SeaGlide_TEAM	Scientific Method	Lesson #1 (60 minutes)

Description:

Students will learn about the scientific method by becoming a Horticulturist. As a Horticulturist, students will investigate whether soap can affect flower growth by experimenting based on a complaint made by their Lead Scientist. They will set up their experiments using given observations, formulate hypotheses and use a virtual laboratory simulator in order to test their hypotheses. Lastly, they will record their results, analyze their findings, and communicate them to their City's Parks Department.

Students will be able to:

- Define the scientific method and its steps
- Use the scientific method to perform an experiment
- Identify the difference between a control group and an experimental group
- Use the scientific method to create an experiment

Students will understand:

The scientific method is a process used to conduct experiments in order to explore observations and answer questions. Even though the scientific method is presented as a series of steps, new information or ideas may cause a scientist to back up and repeat steps at any point during the process. A process - like the scientific method - that involves steps that can be repeated is called an iterative process. By using various online resources, students will use the steps of the scientific method to perform and create experiments.

Key Definitions & Concepts: [1]

- **Control Group**: the group in an experiment or study that does not receive the variable being tested to check or verify evidence for the experiment.
- **Experimental Group**: the group in an experiment or study that receives the variable being tested to check or verify evidence for the experiment.
- **Hypothesis**: a testable scientific assumption made in order to draw out and test its consequences.
- **Iterative Process**: a process that utilizes the repetition of a sequence of procedures used for calculating a desired result.
- **Scientific Method**: principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses.
- **Variable**: a factor, trait, or condition in a scientific experiment that can exist in differing amount or types and may be subject to change.

Standards: [Copied from: 2]

RST.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Background Information

Prior Knowledge:

- Logical thinking
- Methodical thinking
- Organizational techniques
- Basic knowledge of the of taking minimal measurements

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 • Planning and Carrying Out Investigations • Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information	• Defining and Delimiting Engineering Problems • Developing Possible Solutions • Optimizing the Design Solution	• Patterns • Cause and Effect • Systems and System Models • Stability and Change • Influence of Science, Engineering, and Technology on Society and the Natural World

Possible Preconceptions/Misconceptions:

Since this lesson is designed to be an introductory lesson, instructors should not expect students to experience preconceptions. The lesson is designed in a way to help students thoroughly understand any associated concepts with the scientific method and the conduction of experiments. There should be no outstanding misconceptions.

Lesson Plan - 5E(+) Model

Engage: [6]

The instructor will hand out *The Scientific Method* half sheets that should be individually completed while watching a short video (Scientific Method Video). This video teaches the steps of the scientific method using modern, everyday situations students may face as an example of how the method is used. The purpose of this video is to introduce students to the scientific method and to engage them in a brief class discussion of what the scientific method is and how it is useful to us. The students will be engaged in a class discussion after completing the half sheet to review their answers and address any misconceptions as necessary. This section should take about 10 minutes to complete.

Explore:

Part I: Introduction

The instructor will propose a question along the lines of “What are some of the different ways the scientific method is used by scientific professionals?” This will encourage students to think and to discuss real life scenarios in which the scientific method is applicable as a class. The instructor should use this question to bridge the gap between the video on the scientific method and the upcoming lab activity. The purpose of this question is to have students come up with their own ideas for where they see the scientific method in their daily lives. The goal of this section is to have students to collaborate and make a connection to the real world which will prepare them for the next activity. This section should take no more than 5 minutes to complete.

Part II: *Benchmark Lesson*: Implementing the Scientific Method [7]

The instructor will distribute the worksheet *Virtual Lab Activity*. Students will work in groups of 4 and set up an experiment using the scientific method to test whether dish soap affects plant growth. They will test their predictions using a plant growth simulator (Virtual Lab: Plant Experiment). Students will apply learned key concepts from the engage activity and discussion to further investigate how to implement the scientific method its individual steps. Students will work in their groups to write down their observations, identify the question, and formulate a hypothesis. Each student within a group will be responsible for running 4 out of the 16 tests and record their answer in the corresponding table. Students will then work in their groups to answer the analysis questions. The purpose of this experiment is to have students run through an experiment using the scientific method. Students should be able to identify the steps of the scientific method, formulate a testable hypothesis, and know the importance of the various parts that make up an experiment. This section should take about 30 minutes to complete.

Part III: *Investigation Lesson*: Predictions Based on Variables

At the end of the *Virtual Lab Activity* worksheet, students will be challenged with a bonus question. They will be asked to use what they learned in the previous section of the worksheet to predict how their results would change if a new variable was introduced into the experiment. Students should be able to extend their learning to theorize the changes that would occur. The goal here is to have students see that the scientific method is an iterative process. This section should take about 5 minutes to complete.

