Bar graphs show comparisons among individual items, but not data that changes over time. Bars on these charts are horizontal.
  - Line charts show trends among categories or over time.
  - Pie charts show how each part relates to a whole.
  - Scatter plots are often used for scientific studies since they allow the user to plot multiple data points which reveal the relationships among points from more than one set of data.
  - Area charts are useful for showing how parts contribute to a whole as well as trends over time.
  - Doughnut charts, like pie charts, show how each part relates to a whole, but each ring can represent different data sets.
  - Radar charts are used for scientific and technical problems. The axis, which connects the values of the same series of data, is rotated around the center of the graph.
  - Surface charts illustrate the ideal combination of different sets of data.

**Question:** Which graph will you use and why?

**Answer:** An XY scatter plot is the best choice to represent this data, since the data represents different trials of oxygen profiles showing volts and depth. A scatter plot will reveal the relationships among points for each trial and reveal any trends between depth, oxygen concentration and light.

## Explore: Spreadsheet Instruction cont.

7. Select the XY scatter plot. The scatter chart sub-type is the appropriate selection to make. Ignore the custom types tab.
8. Press the Next button. Select the series tab.

Select data for each axis. Normally, the x-axis is the independent variable, or the variable that you change on purpose to ascertain the effect on the dependent variable. Typically, the y-axis is the dependent variable, or the variable that responds to a change in the independent variable.

**Question:** Using these guidelines, would volts or depth be your independent variable?

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**Answer:** Depth would be the independent variable.

**Question:** Again, using the above guidelines, would volts or depth be your dependent variable?

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**Answer:** Volts would be your dependent variable.

Consider the visual impact of your graph.

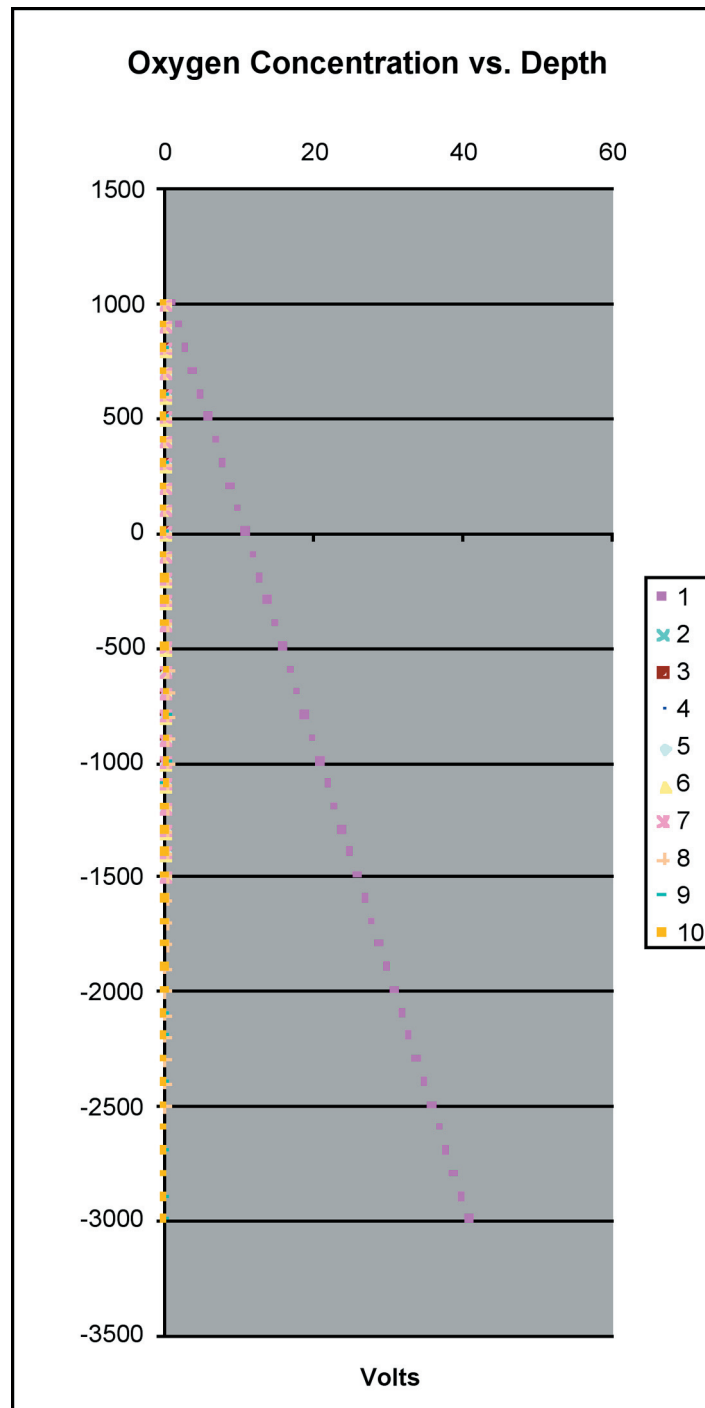
**Question:** How would you set up your independent and dependent variables to best represent the relationship between depth and oxygen concentration so it looks most like a oxygen probe reading the volts in a microbial mat?

