Gather Reason Communicate

Template for Developing GRC Lessons Aligned to Three-Dimensional Science Standards

3D-Student Science Performance *Author(s): Kelsey Foster, Mapleton Elementary School, Nebo District*	
Grade MS PS	**Lesson Title** **Dye in Motion**
Lesson Topic - Particle Motion	

Performance Expectations (Standard) from State Standards or NGSS:

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. *[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases the kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]*

MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. *[Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object.] [Assessment Boundary: Assessment does not include calculations of energy.]*

Lesson Performance Expectations:

- **Develop questions** to **plan an investigation for** what **causes** the food coloring to move differently in containers of water of different temperatures.
- **Plan and carry out an investigation** to gather evidence for what **causes** the food coloring to move differently in containers of water of different temperatures.

Student Science Performance

Phenomenon: Food coloring moves differently in cold water than in hot water.

Engage

Gather

1. Students **develop questions** to **plan an investigation** of the **causes** of food coloring moving differently in containers of water of different temperatures.
2. Students **plan and carry out an investigation** to gather evidence for what **causes** the food coloring to move differently in the water of different temperatures. *(Materials: Different colors food coloring, thermometers, large clear containers, cell phones for video, graph paper, large clear container.)*

Explore

Class Discussion - to develop one investigation for the Class

3. Students use the **class data chart** to contribute their data to the class. (See Appendix B-2)
4. Students **obtain information** from reliable online resources and books for how **changes** in energy **affect** the motion of particles.

Explain

(Teaching Suggestions: Students will need to fill one container with cold water and one with hot water, preferably very hot tap water, in some schools tap water is not hot enough so you may need a hot plate. Do not get the water so hot it burns the students. You can do this as a demo, but then students are not planning and carrying out an investigation. The biggest problem is food coloring on the students' hands, so demo on how to use food coloring without getting in on your hand and/or have a plastic glove for students to use. Make sure that only one student puts the food coloring in the water. Students need to add one drop of food coloring to the containers at the same time. Allow students time to observe what happens to the food coloring. In the Class Discussion, the entire class decides how each group of three will contribute a piece of data to the data set. Talk about how to make a fair test. Independent variable, dependent variables and things that will be controlled.)
Some teachers skip obtaining information until after the investigation is complete.
Resources: States of Matter video: https://www.youtube.com/watch?time_continue=89&v=AVY5aKpy55s
The video is a brief overview of the states of matter and their characteristics. It's a helpful visual and explanation for your struggling readers.
Particle Movement: https://www.chem.purdue.edu/gchelp/liquids/character.html

Core Idea - *When energy is added to*

Template for Developing GRC Lessons Aligned to Three-Dimensional Science Standards

matter (water) the density decreases. The three related phenomena and visual representations used should work together to develop the idea that energy affects the density of matter. Density water tanks and straws will allow children to investigate how hot and cold water behaves when they are mixed together.	*The website has additional information, specifically regarding the particle movement in each phase and a chart students can copy into their notes.* *Simulation: https://phet.colorado.edu/sims/html/states-of-matter/latest/states-of-matter_en.html* *The simulation has 3 different tabs. You will want to have students click on the "States" tab when they go to the Phet website. They can observe how a few different atoms and molecules behave when energy is added and removed. Have students first complete the simulation with water and then they can play around with the other options. When playing with the simulation, students will need to click and drag the lever to add heat(shows a flame) or remove heat(shows ice cubes). They will need to click and hold the lever in place when they let it go it will go back to the center.* ***Reason*** 5. Students **analyze the data** from the class data chart to find **patterns** in the rate of motion. 6. Students **construct an explanation** for the **cause** of food coloring dispersing at different rates in different temperatures of water. ***Class Discussion:*** *Questions to initiate Discussion:* *Q: What could cause differences in the way food coloring is dispersed in the water?* *Q: How does the particle (molecule) motion of the water change when energy is added?* *Q: Why does the input of energy cause food coloring to act differently?* *Q: Hows is the motion of particles related to the speed the particles are moving?* *(Teaching Suggestions: During class discussion, you will want to help bring out the following ideas: Heating a substance causes molecules to speed up and spread slightly further apart, occupying a larger volume that results in a decrease in density. By adding heat energy to molecules move more rapidly than the cold water, therefore distribute the food coloring through the water more quickly. Likewise, cooling a substance causes molecules to slow down and get slightly closer together, occupying a smaller volume that results in an increase in density. The cold water has less energy, less particle movement, which inhibits the food coloring dispersion.)* ***Communicate Reasoning*** 7. Students **use a model** to present an **explanation** for why the motion of particles **changes** when **energy** is put into a **system** of food coloring in water.

Formative Assessment for Student Learning

Elicit Evidence of Learning: **Use a model** to present an **explanation** for why the motion of particles changes when **energy** is put into a **system** of food coloring in water.

