Managing PFAS in our Daily Lives

(Time Frame: 10 Days)

Authors

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Materials

- Materials listed in each section of the plan.

SUBJECT/GRADE LEVEL

Subject Area: Science/Math

Grade Level: Middle School

STANDARDS

Next Generation Science Standards

- MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.6.RP.A.1
  Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
- CCSS.MATH.CONTENT.6.NS.B.3
  Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.
- 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.

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.SL.11-12.1.A: Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
- *See example above*

LESSON OBJECTIVE(S)

Students will be able to (include measurable and observable objectives for students):

- Revise one's own understanding of concepts related to drinking water contamination and regulation, and articulate those revised ideas in one's own words
- Explain and understand the meaning of concentration (in parts per million (ppm) and parts per billion (ppb) and dilution (serial dilutions).

CAREER CONNECTION(S)

Mentor Background: Helen Mearns, Deputy Director of the Chemical Security Analysis Center (CSAC)

Prior to joining CSAC in 2017, Ms. Mearns worked for the Joint Chemical, Biological, Radiological, and Nuclear (CBRN) Defense Program Analysis Integration Office, where she served as the Principal Advisor to the Deputy Assistant Secretary of Defense (DASD) for Chemical and Biological Defense on matters of CBRN survivability. Drawing from over 25 years of experience in Chemical, Biological, Radiological contamination survivability, Ms. Mearns, in coordination with the office of the DASD for Nuclear Matters, managed the Department of Defense CBRN Survivability Program.

A member of the Defense Acquisition Workforce, Ms. Mearns holds a patent in sorbent decontamination technology. Additionally, Ms. Mearns has been involved with the American Society of Mechanical Engineers on the Committee on Nuclear Air and Gas Treatment since 1995, generating and maintaining codes and standards for filtration technologies. In recognition, ASME awarded Ms. Mearns the 2023 Bernard F. Langer Nuclear Codes and Standards Award.

STEM Careers:

- **Research Assistant**
- **Lead Chemical Research Scientist**
- **Cyber Chemical Scientist**
- **Nuclear Chemist**
- **Homeland Security Researcher**

ENGAGEMENT

Brief Description (60 minute lesson/day 1):

Teacher shows common household items on a table to hook student interest. Teacher shows a brief PFAS video to further engage students and begin to outline the focus of the unit plan. Students engage in writing prompts to outline the scientific and mathematical challenges of PFAS in our lives.

Procedures:

On a table in front of the classroom, the teacher lays out a nonstick skillet, wrapper from a fast food burger, microwave popcorn bag, cosmetics, cleaning product, and small home fire extinguisher. Students are asked, what do they all have in common as think-pair-share. Students are given 3-5 minutes to discuss with an elbow partner. Then, teams share with the whole class for 10-15 minutes.

Then, the teacher shows the YouTube video on PFAS: https://www.youtube.com/watch?v=XA6sAfr2GZc

Pre-Assessment Survey
Next, the teacher gives a short writing activity and asks students to respond to a series of prompts. Students complete the activity in 20-25 minutes before beginning the unit to activate their prior knowledge on the topics at hand and gain insight into important questions the unit will explore: https://cdn.serc.carleton.edu/files/teachearth/activities/whats_water_benchmarking_activity.docx

Instructors can use this pre-unit benchmarking activity as a way to take stock of student questions and ideas, such as common misconceptions or nonscientific alternative conceptions, and use them to tailor the unit.

Students then complete the same benchmarking activity again at the end of the unit, and compare their answers from before and after the unit to take stock of their learning. This pre-post pairing can also be used to assess the effectiveness of the unit from an instructional perspective by looking for student understanding of specific key concepts or changes in student attitudes fostered by the unit.

At the end of the writing prompt teacher facilitates a think-pair-share activity for 3-5 minutes that asks students to consider and then discuss specific ways in which their understanding has changed:

How have their initial ideas become more nuanced or complicated? (Sometimes learning leaves you with more questions than you started with!)
How, if at all, have their attitudes or values shifted as a result of the engagement activity?

