5E Integrated STEM Lesson Plan – Template

This template serves as a guide for developing a lesson that integrates across subject areas and includes the components of a quality STEM lesson. Please use it to support your work and engage in discussions with your instructors and peers when you have questions.

Lesson Title: Why does it rain water on Earth, but not on the other planets?

Author: Lori Fine

Topic: Water Cycle, Sun as the energy source, the role of gravity and our atmosphere

Targeted Grade Level: 6th - 8th grades (Earth Science)

Time Needed: *3-4 weeks*

Subject Integration: Science, Math, and ELA

Justification:

This unit originates from the science standard to develop a model explaining the movement of water in the water cycle. While working on their investigations, students will also apply various mathematical concepts in context, such as setting up and using a data table, applying knowledge of measurement, and calculation of temperature differences and rates of change. As part of the Elaboration phase, ELA standards will be incorporated to deepen students' understanding as they analyze data to construct an evidence-based argument about the relationship between different factors affect the functioning of the water cycle. The integration of math and ELA standards are seamless and encourage students to use their knowledge in context as a means for deepening their scientific understanding as well as the application of the mathematical and writing procedures.

Endeavor STEM Teaching Certificate Project
Lori Fine
April 26, 2021

Standards:

NGSS Performance Expectations

MS-ESS2-4: Cycling of Water Through Earth's Systems

Develop a model to describe the cycling of water through earth's systems driven by energy from the sun and the force of gravity. (Energy and Matter)

Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. x Develop a model to describe unobservable mechanisms	ESS2.C: The Roles of Water in Earth's Surface Processes • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity	Energy and Matter x Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

Common Core State Standards:

Math:

CCSS.MATH.CONTENT.6.NS.C.5: Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.

CCSS.MATH.CONTENT.6.RP.A.2: Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship.

CCSS.MATH.CONTENT.6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

ELA:

CCSS.ELA-LITERACY.WHST.6-8.1.A
Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.

CCSS.ELA-LITERACY.WHST.6-8.1.B
Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

CCSS.ELA-LITERACY.WHST.6-8.1.E
Provide a concluding statement or section that follows from and supports the argument presented.

Measurable Student Learning Objectives:

Students will be able to design a model that shows the transfer of energy that occurs as water changes states throughout its movement in the water cycle.

Students will be able to prove how water continually cycles among land, ocean, and atmosphere due to the presence of sunlight and gravity.

Students will synthesize that due to Earth's atmosphere, distance from the sun, and gravity all contribute to the cycling of water on this planet versus the conditions that are present on our neighboring planets.

Students will synthesize that due to the cycling of water on we must care for this precious resource and keep it free of contamination.

Nature of STEM: This storyline clearly addresses the nature of Science in that it creates the opportunity for students to think and do as scientists would. We begin by observing a phenomenon in the natural world. This naturally leads to pursuing students' questions regarding different aspects of the phenomenon. During this phase, students are empowered to establish their own line of investigation and or research to gather data to help them clarify understanding. Students begin the unit by forming an initial model that will get modified and improved over time as more evidence becomes clear. This aligns with the Nature of Science, in that our human scientific understanding is in an evolving state, and can change as more evidence is revealed. Through the close analysis of data, students will modify and polish their models.

Engaging Context/Phenomena:

Time Lapse of clouds forming. It takes a familiar concept, rain, and zooms in to allow students to make unique observations. This video was chosen because it provides students many opportunities to make observations, and generate wonderings about different aspects of the water cycle. The images are stunning and the music is engaging. This unit will also be conducted during Nicaragua's rainy season. This will also provide students with a real life connection as they will be observing different weather events throughout the unit.

Data Integration:

In the exploration phase of the lesson, student will design their own investigations and collect data accordingly. Students will analyze and interpret their data to draw conclusions and add to our collective understanding.

During the Elaboration phase, students will extend their understanding of the water cycle by taking a closer look at the role of the ocean in this process. They will examine different data sets from My NASA Data to identify and infer

relationships among key science variables that include sea surface salinity (SS), air temperature at the ocean surface (AT), sea surface temperature (ST), evaporation (EV), precipitation (PT), and evaporation minus precipitation (EP).

Differentiation of Instruction: Several strategies that will be implemented to reach all learners are the use of graphic organizers to scaffold the learning and help students stay organized. Also, a Driving Question Board and Word Wall will be used to collect student thinking and academic vocabulary. Discussion stems will be provided for students' use when discussing ideas and sharing evidence, and the teacher will explicitly teach how to use scientific argumentation stems appropriately. All of the above strategies are used to help both ELLs and students with Learning disabilities participate fully.

