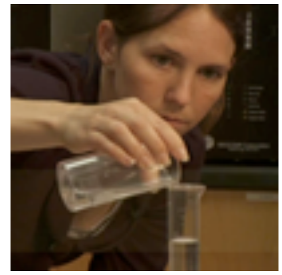
Talk Science

Professional Development

Transcript for Grade 5 Scientist Case: The Mini-Lake Investigations



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1. The Mini-Lake Investigations through the Eyes of a Scientist

We met Dr. Laurie Baise at Tufts University, where she is Associate Professor of Civil and Environmental Engineering and researches the behavior of soil during earthquakes. We asked her to do some of the very same mini-lake investigations the students do in the 5th grade Inquiry Project curriculum. Students begin by building a mini-lake in a sandwich box with sand, gravel, stones and water. They keep track of its weight for many days, and observe changes in the mini-lake due to the addition of salt and the removal of the cover, which changes the mini-lake from a closed to an open system.

This case focuses on the core science concept, weight. **Keeping track of weight is a way to keep track of how much matter is in a system.**

Students use weight data as evidence to support claims about the transformation of materials in the mini-lake. For example, when salt dissolves in the mini-lake it disappears, but students have evidence that the salt is still there, because its weight is conserved in solution. When eventually the liquid evaporates from the mini-lake, students have evidence that all of the water, and only the water, has evaporated because all of the water weight is missing.

In these videos, watch how Dr. Baise grapples with challenges that will confront your students when they work with weight data. Laurie discusses reasons for discrepancies in measurements. She discusses the precision of the scale and rounding errors that arise when she weighs the individual materials and the combined materials in the mini-lake. She uses a graph of weight over time to tell the story of the mini-lake. The better you understand how the scientist reasons about weight data, the better you'll be able to appreciate the development of your students' ideas.

2. How Does a Scientist Think About the Materials in the Mini-Lake?

Watch how Laurie explains patterns in weight and volume data for the mini-lake materials.

Sara: In the inquiry project, students make mini- lakes like this. They make them out of gravel and sand and some mini-stones and some water in a lunchbox. And I'm wondering if you could look at these materials and tell me about them in terms of

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their weight and volume.

Laurie: Three materials weigh the same but as we can see, the volume is slightly different. If we look at the height of the water—so if you want to think about the volume again—the height of the water, and the sand is a little over a half, between half and maybe two-thirds and the same with the gravel compared to the water. So we have less volume of sand and gravel than we do of water.

Sara: In the classroom, the students found the weights and volumes of the water and the sand. And I'm wondering if you'll look at the classroom data and tell me what you see?

Weight and Volume of Water and Sand			
Team	Weight	Water Volume	Sand Volume
Team 1	150g	150cc	94cc
Team 2	150g	149cc	94cc
Team 3	150g	150cc	92cc
Team 4	140g	141cc	87cc
Team 5	140g	141cc	88cc
Team 6	140g	140cc	87cc
Team 7	130g	128cc	82cc
Team 8	130g	130cc	81cc
Team 9	130g	130cc	81cc
Team 10	120g	120cc	75cc
Team 11	120g	120cc	76cc
Team 12	120	122cc	75cc

Laurie: Okay, we had in the classroom, we had twelve teams. If I look at the weights, initially I see that there's three teams that had a hundred and fifty grams, three teams that had a hundred and forty grams, three with a hundred and thirty, and three with a hundred and twenty grams.

When I go next to the water volumes, if you look at any one group—so in the first group where the weight was a hundred and fifty grams, you had two that measured a hundred and fifty cubic centimeters and one that measured a hundred and forty-nine cubic centimeters. And you see that same inconsistency in each of those sets. So that is what we call a measurement error, meaning that even though the weight is the same, and you're measuring the volume there, it's hard to read the graduated cylinder that you are measuring the volume in. So sometimes it's maybe a little bit above or a little bit below, and so when you take that measurement you might get a number that's even a little bit higher or a little bit lower.

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Sara: So is there a big picture that you see in the pattern of weight versus volume for water?