STUDENT ACTIONS

- ☐ Ask questions such as, “Why did this happen?” “What do I already know about this?” “What can I find out about this?” “How can this problem be solved?”
- ☐ Shows interest in the topic through curiosity and expression of wonderings
- ☐ Demonstrates engagement by expressing ideas, sharing observations, and creating initial models
- ☐ Expresses current understanding of a concept or idea

TEACHER ACTIONS

- ☐ Raises questions or poses problems
- ☐ Elicits responses that uncover students’ current knowledge
- ☐ Helps students make connections to previous work
- ☐ Posts learning outcomes and explicitly references them in the lesson
- ☐ Invites students to express what they think
- ☐ Invites students to raise their own questions

Thoroughly describe the procedures for the activity, including time frame. Be sure to include background information of the content, teacher and student actions, opportunities for formative assessment, hyperlinks, and possible adaptations for individual learners and/or virtual options.

EXPLORATION

Brief Description (60 minute lesson/day 2):
Students will explain the meaning of concentration and dilution. Students will build an understanding of concentrations expressed as parts per million and parts per billion. The teacher will lead students to carry out a serial dilution procedure. Students with the support of the teacher will attempt to understand how ppm and ppb relate to water quality.

Procedures:
Students mix food coloring with water, producing a serial dilution of food coloring in water. Students observe a gradual decrease in color of the solution as more water is added, until color is no longer visible. Students learn the meaning of concentration and dilution and how these terms are expressed.

Materials
For each student:
Student Sheet 3.1-Parts per Million

- Lab materials for each group of 4-5 students:
- Chemplate
- Medicine dropper
- Paper towel
- 15-20 ml tap water for filling large cup in each Chemplate
- Small cup for rinse water

For the teacher:

- Transparencies of newspaper articles with a ppm or ppb reference (at end of this lesson)
- Transparencies of relationship between cups, ppm examples, and math examples (at end of this
- lesson)
- Dropper bottle of food coloring
- Overhead of Student Sheet 3.1

1. Distribute chemplates, medicine droppers, and food coloring. The large reservoir of the chemplate holds sufficient water for the activity. Students may abstain water from the tap, or you may prefer to distribute water to students in a small beaker or similar container.
2. Demonstrate how to add drops of food coloring. It is important that they hold the bottle of food coloring vertically so that the drop produces a consistency the same size. A piece of white paper placed under the chemplate makes it easier to detect and describe colors.
3. Model the correct technique for using the medicine dropper. In order to fill the dropper, students should first squeeze the bulb gently and place the tip into the solution. If the bulb is then released , the solution may be drawn up evenly without splattering or introducing solution into the bulb. The dropper should never be turned over so that solution runs into the bulb.

Holding the dropper vertically makes it possible to abstain drops of water between uses. Monitor student progress and assist them as needed. Encourage them to proceed as independently as possible. Have students fill out the results table on the student sheet. 3.1(formative assessment):
https://www.austintexas.gov/sites/default/files/files/Watershed/ichthycide/ssppm.1.pdf

STUDENT BEHAVIORS

- ☐ Tests predictions and hypotheses; Forms new predictions and hypotheses
- ☐ Discusses problems with others
- ☐ Plans and conducts investigations in which they observe, describe, and record data
- ☐ Tries different ways to solve a problem or answer a question
- ☐ Creates initial models
- ☐ Compares ideas with those of others

TEACHING STRATEGIES

- ☐ Provides or clarifies questions or problems
- ☐ Provides common experiences
- ☐ Observes and listens to students as they interact
- ☐ Acts as a consultant for students
- ☐ Encourages student-to-student interaction
- ☐ Asks probing questions to help students make sense of their experiences and redirect them when necessary
- ☐ Provides time for students to puzzle through problems

Thoroughly describe the procedures for the activity, including time frame. Be sure to include background information of the content, teacher and student actions, opportunities for formative assessment, hyperlinks, and possible adaptations for individual learners and/or virtual options.

EXPLANATION

Brief Description (120 minute lesson/day 3 and 4): Students will delve into the scientific and mathematical meaning of PFAS in our water through the hands-on lab dilution activity. Students will write and revise their lab activity sheet after being remediated in the math standard on ratios as needed. Students will receive additional information on PFAS in our water system and the dangers. Students will continue to discuss math and science in small groups and whole class discussions.

Procedures:
Warm-Up
Journal Activity: What have you learned about PFAS? What are your questions about PFAS? What can you do to minimize PFAS?

Teacher shows PBS video news:
https://www.pbs.org/newshour/classroom/daily-news-lessons/2021/12/what-are-pfas-and-what-makes-these-forever-chemicals-dangerous

Follow-up discussion

1. Ask the students, "In which cup are you first unable to observe any color?" This will generally occur in cup 6, but be prepared for a range of answers. Discuss their answers, pointing out that any time a task requiring a measurement is performed by individuals, variation is expected. For example, drop sizes vary somewhat when using droppers. The physical quantity or relationship does not change; the ratio of color to water that is detectable by the average human eye are not expected to vary. The variation arises as we carry out the procedures that depend on our perception, technique, and judgment.