Evidence of Student Proficiency	***Range of Typical Student Responses***	***Acting on Evidence of Learning***
The students' response should describe and explain that the warm water has more energy. The increase in energy causes the movement of water molecules to be more spread out and allows the food coloring to spread more quickly and evenly. The cold water has less energy, and therefore significantly less particle movement. The food coloring can't disperse as quickly or as evenly in colder, denser water.	*Descriptors of grade-level-appropriate student responses:* • *Full understanding - My model shows the particles are moving faster when energy is added to the system. My evidence is that when the temperature is increased the food coloring spreads faster.* • *Partial understanding - My model shows the particles of food color moving faster when the temperature changes.* • *Limited understanding - The food color moves faster in hot water than in cold water.*	*Description of instruction action and response to support student learning.* • *action for students who display partial or limited understanding - Return to the data chart and the PHET to help students at this point.* • *extensions of learning for students who display a full understanding - Open a bottle of strong perfume in one corner of the room and graph the student responses as the perfume moves across the room. Have students develop a graph that shows the spread of the perfume. Strong food flavoring oils also work. YOU can only do this once in a room.*

Gather → Reason → Communicate

Template for Developing GRC Lessons Aligned to Three-Dimensional Science Standards

SEP, CCC, DCI Featured in Lesson	**Science Essentials** *(Student Performance Expectations From Appendix C, D, E)*
Science Practices Asking Questions Obtaining Information Constructing Explanations Using Models	Ask questions to obtain information. Obtain information to support explanations for natural phenomena. Use models to reflect on how things work. Use representation to clarify cause and effect relationships. Construct science explanations to explain phenomena.
Crosscutting Concepts Energy and Matter Stability and Change Systems	Explain the relationship of energy to change the motion of particles within the system. Analyze interactions within a system. Model simple systems.
Disciplinary Core Ideas Energy and Matter	Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. Conceptual Models - Matter is made of particles. The matter is conserved. Energy is involved when matter changes.

Appendix A - Student Prompts for the Lesson

Phenomenon: Food coloring moves differently in cold water than in hot water.

Group Performances:

1. **Develop questions** to **investigate** the causes of food coloring moving differently in the water of different temperatures.
2. **Plan and carry out an investigation** to gather evidence for the causes of food coloring moving differently in the water of different temperatures. *(Materials: Different colors food coloring, thermometers, large clear containers, cell phones for video, graph paper, large clear container.)*

Class Discussion about Planning a Class investigation

3. Obtain information from reliable online resources for how changes in energy affect the movement of matter particles.
4. Add your data to the **class data chart**.
5. Each group **analyzes the class data** chart to find patterns.
6. Construct an explanation for the cause of food coloring moving more quickly in hot water but much slower in cold water.

Class Discussion

Individual Performances:

7. **Use a model** to present an **explanation** for why the motion of particles changes when **energy** is put into a **system** of food coloring in water.

(Teaching Suggestions: Use a data chart on the board. Some teachers use an electronic chart if they have that capacity in the classroom. Students analyze the class data, often they graph the data on the same piece of graph paper they used to measure the movement. The cameras on phones are critical to good data. The first-class discussion is about planning an investigation and is a good opportunity to talk about experiments. Each group needs its own two temperatures of water. You may wish to maintain a tub of ice water for students to take the water from a tub of very hot tap water. ***CAUTION:*** *Not so hot as to burn students.)*

(Teaching Suggestions: Some analogous phenomena that could come out in the discussion: Density Water Tank: water doesn't mix immediately. The cold (blue) water remains at the bottom of the tank while the hot (red) water stays above the cold water. Eventually, the water will begin to mix and turn purple. Drinking Straw: When you pick up hot (red) water in a straw and then pick up cold(blue) water in the same straw the water stays separated. If you pick up cold(blue) water first and then pick up hot(red) water the water mixes almost immediately. Students can carry out an investigation with the water and straws to develop understanding.)

Appendix B - 1 Reading

The source of water (matter) for the engage phase with the frozen mugs is from the air, the source of water from breathing out is from your breath. When we breathe, we use liquid water. When we don't see breath, we still breathe out gas but warmer temperatures prevent us from seeing our breath. When we exhale, there is heat from warm air, water molecules condense and change state.

Motion of Particles

The matter is made of particles. When particles have more energy they move faster. Adding energy to a system causes the particles in the system to move faster. Hot air balloons work by heating air and the air moves faster causing less air to occupy the same space. When the air in a hot air balloon expands it pushes air out the bottom of the balloon causing the balloon to weigh less because it has less air in the same space.

The more kinetic energy a substance has, the warmer it will be and the faster particles will be moving, which reduces the density of the substance.

When the change in temperature is significant enough, a substance can change its phase from a solid to a liquid or gas, or condense from a gas to a liquid or solid. Cooling a substance causes molecules to slow down and get slightly closer together, taking up less space, which results in an increase in density. Warming a substance increases the energy the particles have and the molecules spread out, decreasing density.

When temperatures increase, objects expand and become larger and therefore the density decreases. When temperatures decrease, objects condense and become smaller so density increases.

Resources: https://sciencing.com/temperature-effects-density-5521664.html

https://www.youtube.com/watch?v=MLO9yxXMBOI

Appendix B - Typical Data Chart for Class Data

	Each Group uses graph paper behind the cup and a camera to measure how far the coloring moves.			
Group/ Temperature	***1 minute***	***2 minutes***	***5 minutes***	***10 minutes***
1 - Hot				
1 - Cold				
2 - Hot				
2 - Cold				
3 - Hot				
3 - Cold				
4 - Hot				
4 - Cold				
5 - Hot				
5 - Cold				
6 - Hot				
6 - Cold				
7 - Hot				
7 - Cold				

Appendix C *- Acting on Evidence of Learning*

Description of instruction action and response to support student learning.

- *action for students who display partial or limited understanding - Return to the data chart and the PHET to help students at this point.*
- *extensions of learning for students who display a full understanding - Open a bottle of strong perfume in one corner of the room and graph the student responses as the perfume moves across the room. Have students develop a graph that shows the spread of the perfume. Strong food flavoring oils also work. YOU can only do this once in a room.*
-