SeaGlide_TEAM	Dissolved Oxygen	Lesson # 8 (60 minutes)

Description:

For this lesson, you will assume the role of a hydrologist, a scientist who researches the distribution, the circulation and the physical properties of underground and surface waters. Part of your job entails going into forests or wooded areas and studying the water bodies present. In this experiment, you are given two samples of water, one from and urban area and the other from a wooded area. Your objective is to determine the oxygen levels of the water from these areas, and to use that data to answer analytical questions. You will have to prepare a report based on your findings and include your interpretations of what the values mean. The purpose of this project is to observe how water quality is affected by human activity in the areas.

Students will be able to:

- Understand the necessity for sensors
- Properly utilize sensors to collect data
- Find trends found in the data and interpret what these trends mean
- Figure out reasons for any usual data found. It could be because of environmental reasons or human interference in natural processes
- Determine ways to improve conditions if they are bad, or find methods to preserve and maintain current conditions if they are good

Students will understand:

In this lesson, students will experiment on a real, existing water body. They will record several data, and students will be questioned based on their findings. Successfully completing this exercise will ensure that students learn all of the learning goals. Using sensors to test and gather data is an essential part of any and all scientific procedures. Studying output data reveals if a system is functioning the way it is supposed to, or if there are issues that need fixing. In the case of a natural entity, collected data show trends that are observed and studied to determine the state of that entity. For example, using a relative humidity sensor in a rainforest can show if the plants are healthy and photosynthesizing adequately etc.

Key Definitions & Concepts: [1]

- **Dissolved Oxygen:** the amount of oxygen available able underwater. This quantity varies between water bodies and is significant since aquatic life is dependent on the amount of oxygen present in the water
- **Sensor:** a device which detects or measures a physical property and records, indicates, or otherwise responds to it
- **Vernier Computer Interface:** a Vernier device that connects a Vernier sensor to a computer to display the results
- **Dissolved Oxygen Sensor:** a device that measure the amount of oxygen dissolved in a sample of water

- **Logger Pro:** a data collection and analysis software for Windows and Mac. This is the platform on which the collected data is displayed, and the interface provides users with several options to analyze the presented data

Standards: [Copied from: 2]

4.1.10.B: Explain the consequences of interrupting natural cycles.

4.1.10.E: Analyze how humans influence the pattern of natural changes (e.g. primary / secondary succession and desertification) in ecosystems over time.

Background Information

Prior Knowledge:

- Familiarity with computers tools, to use Logger Pro, and connect the Vernier Computer Interface
- Ability to create graphs from a table of data and then find trends after studying the graph
- Students must know how to use Vernier equipment
- Students must understand the importance of the amount of oxygen dissolved in water, and how aquatic life depends on adequate levels of the gas to stay alive

Science Practices:[Copied from: 3]

- Asking questions and defining problems
- Developing and using models
- Carrying and Planning Out Investigations
- Analyzing and interpreting data
- Obtaining, Evaluating and Communicating Information

Core Ideas:[Copied from: 4]

- Earth Material and Systems
- Roles of Water in Earth's Surface Processes
- Biogeology
- Natural Resources
- Human Impact on Earth Systems

Cross Cutting Concepts:[Copied from: 5]

- Patterns
- Cause and effect
- Scale, Proportion and Quantity
- Systems and system models

Possible Preconceptions/Misconceptions:

Students may be given values that are either in the incorrect units or not similar to other students' results. This could be the result of a sensor error or incorrect input values. The instructor should consult the *Dissolved Oxygen* experiment in the Vernier book for guides to alleviate these misconceptions.

	Lesson Plan - 5E(+) Model	

Engage:[6]

The instructor will provide the *Dissolved Oxygen Reading*, and hand out the associated half sheet titled *Dissolved Oxygen Questions* for the students to complete individually. This section is designed to prompt the students to think about the significance of dissolved oxygen and how temperature affects it. It is important for students to understand the importance of dissolved oxygen because otherwise they would not be able to determine if the oxygen level in a water body is high, low or normal. Students will have 10 minutes to complete the reading and the half sheet. The instructor should facilitate an open class discussion to review students' responses and address any misconceptions as necessary. This section should take no longer than 15 minutes to complete.

