# Introduction

# Formative Assessment Exemplar - 8.1.5

**Introduction:**

The following formative assessment exemplar was created by a team of Utah educators to be used as a resource in the classroom. It was reviewed for appropriateness by a Bias and Sensitivity/Special Education team and by state science leaders. While no assessment is perfect, it is intended to be used as a formative tool that enables teachers to obtain evidence of student learning, identify gaps in that learning, and adjust instruction for all three dimensions (i.e., Science and Engineering Practices, Crosscutting Concepts, Disciplinary Core Ideas) included in a specific Science and Engineering Education (SEEd) Standard.

In order to fully assess students' understanding of all three dimensions of a SEEd standard, the assessment is written in a format called a cluster. Each cluster starts with a phenomenon, provides a task statement, necessary supporting information, and a sequenced list of questions using the gather, reason, and communicate model (Moulding et al., 2021) as a way to scaffold student sensemaking. The phenomenon used in an assessment exemplar is an analogous phenomenon (one that should not have been taught during instruction) to assess how well students can transfer and apply their learning in a novel situation. The cluster provides an example of the expected rigor of student learning for all three dimensions of a specific standard. In order to serve this purpose, this assessment is NOT INTENDED TO BE USED AS A LESSON FOR STUDENTS.

Because this assessment exemplar is a resource, teachers can choose to use it however they want for formative assessment purposes. It can be adjusted and formatted to fit a teacher's instructional needs. For example, teachers can choose to delete questions, add questions, edit questions, or break the tasks into smaller segments to be given to students over multiple days.

Of note: All formative assessment clusters were revised based on feedback from educators after being utilized in the classroom. During the revision process, each cluster was specifically checked to make sure the phenomena was authentic to the DCI, supporting information was provided for the phenomena, the SEPs, CCCs, and DCIs were appropriate for the learning progressions, the cluster supported student sensemaking through the Gather, Reason, and Communicate instructional model, and the final communication prompt aligned with the cluster phenomena. As inconsistencies were found, revisions were made to support student sensemaking. If other inconsistencies exist that need to be addressed, please email the current Utah State Science Education Specialists with feedback.

**General Format:**

Each formative assessment exemplar contains the following components:

1. Teacher Facing Information: This provides teachers with the full cluster as well as additional information including the question types, alignment to three dimensions, and answer key. Additionally, an example of a proficient student answer and a proficiency scale for all three dimensions are included to support the evaluation of the last item of the assessment.
2. Students Facing Assessment: This is what the student may see. It is in a form that can be printed or uploaded to a learning platform. (Exception: Questions including simulations will need technology to utilize during assessment.)

**Accommodation Considerations**:

Teachers should consider possible common ways to provide accommodations for students with disabilities, English language learners, students with diverse needs or students from different cultural backgrounds. For example, these accommodations may include: Providing academic language supports, presenting sentence stems, or reading aloud to students. All students should be allowed access to a dictionary.

**References:**

Moulding, B., Huff, K., & Van der Veen, W. (2021). *Engaging Students in Science Investigation Using GRC*. Ogden, UT: ELM Tree Publishing.

# Teacher Facing Info

**Teacher Facing Information**

**Standard:** 8.1.5

**Assessment Format:** Online Only (Requires students to have online access)

| **Phenomenon** | |
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| You are  feeling tired at the end of the day and decide to boil some water to make hot chocolate.  As you watch the water heat up, you notice small bubbles forming on the bottom of the pot.  The longer you wait, you see larger bubbles rising to the top of the water. | Proficient Student Explanation of Phenomenon:<br><br>As heat is added to the water, the water molecules begin to move faster.  As the water molecules begin to move faster, they change into a gas and become loosely connected. Because these molecules are now able to spread out, their density decreases and they rise to the surface of the water.  This forms the bubbles observed in the boiling water.  The more kinetic energy is added to the system, the more molecules are able to spread out and create larger bubbles. |

**Cluster Task Statement**

(Represents the ultimate way the phenomenon will be explained or the design problem will be addressed)
In the questions that follow, you will develop a model to explain why the size of the bubbles in boiling water start small and grow larger, rising to the surface, as the duration of time exposed to the hot burner increases.

