Physical Science Experimental Design (7EDS)

"Descending to the Depths"

Marine Snow Challenge

Module Description	Students engage as environmental engineers to develop a procedure that determines how to the oil from the Deepwater Horizon spill landed at the bottom of the ocean. Oil combined with algae and other marine particles form "dust bunnies" of the ocean or marine snow. The falling marine snow provides nutrition for deep water organisms but also transports oil to the deep water corals. Therefore, it is important to be able to understand the marine snow is falling to be able to determine which coral ecosystems may have been damaged from the spill. In order to make this prediction, students will have to develop a consistent method to model how objects fall through a fluid. The students use will develop a model of this phenomenon, test their procedure, share their data, and generate histograms. The class works together to iteratively develop a procedure that controls variables and reduces error. The module covers some basic concepts of density and the factors that affect the movement of particles in fluids seeding further exploration of GSE standards later in the semester or year. *This module features the work of Dr. Annalisa Bracco and the and the ECOGIG Research Consortium in the School of Earth and Atmospheric Sciences.*	
Related Georgia Performance Standards	*S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter.* *c. Plan and carry out investigations to compare and contrast chemical (i.e., reactivity, combustibility) and physical (i.e., density, melting point, boiling point) properties of matter*	
Module Timeline	**50-minute class periods:** 5 days Day 1: Section 1, 2 Day 2: Section 2 Day 3: Section 2, 3 Day 4: Section 4 Day 5: Section 4	**90 minute blocks:** 3 days Day 1: Sections 1, 2 Day 2: Section 2, 3 Day 3: Section 4
Documents Included in the Download	**Student Materials Folder** • Student Edition *(recommended to be printed double sided)* • Student Worksheet Packet *(recommended to be printed single sided)* • Histogram Handout *(recommended to be printed single sided)* **Teacher Materials Folder** • Materials List • Annotated Teacher's Edition • Teacher Preparation Guide • Videos	

5E Stage	Student Activities How will students engage actively in the three dimensions throughout the lesson?	Teacher Activities How will the teacher facilitate and monitor student learning throughout the lesson?
Engage How does the lesson capture student interest, activate prior knowledge, and connect to a complex question, global issue, or real world problem?	• Students make predictions if oil and water will mix and create initial explanations of their observations of the mixing of these two liquids *(1.1)* • Students watch Marine Snow Video #1 *(1.2)* • Students are introduced to challenge and why they will use a model for their investigation *(1.3)* • Students complete Predict, Observe, Explain activity by predicting whether certain objects would sink or float in water and then observe their interaction with water and write simple explanations of the interaction. *(1.4)* • Students learn more about ECOGIG research so they can connect the module content to real-life applications. *(1.2, 5.1)*	• Guide students through text to check for understanding • Set up a demonstration showing how oil and water mix and have students make predictions and initial explanations • Facilitate discussion questions about Marine Snow Video #1 • Discuss the need to using models to represent real-life situations • Conduct Predict, Observe, Explain Demonstration by placing different items (of different densities) in water and having the student write predictions, observations, and explanations of whether the objects sank or floated. • Encourage student questions the application of the module to scientific research
Explore How does the lesson allow students to develop a common base of experiences by actively investigating the phenomenon or problem?	• Students plan their investigation and write a procedure for carrying it out *(2.1,3.2)* • Students follow their procedure and record data from their trials *(2.2,4.1)* • Students share their data with the class and record all data on a histogram *(2.3,4.2)*	• Review materials available for use and model constraints with students. • Class procedure- as you guide students focus on what variables need to be controlled. • Allow 15 minutes for students to run investigations and take note of students changing their experiment in-between trials. • Record groups' data on a class histogram that is projected so students can record it..
Explain How does the lesson allow students to develop, share, critique, and revise their own explanations before connecting those to accepted scientific explanations and terminology?	• Students analyze the histogram data, comparing the distribution of data to the procedure that was followed. *(2.4,4.3)* • Students discuss the procedural differences between groups and the need for sound procedures and variable control in order to collect consistent data (*3.1,3.2)* • Students learn the concept of density and the relationship between mass and volume is what determines whether an object sinks or floats. *(4.4)* • Student revise their initial explanations for the Predict, Observe, Explain to connect those explanations to the concept of density. *(4.4)*	• Lead a discussion about the distribution of data and how individual procedures impacted the variation & why a large spread of data is evidence of unreliable data. • Provide students with examples of independent and dependent variables and how to construct a procedure to reduce variation in results • Lead a class discussion comparing the 2 histograms, how the spread has changed and if there is a need for a 3rd investigation • Guide students in revising their explanations to include the concept of density in their Predict, Observe, Explain sheet.
Elaborate How does the lesson allow students to extend their conceptual understanding of the three dimensions through opportunities to apply knowledge, skills, and abilities in new experiences?	• Students will write a lab proposal to their research team explaining their final procedure, how they controlled for error, and evidence that their procedure produced reliable data. *(4.5)*	• The lab proposal is scaffolded for students but remind them to include details of the variables they had to control and why they had to do that and the evidence that their procedure is meeting the goals of the challenge.
Evaluate How does the lesson—through both formative assessments	**Formative:** Ongoing questioning and discussion *(all sections)* *Predict, Observe, Explain Sheet (1.4)*	