Real-life Connection: In Nicaragua, we only have two seasons: rainy and dry. This water cycle unit fits the best during the rainy season when we have ample opportunities to observe weather patterns, thunderstorms and evaporation. It works as a strategic transition from an outer space unit, due to the focus of rain on Earth versus other planet; to a unit on weather. Due to our powerful rainy season, students will have regular connections of observations of different aspects of the water cycle in their daily lives.

Possible Misconceptions:

- The water cycle is only composed of the process of evaporation of water from the earth to the atmosphere and return to the earth from the atmosphere by condensing.

- The water cycle only includes freezing and melting processes of water
- Water only evaporates from seas and oceans.
- Water cycle only includes rain and snow, rain falls only when clouds evaporate.
- Many students struggle to differentiate between heat and temperature, the notion that transfer of heat will always result in a temperature rise if there is no phase change (gas->liquid, solid->liquid, etc.), and a misunderstanding of the concept of latent heat.
- Oceans have the same salinity everywhere.
- Oceans get their salinity from table salt instead of understanding that ocean water's "salt" is made of dissolved minerals from surface runoff (excess water from rain, snow or other sources that must flow over land).

Lesson Procedure:

5E Model	5E Objectives
Engage *Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know.*	**Procedure: Driving Questions: Why does it rain water on Earth, but not on the other planets? Watch this time lapse video of clouds forming.** We will watch the video as a class several times without discussing it out loud. Individually, students will record in their science journal their observations of what is happening, and questions they have. Then students will share their observations and wonderings with their table group. Each table group will identify the four most interesting, or pressing questions they would like to add to our class Driving Question Board. The teacher will prompt students to frame their observations as patterns, cause/effect, or system interactions. Once questions have been collected in a public place, students will begin working on an individual model to explain what they think is happening. They will use this graphic organizer from the Wonder of Science to capture their thinking of the transfer of energy. Then students will share their initial model with their elbow partner and add or change any details they like. Next, partners will share their model with their table group. Each table group will come to a consensus before sharing their group model with the class. The teacher will facilitate the discussion among the student groups, being careful not to "take over" the learning, and will navigate disagreement skillfully as an opportunity for the class to investigate different perspectives further. More questions will be added to the class Driving Question Board as groups identify information that is needed in order to have a clear explanation. **Modifications:** The use of a Driving Question Board and Word Wall to collect student thinking and provide language cues for students when discussing scientific concepts. Also, students will be given think time to process their ideas, and scaffolded opportunities to share their ideas with a partner and group before being asked to share with the whole class. **Standards Addressed**

	MS-ESS2-4: Cycling of Water Through Earth's Systems - Develop a model to describe the cycling of water through earth's systems driven by energy from the sun and the force of gravity. (Energy and Matter) **Formative/Summative Assessments** Teacher will make anecdotal observations gleaned from class discussion, as well as initial models to surface some common misconceptions, and adapt instruction accordingly. The teacher will also use information from the DQB to prepare materials that will likely be needed for the exploration phase of the unit. As well as utilize each student's intial model as a record of their prior knowledge and current understanding. **Resources** Phenomenon Video Science Journal Graphic Organizer for Initial Model
Explore *Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.*	**Procedure: Reflect on our initial models and the class Driving Question Board to select a question to investigate.** Students will review their work from the previous lesson to determine one aspect of the phenomenon that they wish to investigate further and build on our collective understanding. Some students may wonder why rain is fresh water if most evaporation occurs over the ocean. Others may want to test the difference in what happens with in a terrarium with an open jar and a closed jar. Others may wish to test the temperature at which water evaporates and/or condenses, etc. Each group will select their question of choice from the DQB, and set up an investigation to test the variables. This process can last several days to a week depending on the complexity of the investigations. At this phase the teacher is careful not to take over the thinking for the students as he/she facilitates the group investigations. The teacher will provide groups with a graphic organizer to help them determine their variables, controls, and procedure. Students are leading their investigations, gathering and recording data, and ultimately they will interpret their data to draw conclusions.