Explain:

Throughout the exploration, the students will engage in discussions that inquire their understanding and knowledge of the information at-hand. Teachers will be informally asking students to explain the topics and relevant connections throughout the entirety of this lesson. The worksheet will ask questions that will require students to engage in high-level thinking, allowing them to verbalize and self-assess their understanding of the material.

Elaborate:

The entirety of this lesson revolves around content that forms the base of all scientific experiments. The students would be primed to understanding the importance of following an iterative process when conducting an experiment and what defines the steps of the scientific method from the engagement

activity. This allows the students to then be challenged to identify the steps of the scientific method when conducting an experiment and when observing an experiment that has been conducted. The exit ticket is designed to lead to student understanding that the scientific method is incorporated into all experiments.

Evaluate:
This lesson is designed to have both informal and formal evaluations throughout its entirety. The informal evaluations occur throughout the exploration because of the leading and open-ended questions and class discussions. This allows instructors to gauge surface-level student understanding. This is done through listening to student conversations and observing how students work through the activity worksheets. During this time, the instructor has the ability to hear and address misconceptions or misunderstandings. The formal evaluation of this lesson is the virtual lab activity worksheet and exit ticket. The virtual lab activity prompts the students to interpret data results and provided reasoning behind their explanations. The exit ticket is a 5 minute, individual activity which has the student read through an experiment and identify the different parts of the scientific method using the given prompt.

Enrich:
This lesson could be differentiated by introducing students to geometric concepts and instructing them to prove geometric concepts and theorems via proof tables. Since the scientific method is an iterative process, students should understand logical and methodical thinking. Thus, they are primed to learning and applying mathematical methodology to proofing techniques. Mathematical proofs require the same iterative process techniques to construct valid proofs. Proof tables in geometry are usually the first step to learning how to prove mathematical theories.

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

Name: _____ Date: _____

The Scientific Method [6]

1. What are the six steps of the scientific method mentioned in the video?
    a. Step 1:
    b. Step 2:
    c. Step 3:
    d. Step 4:
    e. Step 5:
    f. Step 6:
2. What senses are used to make observations?

3. Explain the difference between an experimental group and a control group.

Name: _____ Date: _____

The Scientific Method [6]

1. What are the six steps of the scientific method mentioned in the video?
    ○ Step 1:
    ○ Step 2:
    ○ Step 3:
    ○ Step 4:
    ○ Step 5:
    ○ Step 6:
2. What senses are used to make observations?

3. Explain the difference between an experimental group and a control group.

Name: _____ Date: _____

Virtual Lab Activity [7]

Introduction: The scientific method is a process used to conduct experiments in order to explore observations and answer questions. Even though the scientific method is presented as a series of steps, new information or ideas may cause a scientist to back up and repeat steps at any point during the process. A process - like the scientific method - that involves steps that can be repeated is called an iterative process. Today, you will become a Horticulturist and you have been assigned a project to investigate a complaint made by your Lead Horticulturist to find out whether soap can affect flower growth. You will use the scientific method to set up an experiment using the given observations, formulate a hypothesis and use the virtual laboratory simulator to test your hypothesis. Lastly, you will record your results in order to analyze and communicate them to your City's Parks Department.

Directions: Using the scientific method, make observations from the description on the virtual lab simulation website. Identify the question asked by your Lead Scientist and use that to formulate a hypothesis. Use the simulator to test your hypothesis, make sure to record your results in the table below. Use the analysis questions to help analyze your results and communicate your findings.

Scientific Method:

1. Make Observations
2. Ask a Question
3. Form a Hypothesis
4. Test the Hypothesis
5. Analyze the Results
6. Communicate the Results

Make Observations: Make observations based on the given description.

Ask a question: Identify the question asked in the description.

Form a hypothesis: Formulate a testable explanation for the question asked.

Test your Hypothesis: Data Table

Flower Type	Pot Material	Soil Type	Detergent or No Detergent?	Plant Height (cm)
Marigold	Plastic	Potting Soil	No Detergent	
			With Detergent	
		Potting Mix	No Detergent	
			With Detergent	
	Terracotta	Potting Soil	No Detergent	
			With Detergent	
		Potting Mix	No Detergent	
			With Detergent	
Chamomile	Plastic	Potting Soil	No Detergent	
			With Detergent	
		Potting Mix	No Detergent	
			With Detergent	
	Terracotta	Potting Soil	No Detergent	
			With Detergent	
		Potting Mix	No Detergent	
			With Detergent	

Average Plant Height (cm)	
Control Group	Experimental Group

Analyze the Results: Analysis Questions

1. Describe your control group and experimental group. Identify what variables were used in each.

2. Explain why a control group is needed to test your hypothesis.

3. Explain why an average is needed to compare the results.

Communicate your Results: Form and discuss a conclusion based on your findings.