embedded throughout the lesson and a summative assessment that might coincide with the elaborate phase—make visible students' thinking and their ability to use practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions?	Investigation Sheet 1 (*2.1,2.2)* Results Graph 1 and 2 *(2.3)* Investigation Sheet 2 *(4.1)* Results Graph 3 *(4.2)* **Summative:** Predict, Observe, Explain Sheet (revised explanations) (4.4) Lab Proposal *(4.5)*

	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	4.1	4.2	4.3	4.4	4.5	5.1
Engage																
Explore																
Explain																
Elaborate																
Evaluate																

Section 1 – How does Oil Get to the Bottom of the Ocean?
(*30-40 minutes)*

Students are introduced to the problems that oil spills cause in oceans and specifically the problems caused in the Gulf of Mexico by the Deepwater Horizon Spill. Through a modeling exercise, students are shown that oil floats on water to understand the initial relationship of these two fluids. Students are then introduced to the Georgia Tech Research Connection: the ECOGIG Team and a phenomenon that they found in their research: that oil is being found at the bottom of the ocean. This should be initially confounding to students as they just watched a demonstration that showed how oil floats on water. They will learn more about this phenomenon of "Marine Snow" and watch a short video to gain better understanding. Students will then be tasked with the challenge to create a model of marine snow that provides consistent and reliable results that can be communicated to the public. In order for students to have some background knowledge on how materials fall through a liquid (and to introduce the concept of density), the teacher will complete a Predict, Observe, Explain Activity with the students where they will make predictions on whether certain objects float or sink, observe the object in water, and write a simple explanation of the action they observe.

Preparation

Materials	Student Pages
○ 1000ml Graduated Cylinder ○ Oil ○ Water ○ Plastic Tub ○ Metal and Wood Cork, Legos, Ping Pong Ball, Golf Ball, Clay ○ Video #1: ECOGIG Marine Snow	*Student Sheet #1: Predict, Observe, Explain*
Prep the Day Before: Review text and video. Review the Predict, Observe, Explain Activity and pull materials out of kit. On the morning of the module, you should fill the plastic tub about half (or 2/3s) full with water and the graduated cylinder about 2/3s full with water. You can use the same water in the tub from class to class but will need to rinse the graduated cylinders between classes. You may want to also test different configurations of the LEGOs and the clay (with regard to floating and sinking) before you perform the demo in front of the class	

Planning

GPS	*S8P1. Obtain, evaluate, and communicate information about the structure and properties of matter.* *c. Plan and carry out investigations to compare and contrast chemical (i.e., reactivity, combustibility) and physical (i.e., density, melting point, boiling point) properties of matter*
NGSS	**Performance Expectations:** **MS-ETS-1**: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.* *MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.* **Disciplinary Core Idea:** *PS1.A: Structure and Properties of Matter* **Practice:** *Developing and Using Models: Develop a model to predict or describe phenomena, Analyzing and Interpreting Data* **Crosscutting Concepts:** *Systems and Models*

Key Terms and Concepts	Essential Questions	Assessment and Grading Opportunities
• Oil Spill • Deepwater Ecosystem • Model • Marine Snow • Predict, Observe, Explain	• How do scientists solve problems? • How can physical and chemical properties be used to identify matter?	• Discussion Questions: **Participation** • **Predict, Observe, Explain Student Sheet: Formative Assessment**