2. Ask the students whether food coloring is present in cups 6, 7, 8, and 9. (Yes, they removed some liquid from cup 5 to add to cup 6; this liquid contained food coloring; therefore, food coloring is present in cup 6, but at a dilution too small to be visually detected.)

3. Ask them whether they can think of a way to prove the presence of food coloring in each cup. Allowing the water to evaporate is one possibility. If this is done, a colored residue will generally form in cups 1-6. They can also run a chemical test to detect the presence of food coloring in very small concentrations.

Mini-Lecture: Ratios in Math

Materials

- Linking cubes
- Chart paper (optional)
- Determining Proportional Relationships and Unit Rates activity sheet (attached)
- Creating a Table of Ratios and Determining the Existence of Proportional Relationships
- activity sheet (attached)

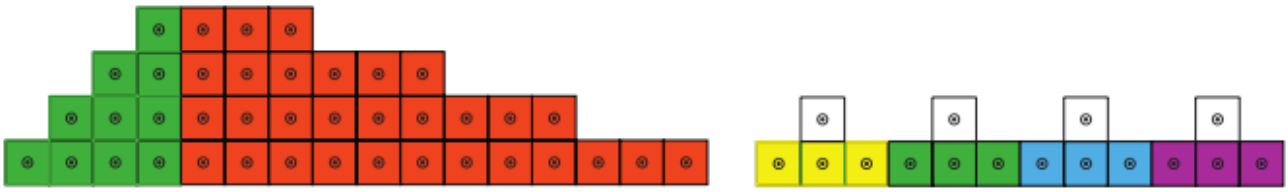
Vocabulary
additive relationship, multiplicative relationship, proportion, proportional relationship, ratio, ratio table, unit rate (6.12)

Student/Teacher Actions: What should students be doing? What should teachers be doing?

1. Discuss the term ratio. Make sure that students understand that a ratio is a comparison of any two quantities and that it is used to represent a relationship within a quantity and between quantities. Students must first understand the concept of ratios in order to recognize and determine the existence of equivalent ratios. Equivalent ratios arise by multiplying each value in a ratio by the same constant value. For example, the ratio of 8:4 would be equivalent to the ratio 16:8, since each value in the first ratio could be multiplied by 2 to obtain the second ratio.
2. Share with students that a proportional relationship consists of two quantities where there exists a constant number (constant of proportionality) such that each measure in the first quantity multiplied by this constant gives the corresponding measure in the second quantity. Provide students with additional examples that will allow them to identify the constant of proportionality.
3. Use the Determining Proportional Relationships and Unit Rates activity sheet to as a means of

practical application and discovery of the following concepts:
Understanding the difference between a multiplicative relationships and additive Relationships. Understanding that a rate is a ratio that involves different units and how they relate to each other. A unit rate describes how many units of the first quantity of a ratio correspond to one unit of the second quantity.

An example of using the linking cubes to demonstrate the relationship 1:3 and unit rates:



4. Use the Creating a Table of Ratios and Determining the Existence of Proportional Relationships activity sheet to help students understand that a ratio table is a table of values representing a proportional relationship that includes pairs of values that represent equivalent rates or ratios. A constant exists that can be multiplied by the measure of one quantity to get the measure of the other quantity for every ratio pair. The same proportional relationship exists between each pair of quantities in a ratio table.

Strategies for Differentiation

- Use two-color counters to represent unit rates and manipulate ratios to create equivalent ratios.
- Create a graphic organizer to show the connections between ratios, unit rates, equivalent ratios, ratio tables, and proportional relationships.
- Allow students to work with a partner for all learning activities and permit them to collaborate to complete the attached activity sheets.