Explore:

Part I: Introduction

The instructor will give a brief overview of the *Dissolved Oxygen* Vernier Experiment. The instructor will distribute materials, go over safety guidelines, and answer any questions that students may have prior to experimentation. The instructor should allot 5 minutes for this.

Part II: *Benchmark Lesson*: Experiment

Students will work on the *Dissolved Oxygen* Vernier Experiment in pairs or small groups of three. This activity is designed for students to gain first-hand experience in using a Dissolved Oxygen (DO) sensor to determine the level of oxygen dissolved in samples of water. Students will following along with the *Dissolved Oxygen* Vernier Experiment worksheet procedure. The two samples of water will be tested using the two different methods explained in the manual. The experiment should be done in a lab. The instructor should circulate around the classroom to assist the students with any issues they face or with any questions they might have. This activity should take 20-30 minutes to complete.

Part III: *Investigation Lesson*: Analysis

After the *Dissolved Oxygen* Vernier Experiment, students will be required to answer questions that pertain to the experiment and the application of the lesson goals. Working individually, students will need to invoke critical and higher-level thinking to answer these questions. The content of these questions range from simple experimental details (including the learning objectives) to more complex topics (such as experimental errors within the activity). Students will also be extending the lesson topic to their SeaGlide and how oxygen level in water affects its function.

Explain:

Throughout the exploration of this lesson, students will engage in discussions and activities that seek to discover their understanding of the topic at-hand as it relates to oxygen level determination. Instructors should informally ask questions to promote thoughtful discussion that is designed to aid in addressing any questions or concerns that some students may have. Students are expected to formalize their answers throughout the entirety of the lesson via the worksheets and the activities.

Elaborate:
The amount of oxygen that is dissolved in a water body does not affect the operations of a SeaGlide. However, depending on the function of the SeaGlide, the device could be equipped with a DO sensor to collect data pertaining to water oxygen concentration. Oxygen depletion, aka hypoxia, occurs when there is a significant influx of nutrients into the water body. This causes a bloom in the amount of cyanobacteria that uses up most of the oxygen. Water bodies facing such conditions are generally brimming with algae and dead aquatic plants. A SeaGlide would be difficult to maneuver in these conditions, mostly because of low visibility.

Evaluate:
Throughout this lesson, there are both formal and informal evaluations. The informal evaluations occur throughout the exploration portions via leading and open-ended questioning, as well as through the open class discussions. The informal evaluations will allow for the teacher to gauge surface-level understanding of the students. By surveying the students during completion of the worksheets and activities, teachers will be able to hear and to address any misconceptions or misunderstandings as necessary. The formal evaluations of this lesson are the *Dissolved Oxygen* Vernier Experiment, and the *Analysis Questions* worksheet.

Enrich:
This lesson can be extended to an aquatic ecology course because of the *Dissolved Oxygen* Vernier Experiment activity. In aquatic ecology, field work involving stream water sampling and aquatic environmental factor data collection is heavily emphasized and required for coursework. This lesson and its associated activity can be further extended by including other data collection methods, such as: plant life collection, predator-prey interactions, microenvironment analysis, and how dissolved oxygen affect all of the above.

All associated documents are attached below
Reference *Annotated Bibliography* on the very last page of this packet

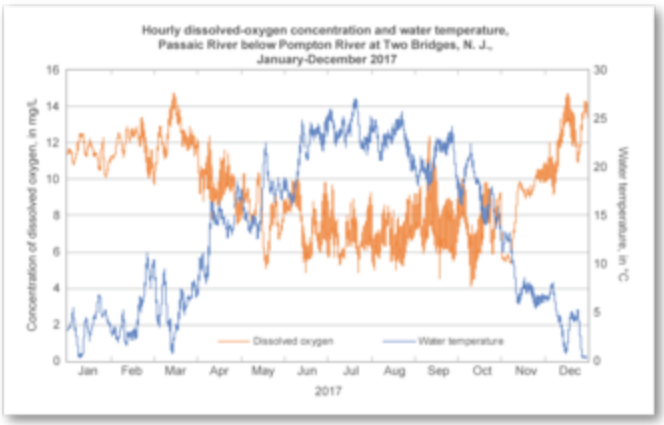
NOTE:
This lesson incorporates the use of the *Water Quality with Vernier by Robyn L. Johnson, Dan D. Holmquist, and Kelly Redding, Second Edition*. The SeaGlide Curriculum Team created an engagement to preface this experiment and added an additional analysis to conclude this lesson. The engagement activity is designed to pique students' interest in completing the experiment. The purpose of the analysis is to promote critical thinking techniques as students relate this lesson to SeaGlide by completing the *Analysis Questions* worksheet.