	Teams will share their findings with the rest of the class. The teacher will facilitate the data collection by providing mini lessons on the different mathematical concepts being applied during this time. **Modifications** The use of graphic organizers will scaffold student inquiry and help guide their thinking. The use of the Word Wall and DQB are ongoing tools that will provide language cues for students when discussing scientific concepts. Additionally, the teacher will use the guided release approach of modeling, in order to allow for students success in the application of the different data collection and analysis tools. **Standards Addressed** MS-ESS2-4: Cycling of Water Through Earth's Systems - Develop a model to describe the cycling of water through earth's systems driven by energy from the sun and the force of gravity. (Energy and Matter) CCSS.MATH.CONTENT.6.NS.C.5: Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. CCSS.MATH.CONTENT.6.RP.A.2: Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. CCSS.MATH.CONTENT.6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. **Formative/Summative Assessments** The teacher will make anecdotal notes gleaned from group observation and discussion as teams set up their investigations. The second to last page that includes the data table and information recording therein, can be used to assess students' understanding of the different variables and

	mathematical understandings required for their independent investigations. The teacher can use the final page of the investigation graphic organizer to assess students' reasoning in the analysis of their data and the conclusions drawn from it. **Resources** The Class Driving Questions Board Graphic Organizer for Investigation
Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure: Interpret their data, looking for patterns and trends, and draw conclusions.** Once groups have completed their investigations, they will take time to analyze and interpret their data. Teams will then share their findings with one another. The class will gather the information to develop a clear understanding of the factors that cause evaporation and condensation. The emphasis in the first part of this phase is for students to share their discoveries and findings. However, there is also an opportunity for direct instruction on the part of the teacher to fill in gaps in understanding and to begin clarifying lingering misconceptions. Now that students have had the shared experience of the anchoring phenomenon and independent testing, they have the context with which to relate the direct instruction. Here the teacher will emphasize what is happening at the molecular level when water changes between states. Emphasis will be made on the difference between water vapor and air, and the relationship between them. There will also be clarity as to the factors that cause water to change states, and move between evaporation/transpiration, condensation, and precipitation. Emphasis will also be placed on the various sources of evaporation, including the biosphere. Students will add to their initial model of the energy flow (from the Engage portion of the unit), and begin to finalize their understanding of the energy flow and movement of water molecules in the water cycle. **Modifications** In addition to students sharing their own discoveries through investigation, the teacher will also share multimedia resources such as informative video clips with guides to help students capture and process their thinking, as well as continuing to build on undersanding using the original graphic organizer.

	Standards Addressed MS-ESS2-4: Cycling of Water Through Earth's Systems - Develop a model to describe the cycling of water through earth's systems driven by energy from the sun and the force of gravity. (Energy and Matter) CCSS.MATH.CONTENT.6.NS.C.5: Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. CCSS.MATH.CONTENT.6.RP.A.2: Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. CCSS.MATH.CONTENT.6.RP.A.3: Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations. **Formative/Summative Assessments** The teacher will make anecdotal notes gleaned from group observation and discussion as teams set up their investigations. The second to last page that includes the data table and information recording therein, can be used to assess students' understanding of the different variables and mathematical understandings required for their independent investigations. The teacher can use the final page of the investigation graphic organizer to assess students' reasoning in the analysis of their data and the conclusions drawn from it. **Resources** Graphic Organizer for Initial Model Science Journal to take notes States of Water Video Video: NASA Earth's Water Cycle – This video begins to address he relationship between sea

	surface temperature, wind, and evaporation. Which creates a nice segue to the following data analysis lesson.
Elaborate *Provide applications of concepts and opportunities to challenge and deepen ideas; build on or extend understanding and skills.*	**Procedure: Building on students' understanding of the Water Cycle, we will challenge and deepen their ideas by exploring how changes in the salinity of the ocean impact the water cycle.** The whole group will begin by brainstorming the physical and chemical characteristics of ocean water. Responding to the likely most common characteristic is the ocean's saltiness. Show the following mapped image of Sea Surface Salinity. Students brainstorm and write one scientific process that may affect the ocean's salinity per note. Provide students with multiple sticky notes to identify at least two processes. They post the note in the sphere The teacher will Model for students how to observe common characteristics of the maps using the Cubes. Students write down their observations (and ones shared by their peers) in #1: Initial (Quantitative/Qualitative) Observations on the Student Sheet. The teacher will Assign each group a different set of dates (ex., Jan & Feb - Group A, Mar & Apr - Group B, etc.) and have students analyze their images and document their findings. Students develop questions and write them in Cell #2: Your Questions. Students share their findings. They summarize the class's findings in Cell #1. Summarize these data into concise statements about Sea Surface Salinity in the North Atlantic. Students will write a CER paragraph to make an evidence-based claim about salinity and another factor of the water cycle. The teacher will ensure by the end of this lesson, students have a better understanding of how salinity can impact the water cycle. With Aquarius data, scientists are able to relate ocean surface salinity variations to evaporation and precipitation, providing insight into how the ocean responds to seasonal and annual variability in the water cycle. Salinity plays a major role in how ocean waters circulate around the globe. Salinity changes can create ocean circulation changes that, in turn, may impact regional and global climates. Just as too much or too little salt in our diets affects our health, so too do high and low salinity have profound effects on how the ocean circulates, how freshwater cycles around Earth and how our climate works. The concentration of salt on the ocean surface — the part of the ocean that actively