Section 2 – Investigate an Oil Spill *(60-90 minutes)*

*Students design and run a procedure to determine the minimum **number** of washers it will take to sink your cork and to determine the minimum **mass** of washers it will take to sink your cork. Students are introduced to the idea of model and the criteria and constraints of the challenge. They learn that the ECOGIG team uses models in their labs to investigate Marine Snow and they will be following the same process. Students will be assigned specific materials (a cork to represent the oil, washers to represent the plankton, and a paperclip to represent the glue that holds them together) to use and given a short period of time to discuss and develop a procedure for determining the least amount of washers and least mass of the washers that will sink the cork. Students will then carry out their procedure with two different sized/shaped corks. When the cork sinks (reaches the tipping point), they will record the number of washers on the paper clip, then the students will remove the washers and record the mass of these washers. They are recording both numbers to look at variation in procedures and also determine that "mass" is factor in whether an object sinks or floats. After each group records their data, they will report and record their results on class histograms (one histogram for number of washers, and one for mass of washers). The class will then analyze the histogram and data through participating in a class discussion using guiding questions in the student text.*

Preparation

Materials	Student Pages
• 1000ml Graduated Cylinder (you can use the 1000ml beaker instead if easier) • 1000ml Beaker • Large Paper Clips (2 per group) • Different Sized Washers (a handful per group) • Mixed shapes/sizes corks (2 different corks per group) • Mass Balance • Paper Towels You can use the beakers, graduated cylinders, washers, and mass balances again for each class period. You will need new paper clips each class period and may need new corks depending if they are damaged from the prior class.	• Marine Snow Investigation Sheet • Marine Snow Results Graph #1 • Marine Snow Results Graph #2
Prep the Day Before: Sort materials by group; Download class histograms on computer for projection; Perform the investigation as practice (if needed). Create set-ups for each group to bring back to their tables (1 cylinder, 1 beaker, paper towels, washers, 2 corks, mass balance, and 2 paper clips). Think about how you want students to get water. You may want to pre-fill the graduated cylinders or beakers with water the morning of the investigation.	

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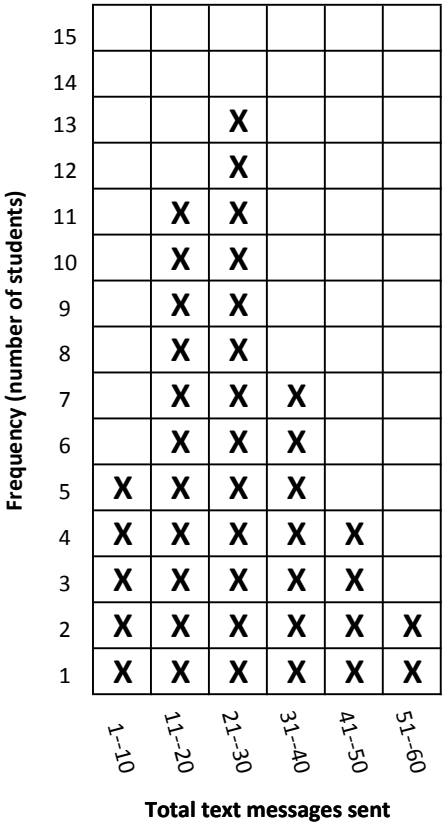
Key Terms and Concepts	Essential Questions	Assessment and Grading Opportunities
• Model • Procedure • Graduated cylinder • Histogram • Mass	• How can consistent procedures be developed?	• Procedure and Data Collection: **Formative** • Student histograms: **Formative** • Class Discussion Questions: **Participation**

COMMUNICATE YOUR RESULTS- Histogram Tutorials

Tutorial: Graphing a Histogram

A histogram is a type of graph that shows the **frequency** (number of times) that a specific outcome occurred.

For instance, suppose you wanted to see the number of text messages that the students in your class sent last week. You could count the number of students that the sent 0-10 messages, the number of students that sent 11-20 messages, etc. If four students sent 0-10 messages, then the frequency of 0-10 messages is four. A hypothetical graph of these data is on the right. *Text messages sent* is on the X-axis and *Frequency (number of students)* is on the Y-axis. How many students sent between 31-40 text messages?



Section 3 – Redesign Your Investigation *(40 minutes)*

Students identify factors in their procedures that led to inconsistent results, and then design a more precise class procedure to control these factors. They design a class procedure that is detailed and replicable, controlling each factor they identified. Students reflect on their new procedure by comparing it to the original procedure and they see how their ability to plan an investigation has improved. In Part 1, students will learn about trustworthy procedures and the process of developing a standardized procedure. Students will learn key terms such as error, independent variable, dependent variable, and variation. Students will review the challenge and develop a list with teacher facilitation on procedural differences between groups. As a class, students will develop a standardized procedure and record on a second Marine Snow Challenge investigation sheet. In Part 2, students will review and answer discussion questions based on their new procedures.