**Supporting Information**

When the pot is placed on the stove, the temperature is set to deliver a constant source of energy to the pot and water.

Time Lapse Video

Figure 1: Boiling Water

Figure 2: Boiling Water



**Glossary of terms:**
**Density:** how much matter or mass is in a given volume
**Particle motion:** How fast or slow atoms move.
**Thermal energy:** Energy in the form of heat.

| **Cluster Questions** | |
|---|---|
| Gather:<br>Cluster Question #__1__<br>Question Type: **Short Answer**<br>Addresses:<br>___x_ DCI (PS3.A, PS1.A)<br>_____ SEP<br>___x_ CCC: Cause and Effect<br>Answer:<br>As heat is added to the water, the water molecules begin to move (faster/slower/stay the same). This causes the density of the water molecules to (increase/decrease/stay the same). | Question 1:<br>As heat is added to the water, the water molecules begin to move (faster/slower/stay the same). This causes the density of the water molecules to (increase/decrease/stay the same). |
| Reasoning:<br>Cluster Question #___2___<br>Question Type: **Multiple Choice**<br>Addresses:<br>__X__ DCI: PS1.A<br>__X__ SEP: Develop a model<br>_____ CCC<br>Answer: B is a liquid | Question 2:<br>In the following image, the water has just been placed over the flame. Circle the model that best shows how the molecules of water would appear in its liquid form. |

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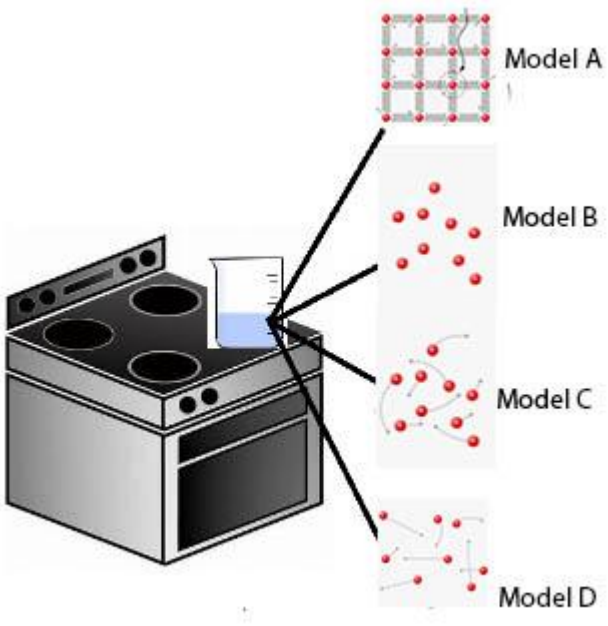
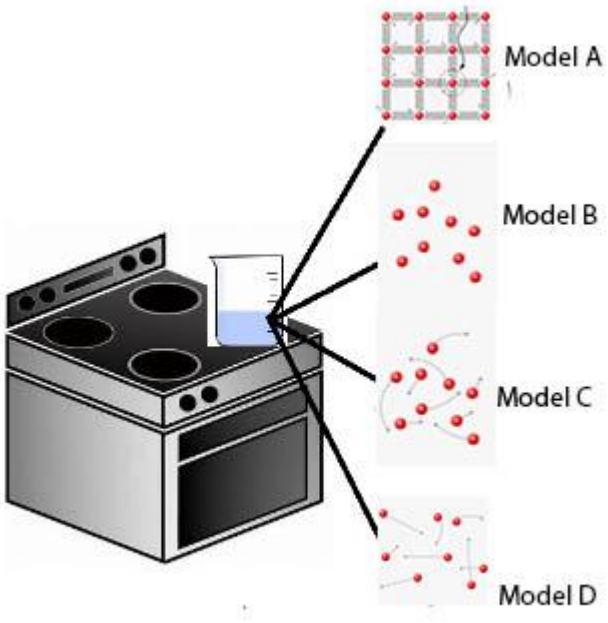
| |  |
| Reasoning:<br>Cluster Question #___3___<br>Question Type: **Multiple Choice**<br>Addresses:<br>__X__ DCI: PS1.A<br>__X__ SEP: Develop a model<br>____ CCC<br>Answer: D | Question 3:<br><br>After the water has a chance to sit over the flame for a while, tiny bubbles start to form near the bottom of the pot. Circle the model that best shows how the molecules would appear inside the vapor.<br>  |
| Reason: | Question 4: |