Additionally, the experiment (Experiment 5: Dissolved Oxygen) used during the exploration can be found in the Water Quality with vernier lab manual, starting on page 5-1.

Dissolved Oxygen Reading [6]

Although water molecules contain an oxygen atom, this oxygen is not what is needed by aquatic organisms living in natural waters. A small amount of oxygen, up to about ten molecules of oxygen per million of water, is actually dissolved in water. Oxygen enters a stream mainly from the atmosphere and, in areas where groundwater discharge into streams is a large portion of streamflow, from groundwater discharge. This dissolved oxygen is breathed by fish and zooplankton and is needed by them to survive.

Rapidly moving water, such as in a mountain stream or large river, tends to contain a lot of dissolved oxygen, whereas stagnant water contains less. Bacteria in water can consume oxygen as organic matter decays. Thus, excess organic material in lakes and rivers can cause eutrophic conditions, which is an oxygen-deficient situation that can cause a water body to "die." Aquatic life can have a hard time in stagnant water that has a lot of rotting, organic material in it, especially in summer (the concentration of dissolved oxygen is inversely related to water temperature), when dissolved-oxygen levels are at a seasonal low. Water near the surface of the lake– the epilimnion– is too warm for them, while water near the bottom–the hypolimnion– has too little oxygen. Conditions may become especially serious during a period of hot, calm weather, resulting in the loss of many fish. You may have heard about summertime fish kills in local lakes that likely result from this problem.



As the chart shows, the concentration of dissolved oxygen in surface water is affected by temperature and has both a seasonal and a daily cycle. Cold water can hold more dissolved oxygen than warm water. In winter and early spring, when the water temperature is low, the dissolved oxygen concentration is high. In summer and fall, when the water temperature is high, the dissolved-oxygen concentration is often lower.

Dissolved oxygen in surface water is used by all forms of aquatic life; therefore, this constituent typically is measured to assess the "health" of lakes and streams. Oxygen enters a stream from the atmosphere and from groundwater discharge. The contribution of oxygen from groundwater discharge is significant, however, only in areas where groundwater is a large component of streamflow, such as in areas of glacial deposits. Photosynthesis is the primary process affecting the dissolved-oxygen/temperature relation; water clarity and strength and duration of sunlight, in turn, affect the rate of photosynthesis.

Field and lab meters to measure dissolved oxygen have been around for a long time. As this picture shows, modern meters are small and highly electronic. They still use a probe, which is located at the end of the cable. Dissolved oxygen is dependent on temperature (an inverse relation), so the meter must be calibrated properly before each use.

Name:_____ Date:_____

Dissolved Oxygen Questions

1. Describe the relationship between temperature and dissolved oxygen.

2. Based on the reading, how does dissolved oxygen impact aquatic life?

3. During data and sample collection, you notice a discrepancy between your data and another student's data. You conduct the test again, but the results are still inconsistent. Provide one reason as to why this may occur.

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Analysis Questions

1. What was the objective of this activity? Refer back to the data you were collecting and how you were collecting it.

2. Explain the importance of calibrating the dissolved oxygen (DO) sensor probe when testing a new sample.

3. No experiment is 100% correct or without fault. Describe at least one source of error that is present in this experiment.

4. Suppose you collect data from a sample site for several months using your SeaGlide. However, in your most recent data collection, you notice that the level of oxygen in the water is extremely low. Predict one reason why this may occur, and explain how it will affect the aquatic environment.