Laurie: Yes. So the weight of the water, because we're measuring in grams and cubic centimeters in terms of weight and water, a hundred and fifty grams of water equals a hundred and fifty cubic centimeters. So that you'll get—one gram equals one cubic centimeter in water. But when you go to the sand, a hundred and fifty grams of sand is here, you get ninety-four, ninety-four, or ninety-two. So the volume of the sand is less, roughly not ninety-three cubic centimeters.

For each of the groups, there is a little discrepancy in volume. It may not be measurement error. It may be the way that the sand is packed in the container. So if it was denser, meaning the sand particles were much closer together, it would take up less space. It would make less volume.

Summary:
- Each material has a characteristic relationship between weight and volume (i.e. density). In the case of water, 1 gram of water is 1 cubic centimeter.
- When sand particles are packed more closely, the same weight occupies a smaller volume.

3. How Does a Scientist Think about Precision of the Weight Measurements?

Watch how Laurie explains rounding errors that arise when she weighs the mini-lake materials.

Sara: So would you build a mini-lake now and talk about the weights and volumes of the materials before you put them in and then as a mini-lake when they're together.

Laurie: Okay, so I'll record the material as we go. So we're going to start with our container. Okay, so the weight of the container is thirty grams.

And then next I'm going to add the sand, make a nice beach for my mini-lake. We're going to add the rocks. Next we have the water. We know the volume of the water is larger than the sand, gravel and rocks. If you remember what it looked like in these containers, there was more volume of water than any of the other materials but we also measured that the weight was the same as the sand and the gravel, so we'll pour that in. And we notice as we pour it in, you can see the water starting to come into the sand. So if you think about your lake, your lake level is lower than all the other materials: the sand, the gravel and the rocks. And at first the sand was dry.

So we poured the water in and the sand was dry. But now we can see that the sand is wet. And probably also what happened is this lake level went down a little bit. So when I first poured it in, it was just on the outside of these materials. But as the water sort of seeped into the sand and the gravel, some of it is now taking up space in there. And so the sand especially is now wet to the touch.

So now if I add the sum of the individual components, I should get the same amount as what I measure by weighing it. So if I add thirty plus one hundred and twenty plus one hundred and twenty plus fifty-nine plus one hundred and twenty, I'm going to get four hundred and forty-nine. Whereas what this is measuring is four hundred forty-seven over four hundred and forty-eight. So what that tells me is that there is a little bit of what's called rounding error, whereas each, even though I measured a hundred and twenty, in each of those there might be a little bit more or a little bit less than a hundred and twenty. So when you add them all together, you may end up getting slightly more or slightly less than the individual components.

Sara: So how much more could it be for each individual thing or how much less?

Laurie: Well our scale is only to a gram, so that's what we call precision, so the precision of the scale can only measure to one gram. So if you go like half a gram over or a half a gram under on each of those measurements, you wouldn't see it when we measure that volume. But when we add them all together, a half a gram for each of those four materials could be up to a two gram difference if you had a little bit more in each one, or two grams less. So there's going to be – – because we're dealing with something that's four hundred and forty-nine grams, one or two grams difference is a very small difference in weight.

Sara: Now sometimes when students see differences between the whole and the sum of the parts, they think it's that the material – – so maybe the sand dissolved in the water or something else got in there or something got out, is any of that a possible explanation?

Laurie: No, that's not possible. We were sitting here; we watched it all go in. I didn't spill any sand on to the table, we poured it all in. So all of the material that we put into the sandbox, or the sandwich box, it has to be in there.

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Summary:

- The scale is precise to 1 gram, so each measurement may differ from the actual weight by up to ½ gram.

4. How Does a Scientist Use Weight Data to Keep Track of Matter?

Sara: I've been weighing a mini-lake that I made and I've been recording the weight in grams every day or every few days. And I've plotted them. And I'm wondering if you could tell me what story this graph tells you about the mini-lake materials in terms of their weights?

Laurie: Okay. Well if we start, we have a graph, we have weight plotted here on the side and we have day along the bottom. And you can see each of these dots tells you when you took a measurement. So you started, the first time you took a measurement, you get four hundred and fifty, so this line is fifty and it's a little bit above that. So let's say four hundred and fifty-two grams for your first measurement and that is the same as what you had measured.