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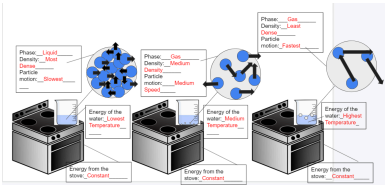
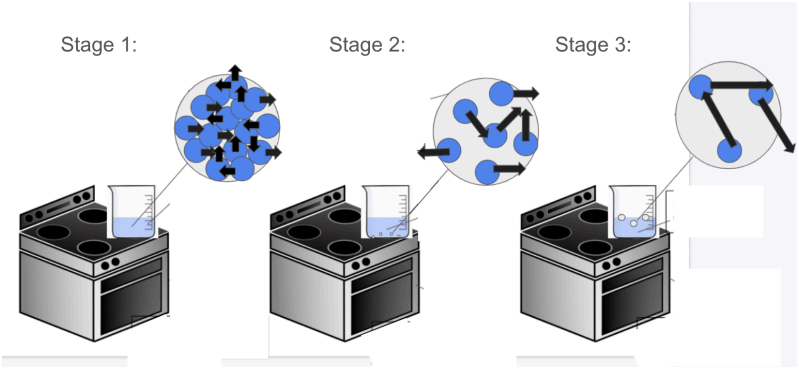
| Cluster Question # __4___<br>Question Type: **Short Answer**<br>Addresses:<br>__X_ DCI: PS1.A<br>___SEP<br>_X_CCC: Cause and Effect<br>Answer:<br>The particle motion of the water molecules will DECREASE and the density of the water will INCREASE because as thermal energy is removed from the system, particle motion decreases and density increases. | What do you predict would happen to the particle motion and density of the water if we add ice to the beaker?<br><br>The particle motion of the water molecules will (increase/decrease/stay the same)_____ and the density of the water will (increase/decrease/stay the same)_____ because _____. |
| Communicate:<br>Cluster Question #__5____<br>Question Type: **Short Answer**<br>Addresses:<br>__X__ DCI: PS1.A, PS3.A<br>__X__ SEP: Developing and Using Models<br>__X__ CCC: Cause and Effect<br>Answer:<br>Model:<br>  <br>**Stage 1**-<br>The phase at stage 1 is liquid.<br>The density at stage 1 is most dense.<br>The particle motion at stage 1 is slowest.<br>The energy of the water at stage 1 is the lowest temperature.<br>The energy from the stove at stage 1 is constant.<br><br>**Stage 2**-<br>The phase at stage 2 is gas | Question 5:<br><br>Below is a model showing water at three stages. In stage 1, the water is first placed on the stove. In stage 2, the water has just begun to boil. In stage 3, the bubbles are growing and rising to the surface of the water.<br>  <br>You will analyze each of the stages of boiling water above the following figures. You should consider phase, density, particle motion, energy of the water, and energy from the stove. Below, you will be asked about how each stage compares to the other stages by inserting the term from the provided word bank for each blank.<br><br>**Stage 1: Water is first placed on the stove** |