Name:_____Answer Key_____ Date:_____

Dissolved Oxygen Questions

1. Describe the relationship between temperature and dissolved oxygen.

   As temperature decreases, the amount of dissolved oxygen in the water increases.

2. Based on the reading, how does dissolved oxygen impact aquatic life?

   Aquatic organisms (like fish) rely on the oxygen to perform bodily processes to survive.

3. During data and sample collection, you notice a discrepancy between your data and another student's data. You conduct the test again, but the results are still inconsistent. Provide one reason as to why this may occur.

   Students' responses may vary, but one example is the following: the other student did not calibrate their DO sensor probe for that sample site, thus throwing off the data.

Name:_____Answer Key_____ Date:_____

Analysis Questions

1. What was the objective of this activity? Refer back to the data you were collecting and how you were collecting it.

   The objective is to determine the amount of oxygen molecules presently dissolved in a given sample of water.

2. Explain the importance of calibrating the dissolved oxygen (DO) sensor when testing a new sample.

   If the sensor is not calibrated between samples, then the probe will not have the correct temperature and thus produce an incorrect value for dissolved oxygen.

3. No experiment is 100% correct or without fault. Describe at least one source of error that is present in this experiment.

   One source of error is the presence of other dissolved molecules in the water. If more dissolved molecules are present in the water, then this could reduce the amount of oxygen in the water and the sensor could misinterpret this value.

4. Suppose you collect data from a sample site for several months using your SeaGlide. However, in your most recent data collection, you notice that the level of oxygen in the water is extremely low. Predict one reason why this may occur, and explain how it will affect the aquatic environment.

   Answers will vary based on student responses.
   Expectation: One reason that the level of oxygen may be low is due to a change in seasons from colder temperatures to hotter temperatures. This may lead to a decrease in number of oxygen-dependent organisms.

Annotated Bibliography

[1] Johnson, R. L., Redding, K., & Holmquist, D. D. (2007). *Water Quality with Vernier: Water Quality Tests Using Vernier Sensors*. Vernier Software & Technology.

This book was used for excerption within the Dissolved Oxygen lesson plan. The reference aided in the completion of the Explore. Test 4 in the book, the Dissolved Oxygen test, was excepted for the students. Pages 5-1 through 5-4 contain information, required material, procedure and a data collection sheet for the students. Pages 5-1I to 5-6I were designed for the instructors, so that they are able to troubleshoot the students' questions and misconceptions. The Vernier book is an excellent resource to learn sensor technology. It contains detailed experiments to test different water conditions, and determine if the findings fall within the normal range.

[2] Nsta. (n.d.). Access the Next Generation Science Standards by Topic. Retrieved January 18, 2019, from https://ngss.nsta.org/AccessStandardsByTopic.aspx

This website was used in each lesson in the Sensor Technology & Programming module to select proper national set standards for science subjects that each lesson is centered around.

[3] Nsta. (n.d.). Science and Engineering Practices. Retrieved January 18, 2019, from https://ngss.nsta.org/PracticesFull.aspx

This website used in every lesson in the Sensor Technology & Programming module to find Standards for Science and Engineering Practices that are applicable in each lesson.

[4] Nsta. (n.d.). Disciplinary Core Ideas. Retrieved from https://ngss.nsta.org/DisciplinaryCoreIdeasTop.aspx

This website was used in each lesson in the Sensor Technology & Programming module to select appropriate disciplinary core ideas set forth by the NSTA that are at the center of each lesson.

[5] Nsta. (n.d.). Crosscutting Concepts. Retrieved from https://ngss.nsta.org/CrosscuttingConceptsFull.aspx

This website was used in each lesson in the Sensor Technology & Programming module to selecting appropriate crosscutting concepts set forth by the NSTA that apply to each science lesson.

[6] USGS. (n.d.). Dissolved Oxygen and Water. Retrieved April, 2019, from https://www.usgs.gov/special-topic/water-science-school/science/dissolved-oxygen-and-water?qt-science_center_objects=0#qt-science_center_objects

This reference was used for excerption purposes. This reference was used to develop a reading to correspond to the Dissolved Oxygen lesson plan. The reading and its associated images were directly excerpted from the reference to develop this reading and the associated worksheet with questions.