Exit ticket: Go back to the student sheet. 3.1and review and/or correct your answers on ratios(formative assessment): https://www.austintexas.gov/sites/default/files/files/Watershed/ichthycide/ssppm.1.pdf

STUDENT BEHAVIORS

- ☐ Shows models, explanations, answers, or possible solutions, to other students
- ☐ Listens critically to and questions explanations offered by others
- ☐ Explains using evidence from investigations
- ☐ Uses labels, terminology, and formal scientific language
- ☐ Compares current thinking with former thinking
- ☐ Records ideas and current understanding
- ☐ Adjusts ideas, models, and explanations as new evidence or reasoning is presented

TEACHING STRATEGIES

- ☐ Encourages students to explain concepts and definitions in their own words
- ☐ Asks for justification (evidence) and clarification from students
- ☐ Formally provides definitions, explanations, and information through mini-lecture, text, internet, or other resources
- ☐ Builds on student explanations
- ☐ Provides time for students to compare their ideas with others and if desired revise their ideas

Thoroughly describe the procedures for the activity, including time frame. Be sure to include background information of the content, teacher and student actions, opportunities for formative assessment, hyperlinks, and possible adaptations for individual learners and/or virtual options.

ELABORATE

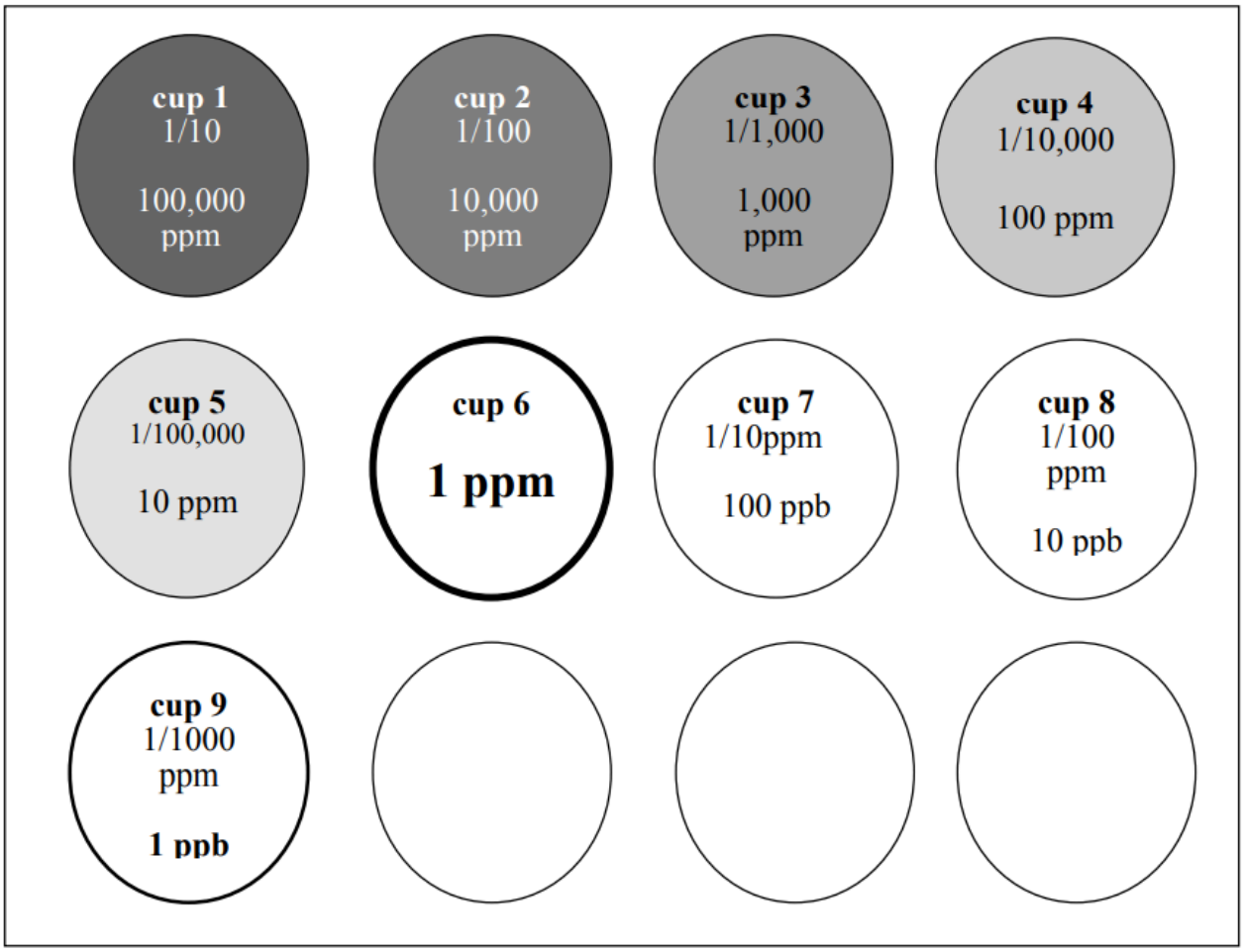
Brief Description (180 minutes/ Day 5, 6, 7): Students will elaborate on their understanding of part per million and part per billion as it relates to PFAS in the water system. Students will participate in a math mini-lecture on comparing fractions, decimals, and percents which is part of the dilution activity. Students will begin brainstorming on the capstone project which is to design a public service announcement (PSA) on the dangers of PFAS in our water system and how to minimize health risks.