And then as we look across the graph, each time you weighed it with the top on, so your mini-lake has the top on, you get that same four hundred and fifty-two grams. So there's a straight line on the graph. So that tells you that the materials are all still there. So all of the materials that you put in are still there. You get the same weight and you get a straight line.

Then after day seven, it looks like you added something to your mini-lake because there is a vertical jump, meaning that you added something in, you took a new weight. And then after you took that weight, you ended up at just over four hundred and seventy grams. So you added salt to your mini-lake. Then you measured again.

After you added salt, you waited a couple of days and measured again, and again the same weight. So the weight is constant while you have the closed system with the top on, all of the materials in there. You added new material, you add weight. And then as you measure again, you get that flat line.

Sara: So if I took the lid off on the eleventh day, what do you predict would happen to the weight after that? What would the graph look like?

Laurie: Okay. So when we had the lid on, we had those straight horizontal lines and that's when it was a closed system. As soon as we take that lid off, then there's the opportunity for the water to evaporate

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into the air. And so once the lid is off, if we continue to take the weight periodically, maybe every couple of days, and we measure that weight, we'll see that there is a drop-off on the graph. And over time, the water will evaporate into the air and all of the water will leave the system. The rate at which it leaves will depend on the condition of the air. But if we connect those dots, we'll see that it's a relatively straight line and then it will plateau again when all of the water is out of the system.

So the water will be at a hundred and twenty of grams of water in the system. Once we added the salt, we were at four hundred and seventy-two, so four hundred and seventy-two minus a hundred and twenty gets us to three hundred and fifty-two. So we will expect that this will plateau again at three hundred fifty-two. So if we take the measurements after the water has evaporated, we'll expect to get points near three hundred fifty-two.

Sara: So now it's an open system. Before it was a flat line because it was a closed system and nothing could go in and nothing could go out. But now it's an open system.

Laurie: Right.

Sara: So why is it a flat line now?

Laurie: So the water is the only thing that has the ability to evaporate into the air. The sand is not going to evaporate. The gravel is not going to evaporate. The salt is not going to evaporate, and the rocks. The water is the only thing that has the ability to evaporate into the air.

Sara: This is a picture of my mini-lake after two weeks had passed. What do you see?

Laurie: Well the first thing I see, so I see all of your materials. I see sand, gravel, and rock. But then I see that the salt is sort of a crust along the sides of the sandwich box and on top of the sand and rocks. So what I expect happened was that the salt had dissolved into the water when you put it into the system. And then as the water evaporated, the salt was left and it left a crust sort of on the other materials.

Summary:

- Weight data that students collect over multiple days are used as evidence to support claims about transformations in the mini-lake.

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5. How Does a Scientist Think About Graphs and Data Tables?

Notice how Laurie compares the pros and cons of data tables and graphs.

Sara: When I took my data, I recorded the data in a table before I plotted it. And I'm wondering… so these are two different representations of the same data. It tells you the day and it tells you the weight that I recorded. And I'm wondering what you get from these two different representations?

Laurie: Well often we use data tables as a way to record our data. You have nice columns. You record the date where you took your measurement. You have the number, your weight, and you can make notes. This is a nice way to record data. The graph, on the other hand, is a nice visual way to represent the data. So here we have to look at all of the numbers and in our heads see the change in the weight as we go through time. Where on a graph, when we plot weight versus time, we can quickly visually see the change. So is the line straight across? Is there a vertical jump? Is there a slope? And we're much better at looking at a graph of numbers over time than we are a long list of numbers. It takes us longer to process the list of numbers than to see a graph of weights over time.

Sara: So do you prefer looking at a graph or a data table?

Laurie: I prefer to record my data in a data table. With that, I think you are less likely to make a mistake. And then once I have the data table, I like to make a graph and then I use the graph to analyze or process my data.

Sara: Do you make graphs in your own work?

Laurie: I do. I make graphs all the time. We find in our work that, any research that we do, we need to make a visual representation of that research to present to people. So we make graphs over time.

Sara: What specifically? What graph would you make?

Laurie: The graphs that we make over time are-- I study earthquakes, so we look at the ground motion over time. So does it go up? Does it go down? And what does that look like over time?

Summary:
- Laurie uses tables to record data accurately.
- She uses graphs as a visual representation to analyze and present data.