	exchanges water and heat with Earth's atmosphere — is a critical driver of ocean processes and climate variability. The teacher will also give mini lesson instruction as to how to frame a scientific claim, acceptable evidence, and how to use reasoning to connect the two. **Modifications** The teacher will use the Guided Release approach to model and facilitate students in analyzing the different data sets. Students will have access to partners to ask questions and share ideas before speaking to the whole group. Graphic organizers will be used to structure and guide student thinking **Standards Addressed** CCSS.ELA-LITERACY.WHST.6-8.1.A Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. CCSS.ELA-LITERACY.WHST.6-8.1.E Provide a concluding statement or section that follows from and supports the argument presented. **Formative/Summative Assessments:** In addition to anecdotal notes on how students were able to analyze and interpret data, the teacher will use each student's CER paragraph to assess the structure and organization of an evidence-based claim. **Resources** Graphic Organizer Data Analysis Sheet Analyzing Monthly Environmental Data Sea Surface Salinity (SS) Air Temperature (AT)

	Sea Surface Temperature (ST) Evaporation (EV) Precipitation (PT) Evaporation Minus Precipitation (EP) Video NASA Aquarius Tour Video Science Cast: The Power of Sea Salt
Evaluate *Assess students' knowledge, skills and abilities.*	**Procedure: Students will share a conceptual model of the functioning of the water cycle, with an emphasis on the changing states and the roles that the sun and gravity play.** Students are invited to create a conceptual model of their choice, a physical model, a digital info graphic, a narrative writing piece from the perspective of a water drop, or a video explanation. The teacher will provide a word bank of essential terms that must be addressed as well as a rubric that describe the criteria for success. Students are free to create a model of their choice. They will then use the rubric to self-assess before turning in their work. **Modifications** The teacher will provide students with a rubric that describes the criteria for success. A word bank is provided for English Language Learners. The teacher will also coach reluctant students to choose a conceptual model based on their known strengths. Students with an IEP will be provided a graphic organizer to help scaffold and guide their thinking. **Standards Addressed** MS-ESS2-4: Cycling of Water Through Earth's Systems - Develop a model to describe the cycling of water through earth's systems driven by energy from the sun and the force of gravity. (Energy and Matter) **Formative/Summative Assessments** A completed conceptual model of the water cycle is the summative assessment **Resources** Rubric

Teacher Background:

A Framework for Science Education Practices

The unit expands students' understanding of weather and climate, and the role of water in Earth's surface processes which include these grades 6-8 elements of the Disciplinary Core Ideas (DCIs). It addresses all of the sections shown below.

ESS2.C: The Roles of Water in Earth's Surface Processes

- Global movements of water and its changes in form are propelled by sunlight and gravity.
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- Because these patterns are so complex, weather can only be predicted probabilistically.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

This unit builds on DCI elements that students should have developed in the prior units. These ideas are elicited and are used in new contexts (primarily different because of time and temporal scale). In many cases, the unit helps students extend these DCIs. The plain text beneath each of the DCI elements below describes how the ideas are used and where they are extended.

- **PS1.A: Structure and Properties of Matter:** Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
    - This particle model is reused and extended in Lessons 3-11, 13-14, and 17-18. It is used to model (1) how energy is transferred from the ground to the air (through conduction), (2) why air changes its density (due to changes in the speed of air particles), (3) why density would affect the amount of air pressure detected by a barometer (due to differences in the amount of force applied to the barometer from changes in the weight of a column of air particles overhead), and (4) how the cooling of water vapor in the air can cause the molecules in it to slow down enough that they stick to, rather than bounce off of, neighboring particles in collisions, thereby causing the particles to condense or solidify out of the air.
- **PS3.A: Definitions of Thermal Energy:** The temperature of a system is proportional to the average internal kinetic energy and potential energy per molecule (whichever is the appropriate building block for the system's material). When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time.
    - The idea that thermal energy transfer can occur through conduction is used to explain how the air above the ground is heated by it, and how warm rising air cools off as it moves higher up, This idea is reused in Lessons 5-8, 10, 12, 13, 14, 17, 18, 20, and 22.
- **PS4.B: Electromagnetic Radiation** When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
    - The idea that light is absorbed by the ground and converted to thermal energy

Disciplinary Core Ideas are reproduced verbatim from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Idea*s. DOI: https://doi.org/10.17226/13165. National Research Council; Division of Behavioral and Social Sciences and Education; Board on Science Education; Committee on a Conceptual Framework for New K-12 Science Education Standards. National Academies Press, Washington, DC.