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**Answer:** In order to best show the relationship between depth and oxygen concentration, the x-axis should show volts, and the y-axis should show depth.

10. When selecting data for each axis, select Source Data → series on step 2 of 4 in the Chart Source Data. Click in the Y value box. Next, click on small spreadsheet icon to the right of the Y value box to make this window smaller. Highlight the Y-axis data from your first column, making certain all boxes from the first reading to the last reading are selected. The boxes for the data that you selected should be shown. Now click on the small spreadsheet icon, click in the box for the X value box, make the window disappear by clicking on the small spreadsheet icon, and then select the data for this box by highlighting it. Return to the window by selecting the small spreadsheet icon; select the name box and type in the number of your trial. Next, press the add button to enter the data for trial two and the successive trials. If you notice on your data chart the number of trials that you have, and which column letters are volts (x-axis) and depths (y-axis) for each trial, you can copy and paste the series in each value box, replacing the appropriate letters for each trial. Make certain that each trial is named and double check that each series number has the correct information entered in the box. When all of the data has been correctly entered, click the next button.
11. Determine the chart options using the next screen. The first tab is the **Title tab**. Type in a name for the chart title, the name of the value for the x-axis and the name of the value for the y-axis. The second tab is the **Axes Tab**. The Value x and y axis should be both checked. Select *automatic* under the value x axis. The next tab is the **Gridline Tab**. Under y, major grid lines should be selected. The following tab is the **Legend Tab**. Make certain that *Show Legend* is checked, but the circles by each selection are clear. The last tab is the **Data Labels Tab**. Labels should not be selected since this creates too much print on the graph. Select the next button.

12. Decide where you want the graph placed. It can be a new sheet or an object placed in your raw data spreadsheet. Create the graph by selecting *Finish*.
13. By right clicking on the chart box, other formatting options become available. By selecting *Format Chart* area, other design alternatives surface. Make certain to select those options that best display the data for interpretation.
14. By right clicking on a part of the chart, a specific patterns box will appear to allow the user to make changes in color, type, border and other formatting options. By right clicking on the axis, a *Format Axes* box will appear with a pattern section where you can adjust the tick marks on the axis. To make the graph more readable select: Major tick mark outside, Minor tick mark none, and Tick mark labels high. By placing the Tick Mark labels high and on the outside, they will not interfere with the picture created by the graph.
15. A sample graph from the oxygen profile data is included below:



## Explain: Graph Interpretation and Summary of Results

1. Interpret results of the data by analyzing the picture shown on the graph what is the relation of oxygen concentration to depth as shown by this graph? What factors and scientific processes can explain the relationship illustrated by this graph? Have students take notes on the results and the evidence from the graph that proves the result.
2. Introduce how to write a summary of graph interpretations using a graphic organizer to plan writing.
  - In the introduction section, the students should write down a few words summarizing the experiment: Scientific question, independent and dependent variable, procedure.
  - In the thesis box, students should include a thesis statement that indicates why the graph looks the way it does.
  - In the body section students should include an explanation of how one can draw conclusions from the graph. For example, how does the graph picture show:
    - The mats are producing oxygen?*
    - The mats are consuming oxygen?*
    - The depths where production and consumption are highest?*
    - The depths where production and consumption are the lowest?*
  - In the conclusion students need to write notes on:
    - Inferences drawn from the experiment.
    - Explanations of the scientific processes demonstrated by the experiment.
    - Explanations of the differences in the profiles.
    - Answers to whether or not these mats are a source or sink of oxygen.
    - An explanation of variation in data and error analysis.
    - An idea for further research or other questions relating to the oxygen concentration experiment.
3. After students have completed the graphic organizer, they are ready to number the ideas in each section of the graphic organizer in the order that they would write about them. Next, they take these ideas and work them into a written summary.
4. Once the summary is completed they need to check their writing using the Rubric for the **Graph Interpretation Summary** to make certain all points are covered in the summary.

## Evaluation

Use the Oxygen Concentration Profile Scatter Plot and Graph Interpretation Summary to evaluate the quality of student work. The paper titled Oxygen Concentration Profile Model Explained included in this unit will help with the interpretation of Oxygen Concentration profiles

## Extend/Apply

Use the Design your own Experiment lesson to allow students further practice in applying mathematical models for data analysis. (Add link to lesson.)

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### Credits

#### Lesson Plan:

**Art, Graphic Design & Layout:** C. Triano & T. Esposito, TopSpin Design Works