Procedures:

Meaning of part per million and part per billion

1. Display the transparency "Relationship between cups". The chart can help students understand the relationships between the cups. As students understand the relationships between cups 1 and 2, the rest should follow by induction. Cup 3 represents a concentration of one part per thousand, cup 6 represents a concentration of one part per million, cup 9 represents a concentration 1 part per billion.

Relationship between cups



2. Highlight the cups showing the difference between ppm and pbb. Discuss the relation between part per million and part per billion shown in the table. Most contaminant screening levels in water are measured in parts per billion. This is one thousand times smaller than ppm.
3. Discuss question #10 and display the drinking water standards. The allowable limit for Toxaphenes (a type of pesticide) in drinking water is 3.0 ppb (or 0.003 ppm). In 1976 it was 5.0 ppb. Some students may disagree with these levels, suggesting that they would not drink water containing any pesticide. For them 0 ppb is the only safe level. You may wish to respond that it is impossible to remove all the pesticides. Even to reduce it to extremely small levels, say 1 ppb or less, is extremely time consuming and costly. The important decision health officials have to make concerns the level at which the pesticide is harmful to our health.

   Drinking water standards according to the EPA: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

Mini-Lecture Math Lesson: Comparing Fractions, Decimals, Percents:
https://www.youtube.com/watch?v=pZkYQK8eLJQ

Student Practice Comparing Ordering Fractions: Compare Order Fractions Decimals Percents.pdf

PUBLIC SERVICE ANNOUNCEMENT POSTER

Activity 10.1: Students will define elements of a good poster.

1. Tell Students: Public Service Advertising (PSAs) are messages in the public interest, which are on television, radio, print or other media. The purpose of commercial advertising is to market a product or service, PSAs are messages that benefit the public by raising awareness of an issue, influencing attitudes or actions for the good. The media time and space is provided for free. The http://www.psaresearch.com website has good information on how to make great PSAs.

2. Display several informational posters in the room. Make sure some are Public Service Announcement (PSA) posters. We've attached copies of PSA posters.

3. Tell Students: On a slip of paper, write one thing about the poster that makes it an effective way to communicate. Put the slip in a box with everyone else's.

4. One by one, draw the slips and write the element on the board. In a class discussion refine this list until you have a manageable number, such as five. Students should copy this list as the required elements of the poster they will be making. Teacher's Note: It is important to give students adequate time to brainstorm ideas. Some groups may need longer than others. You may want to increase motivation by having a contest for the best posters.

Activity 10.2: Students will brainstorm lists of activities

1. Do a classroom carousel. On each of the chart papers, write one category of activity at the top. Examples include: outside activities, by yourself, helping others in your family, to do with friends, to do with family, helping others in your community, things kids did before TV.

2. Divide class into groups of four and give each group a colored marker. Have each group go to one of the charts. In one minute, the group should write three activities for the category.

3. When the teacher calls "Switch", groups should take their marker to the next chart and write three activities without repeating. Allow a slightly longer time with each successive chart, but still keep students working fast.

4. When the groups are back to their starting point, stop. Have one person in the group read the list of possible activities on the chart as fast and clearly as they can. If you have 32 students there will be 24 ideas on each chart times 8 charts - a lot of ideas!

STUDENT BEHAVIORS

- ☐ Applies new labels, definitions, explanations, and skills in new, but similar, situations
- ☐ Uses previous information to ask questions, propose solutions, make decisions, design experiments, or complete a challenge
- ☐ Draws reasonable conclusions from evidence
- ☐ Critiques the models, explanations, or arguments made by others using evidence and reasoning
- ☐ Makes conceptual connections between new and previous experiences
- ☐ Communicates understanding to others

TEACHING STRATEGIES

- ☐ Expects students to use vocabulary, definitions, and explanations provided previously in new contexts
- ☐ Encourages students to apply the concepts and skills in new situations
- ☐ Provides additional evidence, explanations, or reasoning
- ☐ Reinforces students' use of scientific terms and descriptions previously introduced
- ☐ Asks questions that help students draw reasonable conclusions from evidence and data

Thoroughly describe the procedures for the activity, including time frame. Be sure to include background information of the content, teacher and student actions, opportunities for formative assessment, hyperlinks, and possible adaptations for individual learners and/or virtual options.

