

A Model of Matter: Part 8 Getting Students Involved

Over the last several weeks we've looked at some tasks that examine **melting** and **evaporation**. Now is a good time to consider how students might begin their own investigations. Last week we asked you to consider this:

What things should teachers consider when helping students design scientific investigations?

1. identifying the question
2. scoring the question

Let's look at some important issues in student investigations using the following example:

Student activity:

Design an investigation of the effects of variables that influence the rate of evaporation.

Important note: This task would *not* make the cut on a high stakes, large-scale assessment. Without scaffolding and content knowledge, most students would not have the abilities necessary to even start to design the investigation, much less pose a reasonable question.

If we assume that a student has a good understanding of physical properties and changes of state, as well as an understanding of inquiry, the student should, with assistance, have a chance to design an investigation.

The following are some things for teachers to consider when helping students design investigations:

1. Identifying the question

There are many variables students might choose to investigate: some that influence evaporation rate, others that do not.

Some possibilities (listed from more obvious to more sophisticated variables):

- Physical state (i.e., liquids evaporate, solids and gases do not)

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- Surface area exposed
- Temperature
- Substance (e.g., water, cooking oils, alcohols)
- Impurities (e.g., salt, sugar, alcohol in water)
- System (i.e., whether the liquid is in a confined volume)

Types of Questions:

Questions can be either qualitative or quantitative. Qualitative questions are general comparisons; quantitative questions require exact measurements. For instance, when looking at possible effects of added sugar on water evaporation:

- A qualitative question could compare a no-sugar sample of water versus a sugar- water solution. The question could be:

“Does adding sugar affect the rate at which water evaporates?” The answer is either yes or no; only the effect of the *presence* of sugar is important. How much sugar is used or the actual evaporation rates are not issues.

- A quantitative question looking at the same topic might compare evaporation rates of a water sample and three sugar solutions:

“What are the differences in evaporation rates among the following samples: 50 ml distilled water; 50 ml distilled water plus 1T sugar; 50 ml distilled water plus 2T sugar; 50 ml distilled water plus 5T sugar?”

The exact amount of sugar is important, as are any differences in rate. The answer would rank order the different water samples by rate of evaporation.

Quantitative questions are considered more sophisticated; they require a higher level of scientific skill because of the exact measurements needed.

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Possible Questions:

1. Is there any evidence that solids evaporate?
2. How does the surface area exposed to air influence the rate of evaporation? Do the evaporation rates of different substance differ?
3. How do the evaporation rates of substances differ?
4. Does adding an impurity (e.g., salt) to water change the rate at which the water evaporates?
5. How does the mass of salt added to water affect the rate at which the water evaporates?
6. How does confining a liquid in a closed system influence evaporation?

2. Scoring the quality of the questions

- The essential feature of the question is that *an investigation can be designed to seek an answer to it*. Even if the student chooses a variable that does not influence evaporation rate, it should be given credit. Question 1 (above) is an example of such a question. Some critics will argue that this is a poor question, because by definition **evaporation** is the change of state from a liquid to gas. However, it is a reasonable question for youngsters who believe that water disappears from a puddle but have not memorized the definition of evaporation. Also, students who select ice in a freezer to test for "evaporation" will find that the mass of the ice does decrease over time. By definition, however, this is **sublimation**, not **evaporation**. We would argue that this is an OK question because it can be investigated (even if more sophisticated thinkers already know the answer).
- Quantitative questions might be scored higher because of the greater scientific skill required.
- More sophisticated questions (e.g., the effects of impurities; evaporation in closed systems) might be scored higher.

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Scoring considerations:

Design and conduct a science investigation

- Are relevant variables controlled?
- Are necessary quantities measured?
- Is the procedure in a logical order?
- Are observations and data recorded in a clear and unbiased manner?

Use appropriate tools and techniques to gather, analyze, and interpret data

- Is the appropriate tool use to measure quantities? (e.g., thermometer to measure temperature; balance to measure mass)
- Is the data collection organized?
- Is the method of data analysis appropriate?
- Are the interpretations and conclusions supported by the data?

The students should be aware of these guidelines when designing their experiments; these expectations will encourage thoroughness. If your students do create any experiments on evaporation or melting, we'd love to see them!

Send them to <mailto:crsep@schenectady.k12.ny.us>

Coming up

For several weeks we've been discussing our model of matter (tiny particles in motion) in the context of the physical world. But wait! Our model of matter can be used to explain many functions within the living environment as well. We'll look at this next week. In the meantime, consider this:

We want to add **fabric dye to water**, but we're not going stir it to mix it up. (We don't want to clean up the mess from any splashes.) We want the dye to mix uniformly throughout the water.

- Will hot or cold water allow this to happen more quickly?
- How can we use our model of matter to explain this?

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What do the New York State standards say?

In the Elementary and Intermediate Core Curricula, Standard 1, Scientific Inquiry,

Key Ideas state:

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.
2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures...
3. The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

In the Elementary Core Curriculum, Standard 3, The Physical Setting,

Major Understandings state:

- 3.1c Objects have properties that can be observed, described and/or measured: length, width, volume, size, shape, mass or weight, temperature, flexibility, reflectiveness of light.
- 2.1d Measurements can be made with standard metric units and nonstandard units.
- 3.2b Temperature can affect the state of matter of a substance.
- 3.2c Changes in the properties or materials of objects can be observed and described.

In the Intermediate Core Curriculum, Standard 3, The Physical Setting,

Major Understandings state:

- 3.1a Substances have characteristic properties. Some of these properties include color, odor, phase at room temperature, density, solubility, heat and electrical conductivity, hardness, and boiling and freezing points.
- 3.1c The motion of particles helps to explain the phases (states) of matter as well as changes from one phase to another. The phase in which matter exists depends on the attractive forces among particles.
- 3.3b Atoms and molecules are perpetually in motion. The greater the temperature, the greater the motion.

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