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|---|---|
| The density at stage 2 is medium density<br>The particle motion at stage 2 is medium speed<br>The energy of the water at stage 2 is medium temperature<br>The energy from the stove at stage 2 is constant.<br><br>**Stage 3**-<br>The phase at stage 3 is gas.<br>The density at stage 3 is least dense<br>The particle motion at stage 3 is fastest.<br>The energy of the water at stage 3 is the highest temperature.<br>The energy from the stove at stage 3 is constant. | Using the stage 1 diagram, please fill in the blanks with the best answer.<br><br>The phase at stage 1 is _____ (solid/liquid/gas).<br><br>The density at stage 1 is_____ (most dense/medium density/least dense).<br><br>The particle motion at stage 1 is _____ (fastest/medium speed/slowest).<br><br>The energy of the water at stage 1 is _____ (lowest temperature/medium temperature/highest temperature).<br><br>The energy from the stove at stage 1 is _____ (constant/increasing/decreasing).<br><br>**Stage 2: Water begins to boil**<br><br>Using the stage 2 diagram, please fill in the blanks with the best answer.<br><br>The phase at stage 2 is _____ (solid/liquid/gas).<br><br>The density at stage 2 is _____ (most dense/medium density/least dense).<br><br>The particle motion at stage 2 is _____ (fastest/medium speed/slowest).<br><br>The energy of the water at stage 2 is _____ (lowest temperature/medium temperature/highest temperature).<br><br>The energy from the stove at stage 2 is _____ (constant/increasing/decreasing).<br><br>**Stage 3: Water is rapidly boiling, bubbles rising to the top**<br><br>Using the stage 3 diagram above, please fill in the blanks with the best answer.<br><br>The phase at stage 3 is _____ (solid/liquid/gas).<br><br>The density at stage 3 is _____ (most dense/medium density/least dense).<br><br>The particle motion at stage 3 is _____ (fastest/medium speed/slowest). |

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| | The energy of the water at stage 3 is _____ (lowest temperature/medium temperature/highest temperature).<br><br>The energy from the stove at stage 3 is _____ (constant/increasing/decreasing). |

**Proficiency Scale**

**Proficient Student Explanation:**
Students should be able to demonstrate an understanding of how an increase in temperature increases particle motion and spacing. As more heat is added to the system, more liquid water changes to water vapor. Since water in its gaseous state is less dense than liquid water, the bubbles move to the top.

| Level 1 - Emerging | Level 2 - Partially Proficient | Level 3 - Proficient | Level 4 - Extending |
|---|---|---|---|
| **SEP:**<br>Does not meet the minimum standard to receive a 2. | **SEP:**<br><br>Develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.<br><br>Develop and/or use models to describe and/or predict phenomena. | **SEP:**<br><br>Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed.<br><br>Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. | **SEP:**<br>Extends beyond proficient in any way. |
| **CCC:**<br>Does not meet the minimum standard to receive a 2. | **CCC:**<br>Uses cause and effect relationships to routinely identify, test, and explain change. | **CCC:**<br>Uses cause and effect relationships to predict phenomena in natural or designed systems. | **CCC:**<br>Extends beyond proficient in any way. |

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|---|---|---|---|
| **DCI:**<br>Does not meet the minimum standard to receive a 2. | **DCI:**<br>The faster a given object is moving, the more energy it possesses.<br><br>Energy can be moved from place to place by moving objects or through sound, light, or electric currents. | **DCI:**<br>Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.<br><br>In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide.<br><br>The term “heat” as used in everyday language refers both to thermal motion (the motion of atoms or molecules within a substance) and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures. | **DCI:**<br>Extends beyond proficient in any way. |

**(Student Facing Format on following page)**

# Student Assessment

Name: _____ Date: _____

**Stimulus**

You are  feeling tired at the end of the day and decide to boil some water to make hot chocolate.  As you watch the water heat up, you notice small bubbles forming on the bottom of the pot.  The longer you wait, you see larger bubbles rising to the top of the water.

When the pot is placed on the stove, the temperature is set to deliver a constant source of energy to the pot and water.

Time Lapse Video

Figure 1: Boiling Water

"Boil water" by ilmungo is licensed under CC BY-NC-SA 2.0

Figure 2: Boiling Water

"Boiling Waters-1" by zeevveez is licensed under CC BY 2.0

**Glossary of terms:**
**Density:** how much matter or mass is in a given volume
**Particle motion:** How fast or slow atoms move.
**Thermal energy:** Energy in the form of heat

**Your Task**

In the questions that follow, you will develop a model to explain why the size of the bubbles in boiling water start small and grow larger, rising to the surface, as the duration of time exposed to the hot burner increases.