Bonus! Predict and explain how your results would change if an environmentally friendly car wash detergent was an added variable. Defend your answers.

Name: _____ Date: _____

Exit Ticket: Identifying Experimental Design

Directions: Using the prompt below, identify the various parts of the experiment using the scientific method.

Prompt: Luna was told that a certain anti-itching powder was the new best powder on the market. It claims to cause 50% shorter lasting itches. Interested in this product, she buys the anti-itching powder and compares it to her usual product. One test subject (A) is sprinkled with the original anti-itching powder, and another test subject (B) was sprinkled with the Experimental anti-itching powder. Subject A reported having itches for 30 minutes. Subject B reported having itches for 45 minutes.

Identify the…

1. **Observations**: What are some observations that Luna should record?

2. **Question**: What should Luna's question be?

3. **Hypothesis**: What should Luna's hypothesis be?

4. **Data Gathered**: What variables were used? Identify which variable is the control and which is the experimental.

   Control Group Experimental Group

5. **Results**: What were results formed from the experiment?

6. **Conclusion**: What should Luna's conclusion be?

Name: _____ANSWER KEY_____ Date: _____

The Scientific Method [6]

1. What are the six steps of the scientific method mentioned in the video?
    - Step 1: **observation**
    - Step 2: **research**
    - Step 3: **hypothesis**
    - Step 4: **experiment**
    - Step 5: **conclusion**
    - Step 6: **share results**

2. What senses are used to make observations?

   Smell, sight, taste, touch and hearing / all 5 senses

3. Explain the difference between an experimental group and a control group.

   An experimental group has one independent variable altered. A control group remains the same and has all other groups compared to it.

Name: _____ANSWER KEY_____ Date: _____

Virtual Lab Activity [7]

Introduction: The scientific method is a process used to conduct experiments in order to explore observations and answer questions. Even though the scientific method is presented as a series of steps, new information or ideas may cause a scientist to back up and repeat steps at any point during the process. A process - like the scientific method - that involves steps that can be repeated is called an iterative process. Today, you will become a Horticulturist and you have been assignment a project to investigate a complaint made by your Lead Horticulturist to find out whether soap can affect flower growth. You will use the scientific method to set up an experiment using the given observations. Formulate a hypothesis and use the virtual laboratory simulator to test your hypothesis. Lastly, you will record you results in order to analyze and communicate them to your City's Parks Department.

Directions: Using the scientific method, make observations from the description on the virtual lab simulation website. Identify the question asked by your Lead Scientist and use that to formulate a hypothesis. Use the simulator to test your hypothesis, make sure to record your results in the table below. Use the analysis questions to help analyze your results and communicate your findings.

Scientific Method:

1. Make Observations
2. Ask a Question
3. Form a Hypothesis
4. Test the Hypothesis
5. Analyze the Results
6. Communicate the Results

Make Observations: Make observations based on the given description.

Soap runs into the steam and contaminates the water

The water beds are located near the stream causing them to soak up the water

Ask a question: Identify the question asked in the description.

Does soap affect flower growth?

Form a hypothesis: Formulate a testable explanation for the question asked.

Soap does affect flower growth?

Soap does not affect flower growth?

Test your Hypothesis: Data Table

Flower Type	Pot Material	Soil Type	Detergent or No Detergent?	Plant Height (cm)
Marigold	Plastic	Potting Soil	No Detergent	5.25
			With Detergent	2.50
		Potting Mix	No Detergent	5.50
			With Detergent	2.50
	Terracotta	Potting Soil	No Detergent	5.25
			With Detergent	3.25
		Potting Mix	No Detergent	5.60
			With Detergent	4.00
Chamomile	Plastic	Potting Soil	No Detergent	4.50
			With Detergent	2.60
		Potting Mix	No Detergent	4.40
			With Detergent	2.75
	Terracotta	Potting Soil	No Detergent	4.25
			With Detergent	3.25
		Potting Mix	No Detergent	4.75
			With Detergent	3.00

Average Plant Height (cm)	
Control Group	Experimental Group
4.93	2.98

Analyze the Results: Analysis Questions

1. Describe your control group and experimental group identifying what variables were used in each.

   The control group was the flowers that did not have detergent added to them, and the experimental group was the flowers that did have detergent added to them.