EVALUATION

Brief Description (180 minutes/Day 8, 9, 10): Students will design and present their PSA poster to the school community demonstrating scientific and mathematical knowledge. Students will listen to other teams present and give constructive feedback. All students will participate in a gallery walk of PSA posters.

Procedures:

Activity 10.3: Student teams will create a poster 1. Show students the poster materials or assign this for homework. Remind students of the required elements and give them a Poster Rubric to remind them about quality. (Two examples are included.) 73 2. Explain the judging and prizes, if you are doing this. Posters will be put up in the hall and judged. Activity 10.4: Gallery walk for ideas 1. Put all of the posters up in the hallway including posters from other classes. Have one of the judges award the prizes. 2. Have students go on a gallery walk. Ask them to find two things to do. Encourage students to find things to do together. Back in the classroom, ask a few students to share what they want to do. 3. Repeat this each day for PFAS awareness in the community.

ASSESSMENT: See the attached Poster Rubric.

Purpose The purpose of the poster is clearly accomplished.			
Drawings and Illustrations All illustrations, photographs, and drawings add to the purpose and interest of the poster.			
Mechanics (C-U-P-S) There are no errors in capitalization, usage, punctuation, or spelling.			
Layout and Design The overall organization, design, use of color, and use of space help to make the poster interesting and to communicate the message.			
Creativity The poster is highly original and creative.			
Neat and Presentable The poster is very neat and presentable.			

Post-Assessment Survey

To end the unit, the teacher gives a short writing activity and asks students to respond to a series of prompts. Students completed the activity in 20-25 minutes before beginning the unit to activate their prior knowledge on the topics at hand and gain insight into important questions the unit will explore: https://cdn.serc.carleton.edu/files/teachearth/activities/whats_water_benchmarking_activity.docx

Now, students complete the same benchmarking activity again at the end of the unit, and compare their answers from before and after the unit to take stock of their learning. This pre-post pairing can also be used to assess the effectiveness of the unit from an instructional perspective by looking for student understanding of specific key concepts or changes in student attitudes fostered by the unit.

At the end of the writing prompt the teacher facilitates a think-pair-share activity for 3-5 minutes that asks students to consider and then discuss specific ways in which their understanding has changed.

STUDENT BEHAVIORS

- ☐ Gives feedback to other students
- ☐ Evaluates progress or knowledge
- ☐ Checks work with a rubric or against established criteria
- ☐ Assesses progress by comparing current understanding with prior knowledge
- ☐ Asks additional questions that go deeper into a concept or leads to additional learning
- ☐ Demonstrates understanding of Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices
- ☐ Answers open-ended questions by using observations, evidence, and previously accepted explanations

TEACHING STRATEGIES

- ☐ Asks open-ended questions such as, “Why do you think…?” “What evidence do you have?” “How would you answer the question?”
- ☐ Observes and records notes as students demonstrate individual understanding of concepts learned and performance of skills
- ☐ Uses a variety of assessments to gather evidence of student understanding
- ☐ Provides opportunities for students to assess their own progress

Thoroughly describe the procedures for the activity, including time frame. Be sure to include background information of the content, teacher and student actions, opportunities for formative assessment, hyperlinks, and possible adaptations for individual learners and/or virtual options.

REFERENCES

- Provide links to resources that you used in the creation of this unit.
- https://www.youtube.com/watch?v=XA6sAfr2GZc
- https://serc.carleton.edu/teachearth/activities/246206.html
- https://www.austintexas.gov/sites/default/files/files/Watershed/ichthycide/ssppm.1.pdf
- https://www.doe.virginia.gov/home/showpublisheddocument/17296/638037671676000000
- https://www.ktufsd.org/cms/lib/NY19000262/Centricity/Domain/129/Government%20Documents/Portfolio%20Documents/Section%20II/PSA%20-%20Poster.pdf
- https://www.takethechallengenow.net/wp-content/uploads/2014/10/HS-Lesson-10-What-to-do-PSA-Posters.pdf