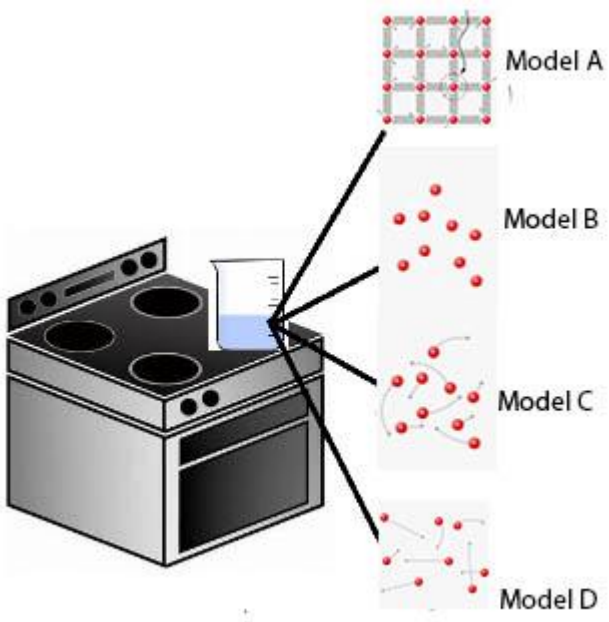
**Question 1**

As heat is added to the water, the water molecules begin to move _____(faster/slower/stay the same).

This causes the density of the water molecules to _____ (increase/decrease/stay the same).

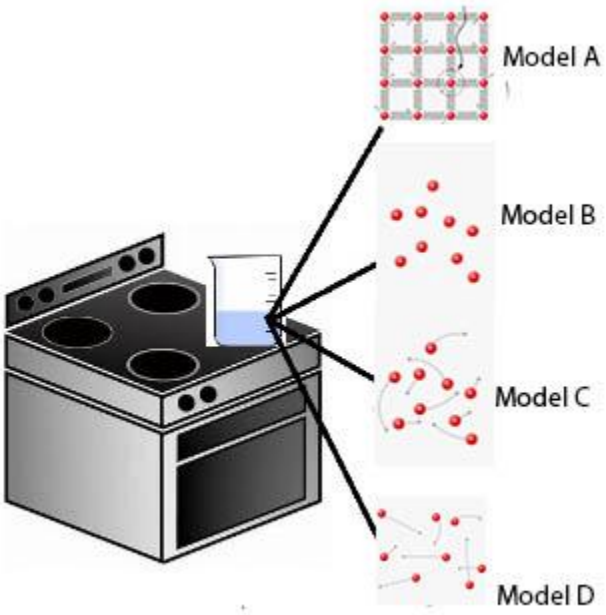
**Question 2**

In the following image, the water has just been placed over the flame. Circle the model that best shows how the molecules of water would appear in its liquid form.



**Question 3**

After the water has a chance to sit over the flame for a while, tiny bubbles start to form near the bottom of the pot. Circle the model that best shows how the molecules would appear inside the vapor.