Preparation

Materials	Student Pages
• Copy of Histograms from Section 2 • Marine Snow Investigation Sheet from Section 2	• Marine Snow Investigation Sheet #2
Prep the Day Before: Review the Class Histograms from Section 2. Develop categories for designing the new procedure. Remember you will only be measuring mass for this new procedure. You will have all of your students use uniform corks. You may want to display these corks as they write the new procedures.	

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Key Terms and Concepts	Essential Questions	Assessment and Grading Opportunities
• Standardized Procedures • Histogram • Variation • Independent Variable • Dependent Variable • Error • Data • Consistency	• How can consistent procedures be developed?	• Marine Snow Investigation Sheet 2 (Revised Procedure): **Formative** • Class Discussion Questions: **Participation**

Section 4: Marine Snow Challenge with a New Procedure (60 minutes)

Students run their revised Marine Snow Challenge procedure and collect data, which they will share on a class histogram. Comparing the spread of data on the histogram to the initial histogram from Section 2 will allow the class to evaluate their new procedure and determine if the class results are reliable. Students will be using uniform cork and only measuring the mass for this procedure. They will compare their results with the new class procedure and determine if the data is clustered on the histogram. Students can determine that they have evidence to show that they have developed a precise and standard procedure that can accurately model how the marine snow falls through the water. Students should understand that well designed procedures control variables to reduce error. In addition to understanding of consistent procedures, students are provided an Add to your Understanding on Density and the factors that affect whether an object will sink or float in water. Students should take this new knowledge and edit their explanations on their Predict, Observe, Explain sheet from Section 1. The final assignment of this section and their summative assessment for this module is for students to write a lab proposal that includes a copy of their final procedure, evidence that their procedure is reliable, and identified sources of error that could occur in their investigation.

Preparation

Materials	Student Pages
• 1000ml Graduated Cylinder (you can use the 1000ml beaker instead if easier) • 1000ml Beaker • Large Paper Clips (2 per group) • Different Sized Washers (a handful per group) • Uniform cork (1 or 2 per group) • Mass Balance • Paper Towels	• Marine Snow Investigation Sheet (2) • Marine Snow Results Chart (Histogram) • Marine Snow Lab Proposal
Prep the Day Before: Sort materials by group; Download blank class histogram along with class histogram from Section 2 on computer for projection. Fill up beakers/graduated cylinders with water prior to the start of class. You will need to locate the bag of uniform corks as each student group gets the same cork for this investigation. You can give each group 1 cork…if for some reason, they damage the cork in the first trial, give them another cork for the second trial.	

Planning

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Key Terms and Concepts	Essential Questions	Assessment and Grading Opportunities
• Standardized Procedures • Histogram • Variation • Consistency • Variable • Controls (controlled variable) • Density • Mass • Volume	• How can consistent procedures be developed? • How is density determined? • How does density affect floating and sinking in water?	• Marine Investigation Sheet: Formative • Marine Snow Results Graph: Formative • Marine Snow Lab Proposal : Summative

Section 5 *Research Connections: ECOGIG Science (15 minutes)*

In Section 5, students return to the initial challenge and discuss how the ECOGIG team is conducting reliable scientific investigations to gather data about the effects of oil on the deep sea ecosystems. The text describes how the ECOGIG team determined that the oil on the seafloor was the same oil that was released in the Deepwater Horizon Spill and shows students some of the tools the team used to make this determination. The students also learn about the specific work of Dr. Annalisa Bracco and she uses models to predict the movement of oil in the ocean to predict the impact on the deep sea ecosystems across the Gulf of Mexico. Students will hopefully understand that both modeling and developing consistent and reliable procedures are important in scientific research.

Preparation

Materials	Student Pages
• Optional: Visiting ECOGIG Site to watch additional videos: https://ecogig.org/	
Prep the Day Before: Review text and go to ECOGIG.ORG to review any possible resources that would engage students in the research connections the module.	

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Key Terms and Concepts	Essential Questions	Assessment and Grading Opportunities
• Procedures • Models • Movement of oil in water • Data • Predictions	• How can consistent procedures be developed? • How does density affect floating and sinking in water? • How are models important in scientific research?	• Class Discussion: Formative