SeaGlide_TEAM	Total Dissolved Solids	Lesson # 5 (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 waters and surface waters. Part of your job entails going into forests or wooded areas and studying the water bodies present. In this experiment, you will be carrying out tests on samples of water provided to you, in order to determine the levels of dissolved solids in the samples. 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 the presence of dissolved solids within a body of water.

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

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]

- **Solubility:** the amount of a substance that dissolves in a unit volume of a liquid substance to form a saturated solution under specified condition of temperature and pressure.
- **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
- **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

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 • Obtaining, Evaluating and Communicating Information	• Earth Material and Systems • Roles of Water in Earth's Surface Processes • Biogeology • Natural Resources • Human Impact on Earth Systems	• 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 *Total Solids* Experiment in the Vernier book for guides to alleviate these misconceptions.

Lesson Plan - 5E(+) Model

Engage: [6]
The instructor will distribute the *TDS Reading* article, and hand out the associated half sheet titled *TDS Reading Questions* for the students to complete individually. This reading and half sheet serve to introduce students to the topic of dissolved solids and their impact of water systems. The half sheet ensures that students are engaged with the reading and obtaining the key concepts from the reading necessary to continue with the lesson. 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 *Total Solids* 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 *Total Solids* Vernier Experiment in pairs or small groups of three. This activity is designed for students to gain first-hand experience in collecting data from a set of beakers. During this activity, students will be actively engaged in the learning process by actively collecting their own data. During this activity, students will be following the procedure in the *Total Solids* Vernier Experiment, collecting the data associated with the experiment, and manipulating the data to answer questions based on the experiment. Students are expected to follow the procedure listed in the *Total Solids* test in the Vernier book to complete the lesson. Students will following along with the *Total Solids* Vernier Experiment worksheet procedure, and carry the experiment out in a lab. This activity should take 15-20 minutes to complete.

Part III: *Investigation Lesson*: Analysis

After the *Total Solids* 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 total dissolved solids 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 total dissolved solids. 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 amount of total dissolved solids present in two sample solutions. This is a process similar to those done by hydrologists testing the water of a sample geological site or an urban city. Not only that, but the total dissolved solids have the potential of creating a solid build-up within a SeaGlide. This experiment creates a unique situation where students are gaining real-world experience in a STEM field while also adapting their SeaGlide.

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 *Total Solids* Vernier Experiment, and the *Analysis Questions* worksheet.
<u>Enrich:</u> This lesson can be extended to an aquatic ecology course because of the *Total Solids* 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 all of the above relates to total dissolved solids in a water sample.

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

<u>NOTE</u>:
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 4: Total Solids) used during the exploration can be found in the Water Quality with vernier lab manual, starting on page 4-1

TDS Reading [6]

TDS stands for total dissolved solids, and represents the total concentration of dissolved substances in water. TDS is made up of inorganic salts, as well as a small amount of organic matter. Common inorganic salts that can be found in water include calcium, magnesium, potassium and sodium, which are all cations, and carbonates, nitrates, bicarbonates, chlorides and sulfates, which are all anions. Cations are positively charged ions and anions are negatively charged ions.

These minerals can originate from a number of sources, both natural and as a result of human activities. Mineral springs contain water with high levels of dissolved solids, because the water has flowed through a region where the rocks have a high salt content. The water in the Prairie provinces tends to have high levels of dissolved solids, because of high amounts of calcium and magnesium in the ground.

These minerals can also come from human activities. Agricultural and urban runoff can carry excess minerals into water sources, as can wastewater discharges, industrial wastewater and salt that is used to de-ice roads.

Alone, a high concentration of dissolved solids is usually not a health hazard. In fact, many people buy mineral water, which has naturally elevated levels of dissolved solids. The United States Environmental Protection Agency (EPA), which is responsible for drinking water regulations in the United States, includes TDS as a secondary standard, meaning that it is a voluntary guideline in the United States. While the United States set legal standards for many harmful substances, TDS, along with other contaminants that cause aesthetic, cosmetic and technical effects, has only a guideline.

Most people think of TDS as being an aesthetic factor. In a study by the World Health Organization, a panel of tasters came to the following conclusions about the preferable level of TDS in water:

Level of TDS (milligrams per litre)	**Rating**
Less than 300	Excellent
300 - 600	Good
600 - 900	Fair
900 - 1,200	Poor
Above 1,200	Unacceptable

Taste of Water with Different TDS Concentrations;
http://www.who.int/water_sanitation_health/dwq/chemicals/tds.pdf

However, a very low concentration of TDS has been found to give water a flat taste, which is undesirable to many people.

Increased concentrations of dissolved solids can also have technical effects. Dissolved solids can produce hard water, which leaves deposits and films on fixtures, and on the insides of hot water pipes and boilers. Soaps and detergents do not produce as much lather with hard water as with soft water. As well, high amounts of dissolved solids can stain household fixtures, corrode pipes, and have a metallic taste. Hard water causes water filters to wear out sooner, because of the amount of minerals in the water.

However, while TDS itself may be only an aesthetic and technical factor, a high concentration of TDS is an indicator that harmful contaminants, such as iron, manganese, sulfate, bromide and arsenic, can also be present in the water. This is especially true when the excessive dissolved solids are added to the water as human pollution, through runoff and wastewater discharges.

Name:____ Date:______________________

TDS Reading Questions [6]

1. What are TDS (Total Dissolved Solids)?

2. Explain how TDS enter a water source.

3. Why do TDS pose a problem?

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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. Why is the purpose of the dessicator in Step 4a so important?

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 determine the TDS of a body of water that you are going to place your SeaGlide in. Describe how this may impact your SeaGlide.

Name:______________Answer Key________________________________ Date:__________________________

TDS Reading Questions [6]

1. What are TDS (Total Dissolved Solids)?

   TDS is the concentration of small, inorganic compounds/salts that are dissolved and present in a solution of water.

2. Explain how TDS enter a water source.

   TDS enter a water source either naturally via minerals in soil or rocks, or through human activities such as farming or urban runoff.

3. Why do TDS pose a problem?

   TDS can cause mineral buildup, clogging pipes, or health problems from increased mineral amounts in the body.

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 is to determine the concentration of dissolved solids (organic and inorganic) in a given water sample.

2. Why is the purpose of the dessicator in Step 4a so important?

   The purpose of the dessicator in Step 4a is to ensure that no water is reabsorbed in the sample. If water is reabsorbed by the sample, then this could decrease the concentration of TBS in a solution.

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

   Answers will vary based on student response.
   Expectation: One source of error in this experiment is the disuse of the dessicator. This caused water to be reabsorbed into the sample and thus affect the concentration.

4. Suppose you determine the TDS of a body of water that you are going to place your SeaGlide in. Describe how this may impact your SeaGlide.

   TDS have the potential to cause a mineral buildup, inhibiting key components of the SeaGlider from functioning properly.

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 Total Dissolved Solids lesson plan. The reference aided in the completion of the Explore. Test 4 in the book, the Total Solids test, was excepted for the students. Pages 4-1 through 4-4 contain information, required material, procedure and a data collection sheet for the students. The following two pages 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] Hancock, N. (2016, December 07). TDS and pH. Retrieved April, 2019, from https://www.safewater.org/fact-sheets-1/2017/1/23/tds-and-ph

This reference was used for excerption purposes. This reference was directly excerpted to provide a reading as an engagement for the Total Dissolved Solids lesson. The analysis questions to accompany the reading were developed by using this resource as well.