2. Explain why a control group is needed to test your hypothesis?

   A control group is needed to test the hypothesis because the it serves as the baseline and is used to be compared to the experimental group.

3. Explain why an average is needed to compare the results?

   An average is needed to compare the results because there are several different variables used when planting flowers. Since a few different variables were tested, the average is used to create a more generalized result that could be expected across planted flowers with several variables. An average also allows for a more accurate result when an experiment is conducted several times.

Communicate your Results: Form and discuss a conclusion based on your findings.

Based on the experimental results, we have concluded that soap does affect plant growth. Our results show that, when soap water was used, the flowers grew an average of 2.98 cm tall. However, when water without soap was used, the flowers grew an average of 4.98 cm tall. Our data supports our hypothesis.

Bonus! Predict and explain how your results would change if an environmentally friendly car wash detergent was an added variable. Defend your answers.

The results would change if an environmentally friendly car wash detergent was added by minimizing the effect on plant growth. However, the detergent would still affect plant growth. Our results would show that the plants grew taller without detergent added and smaller with detergent added. We made this prediction because plants thrive on water alone to perform photosynthesis and because adding impurities that change the chemical composition of water would affect plant growth.

Name: _____ANSWER KEY_____ Date: _____

Exit Ticket: Identifying Experimental Design

Directions: Using the prompt below, identify the various parts of the experiment using the scientific method.

Prompt: Luna was told that a certain anti-itching powder was the new best powder on the market. It claims to cause 50% shorter lasting itches. Interested in this product, she buys the anti-itching powder and compares it to her usual product. One test subject (A) is sprinkled with the original anti-itching powder, and another test subject (B) was sprinkled with the Experimental anti-itching powder. Subject A reported having itches for 30 minutes. Subject B reported having itches for 45 minutes.

Identify the…

1. **Observations**: What are some observations that Luna should record?
   There is a new anti-itch powder that claims to be the best powder on the market
   Claims to cause 50% shorter lasting itches
   The old anti-itch powder stops the itches in 30 minutes.

2. **Question**: What should Luna's question be?
   Does the new anti-itch powder relieve itches faster than my old anti-itch powder?

3. **Hypothesis**: What should Luna's hypothesis be?
   The new anti-itch powder will relieve itches in 15 minutes.

4. **Data Gathered**: What variables were used? Identify which variable is the control and which is the experimental.

Control Group	Experimental Group
Test subject A, i.e. the subject sprinkled with the original anti-itching powder	Test subject B, i.e. the subject sprinkled with the experimental anti-itching powder

5. **Results**: What were results formed from the experiment?
   Subject A reported having itches for 30 minutes
   Subject B reported having itches for 45 minutes

6. **Conclusion**: What should Luna's conclusion be?
   Since the results reported that the old anti-itch powder relieves itches in 30 minutes and the new anti-itching powder relieves itching in 45 minutes, we can conclude that the new anti-itch powder does not relieve itches 50% faster than the old itching powder.

Annotated Bibliography

[1] Dictionary by Merriam-Webster: America's most-trusted online dictionary. (n.d.). Retrieved from https://www.merriam-webster.com/

This website was used for adaptation within the Scientific Method lesson plan as part of the Engineering Design Principles module. This reference aided in the completion of providing definitions for the key concepts and definitions sections and for associated worksheets. The key concepts and definitions were adapted based on the grade and activities at-hand.

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

This website was used in each lesson in the Engineering Design Principles 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 from https://ngss.nsta.org/PracticesFull.aspx

This website used in every lesson in the Engineering Design Principles 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 Engineering Design Principles 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 Engineering Design Principles module to selecting appropriate crosscutting concepts set forth by the NSTA that apply to each science lesson.

[6] The scientific method. (n.d.). Retrieved from https://www.youtube.com/watch?v=SMGRe824kak

This video on Youtube is used as an engagement in the Scientific Method lesson plan as part of the Engineering Design Principles module. Questions were developed based on this video for students to answer in the engagement and the exploration portions of the lesson.

[7]Using the Scientific Method. (n.d.). Retrieved from https://www.biologycorner.com/worksheets/scientific_method_plant_exp.html

This website is an online tool used within the Scientific Method lesson plan as part of the Engineering Design Principles module for students to learn about the Scientific Method and how it is used. This reference aided in the completion of analysis questioning through both adaptation and excerption.