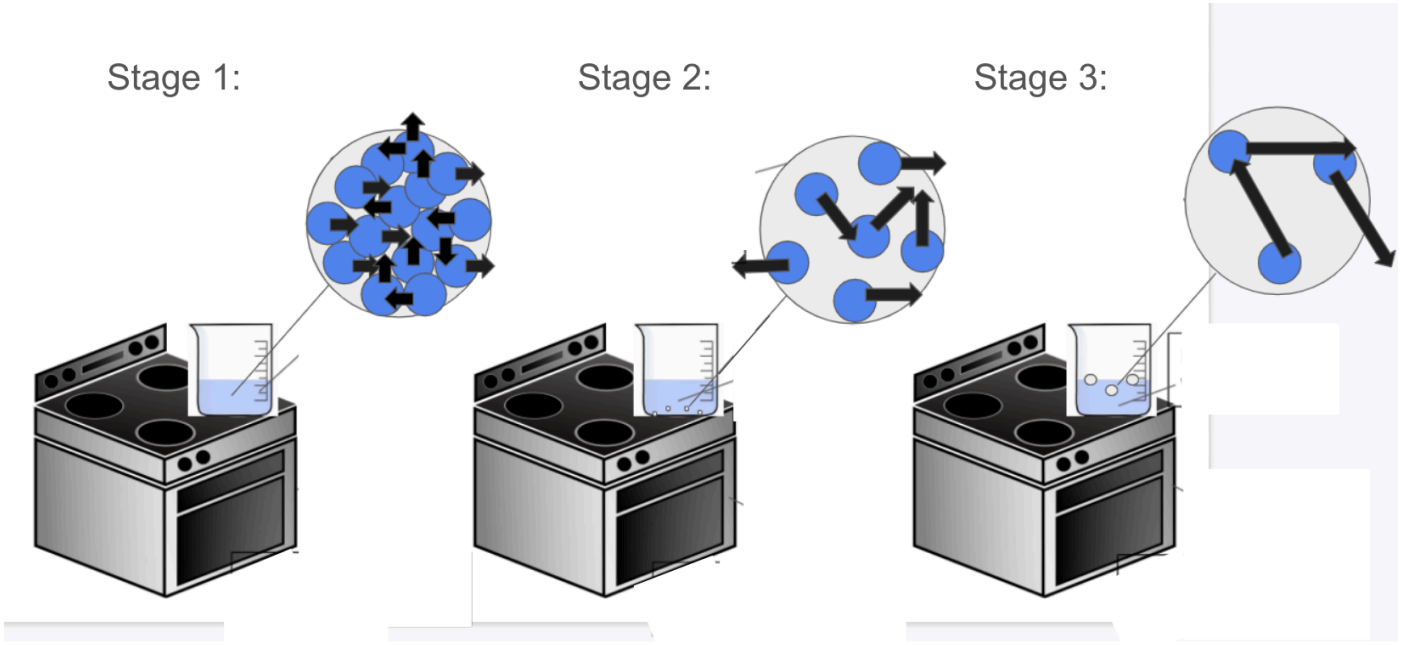

**Question 4**

What do you predict would happen to the particle motion and density of the water if we add ice to the beaker?

The particle motion of the water molecules will (increase/decrease/stay the same)_____ and the density of the water will (increase/decrease/stay the same)_____ because _____.

**Question 5**

Below is a model showing water at three stages. In stage 1, the water is first placed on the stove. In stage 2, the water has just begun to boil. In stage 3, the bubbles are growing and rising to the surface of the water.




You will analyze each of the stages of boiling water above the following figures. You should consider phase, density, particle motion, energy of the water, and energy from the stove. Below, you will be asked about how each stage compares to the other stages by inserting the term from the provided word bank for each blank.

**Stage 1: Water is first placed on the stove**

Using the stage 1 diagram, please fill in the blanks with the best answer.

The phase at stage 1 is _____ (solid/liquid/gas).

The density at stage 1 is_____ (most dense/medium density/least dense).

The particle motion at stage 1 is _____ (fastest/medium speed/slowest).

The energy of the water at stage 1 is _____ (lowest temperature/medium temperature/highest temperature).

The energy from the stove at stage 1 is _____ (constant/increasing/decreasing).

**Stage 2: Water begins to boil**

Using the stage 2 diagram, please fill in the blanks with the best answer.

The phase at stage 2 is _____ (solid/liquid/gas).

The density at stage 2 is _____ (most dense/medium density/least dense).

The particle motion at stage 2 is _____ (fastest/medium speed/slowest).

The energy of the water at stage 2 is _____ (lowest temperature/medium temperature/highest temperature).

The energy from the stove at stage 2 is _____ (constant/increasing/decreasing).

**Stage 3: Water is rapidly boiling, bubbles rising to the top**

Using the stage 3 diagram above, please fill in the blanks with the best answer.

The phase at stage 3 is _____ (solid/liquid/gas).

The density at stage 3 is _____ (most dense/medium density/least dense).

The particle motion at stage 3 is _____ (fastest/medium speed/slowest).

The energy of the water at stage 3 is _____ (lowest temperature/medium temperature/highest temperature).

The energy from the stove at stage 3 is _____ (constant/increasing/decreasing).