SeaGlide_TEAM	Calcium & Water Hardness	Lesson # 7 (60 minutes)

Description:

For this lesson, you will assume the role of a hydrologist, which is 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. Here, you will be testing a sample of water to determine the calcium content of the water, and to use that data to calculate the hardness of the water. 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
- Solve mathematical equations using the data they found
- 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
- Study how anomalies in the data can affect the wildlife in the vicinity

Students will understand:

In this lesson, students will go out and 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. This lesson serves as an excellent introduction to sensor technology.

Key Definitions & Concepts: [1]

- **Hardness:** the amount of heavy ions like Ca^{2+} and Mg^{2+} in a water body
- **Sensor:** a device which detects or measures a physical property and records, indicates, or otherwise responds to it
- **Calcium ISE:** sensor that measures the concentration of calcium ions in a sample of water
- **Vernier Computer Interface:** a Vernier device that connects a Vernier sensor to a computer to display the results
- **Vernier Flow Rate Sensor:** a device that consists of a propeller attached to one end of a rod. This device measures the velocity of the water flowing through

- **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:

- Basic arithmetic and algebraic knowledge to solve mathematical equations
- Familiarity with computers tools, to use Logger Pro, and connect the Vernier Computer Interface
- Familiarity with sensor functions and usage
- Ability to create graphs from a table of data and then find trends after studying the graph

Science Practices: [Copied from: 3]	**Core Ideas: [Copied from: 4]**	**Cross Cutting Concepts: [Copied from: 5]**
● Asking questions and defining problems ● Developing and using models ● Carrying and Planning Out Investigations ● Analyzing and interpreting data ● Using Mathematical and Computational Thinking ● Obtaining, Evaluating and Communicating Information	● Earth Material and Systems ● Biogeology ● Natural Resources ● Human Impact on Earth Systems	● Patterns ● Cause and effect ● Scale, Proportion and Quantity ● Systems and system models

Possible Preconceptions/Misconceptions:

Water hardness is the measurement of the amount of calcium and magnesium ions in the water. Very high readings are also indicative of the presence of other minerals like manganese, iron etc. In most cases, the amount of calcium ions is assumed to be equivalent to the hardness since magnesium hardness represents about ⅓ of total hardness and since calcium hardness represents about ⅔ of the total hardness. Students will be using the calcium ion concentration in water to determine hardness of the water in this experiment. However, hardness of the water actually indicates the amount of heavy metal ions present in the sample.

	Lesson Plan - 5E(+) Model	

Engage:

This lesson involves using a Calcium ISE to determine the hardness of water. This section of the lesson prompts students to recall knowledge from the Electrical Circuits and the Water Chemistry & Biology modules to answer analytical questions. These questions also help students realize how a water becomes "hard." The instructor will hand out the *Calcium in Water* worksheet and students will have about 5 minutes to complete it individually. The instructor should facilitate an open class discussion to review students' responses and address any misconceptions as necessary. This section should last less than 10 minutes.

Explore:

Part I: Introduction

The instructor will give a brief overview of the *Calcium and Water Hardness* 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 *Calcium and Water Hardness* Vernier Experiment individually. This activity is designed for students to gain first-hand experience in determining calcium ion concentration and hence water hardness of samples. During this activity, students will be actively engaged in the learning process. Students are expected to follow the procedure listed in the *Calcium and Water Hardness* test in the Vernier book to complete the lesson. The experiment will be carried out in a lab, with the sample of water for testing provided. The instructor should circulate throughout the classroom to assist the students with any issues they face or with any questions they might have. This activity should take about 30 minutes to complete.

Part III: *Investigation Lesson*: Analysis

After the *Calcium and Water Hardness* 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 the water hardness 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 calcium content and water hardness 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 experiment has the students measure the calcium content of the water and thus the hardness. This is an important factor of water quality that students must be aware of before they plan on sailing their SeaGlide. The hardness of the water would affect the movement of the SeaGlide because very hard water can completely immobilize the SeaGlide via mineral deposition on the rudders and propellers. Therefore, students should know the hardness of their selected water body and build their SeaGlide accordingly.

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 *Calcium and Water Hardness* Experiment, and the *Analysis Questions* worksheet.

Enrich:
This lesson can be extended to an aquatic ecology course because of the *Calcium and Water Hardness* 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, and microenvironment analysis, and how these are affected because of the hardness of water in the vicinity.

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 13: *Calcium and Water Hardness*) used during the exploration can be found in the Water Quality with vernier lab manual, starting on page 13-1.

Name:_____ Date:_____

Calcium in Water

Water hardness is determined by the amount of calcium ions present. Calcium is generally introduced to water as calcium chloride or calcium sulfate, which then ionize in water. Using your knowledge from the Electrical Circuits and the Water Chemistry and Biology modules, complete the following ionic equations:

1. $CaCl_2(s) \rightarrow$ _____$Ca^{--}(aq)$ + ___$Cl^{--}(aq)$

2. $CaSO_4(s) \rightarrow$_____$Ca^{--}(aq)$ + ___$SO_4^{--}(aq)$

Use the formula provided in page 13-1 to find the calcium hardness of a sample of water if the concentration of calcium is 50 mg/L.

Name:_____ 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.

2. Why are the Calcium ISE sensors calibrated twice at two different calcium concentrations?

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

4. Describe how hardness of water will affect the movement of a SeaGlide.

Name:_____ANSWER KEY_____ Date:_____

Calcium in Water

Water hardness is determined by the amount of calcium ions present. Calcium is generally introduced to water as calcium chloride or calcium sulfate, which then ionize in water. Using your knowledge from the Electrical Circuits and the Water Chemistry and Biology modules, complete the following ionic equations:

3. $CaCl_2(s) \rightarrow$ __1__ Ca^{2+} (aq) + __2__ Cl^{1-} (aq)

4. $CaSO_4(s) \rightarrow$ ___1___ Ca^{2+} (aq) + __1__ SO_4^{2-} (aq)

Use the formula provided in page 13-1 to find the calcium hardness of a sample of water if the concentration of calcium is 50 mg/L.

50 mg/L * 100/40 = 125 mg/L

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 of this activity was to determine the hardness of a body of water using the concentration of calcium ions determined with the Calcium ISE.

2. Why are the Calcium ISE sensors calibrated twice at two different calcium concentrations?

   This is done to fix the two points of the range of concentration. First, the highest point is determined by placing the sensor in 1000 mg/L solution. Then, for the lowest point, the sensor is dipped in a 10 mg/L solution.

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

   The containers that hold the samples of water to be tested could be contaminated. This would give wrong values for the calcium concentration and therefore the hardness of the water.

4. Describe how hardness of water will affect the movement of a SeaGlide.

   Sailing in very hard waters would result in mineral deposition on the rudder and propellers of the SeaGlide. This would stop the propeller from rotating and therefore, the SeaGlide would not be able to move. If there are depositions on the rudder joints, the SeaGlide would not be able to navigate sidewise. It can only sail forward.

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 *Calcium and Water Hardness* lesson plan. The reference aided in the completion of the Explore. Test 13 in the book, the *Calcium and Water Hardness* test, was excepted for the students. Pages 13-1 through 13-5 contain information, required material, procedure and a data collection sheet for the students. The following five pages (13-1I to 13-4I) were designed for the instructors, so that they are able to troubleshoot the students' questions and misconceptions. The Venier 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.