Deeply Digital Student Engagement and STEM Learning with Models and Probes

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Technology's pace today is truly astounding.
STEM Activities?

Empty suitcase
Abundance Activities!
Let Students Dive In!

Using models and probes...
Scientific Practices
(From NRC Framework for Science Education)

• Asking questions / defining problems
• Developing and using models
• Planning and carrying out investigations
• Analyzing and interpreting data
• Using mathematics and computational thinking
• Constructing explanations / designing solutions
• Engaging in argument from evidence
• Obtaining, evaluating, and communicating information
Developing and Using Models
Try some different combinations and see if you can tell when the model reaches equilibrium. (Hint: You may need to wait for a few minutes, and use the graphs to help you know when equilibrium has been reached.)

When the model is stopped, you can drag the mouse over one or more molecules to highlight them.

**What is true of the concentrations when equilibrium has been reached?**

- A. They will be higher inside the cell.
- B. They will be higher outside of the cell.
- C. They will reach a minimum inside and outside.
- D. They will be the same inside and outside.

**What is true of the rate at which molecules move into and out of the cell at equilibrium?**

- A. More move into the cell than out of it.
- B. More move out of the cell than into it.
- C. Equal amounts move into and out of the cell.
- D. They move randomly, so it is not predictable.

Set up the model so that it is NOT in equilibrium. Then use the "snapshot" button below the model to take a picture of your setup. Use the "open" button below to place that image here.

Set up the model so that it is IN equilibrium. Then use the "snapshot" button below the model to take a picture of your setup. Use the "open" button below to place that image here.
The complex peaks and valleys of a protein are made even more distinct by the pattern of charges present at the surface. Every different protein has its own shape and charge pattern, giving it a unique molecular ID. In this way, molecules can recognize each other by both shape and charge.

**Your job:** Compare charges at the surface of the protein with the atoms underneath to understand what causes the charge.

**What to do:** To see underlying amino acids, click in the yellow circles in the model, or use the buttons below. Use the "Sidechain surface" buttons to view the surface color more clearly (solid) or to view the atoms underneath (translucent).

**View:**
- Area #1
- Area #2
- Reset all

**Sidechain surface:**
- Solid
- Translucent

Atom colors: carbon oxygen nitrogen hydrogen
Molecular Workbench Research

• Teachers completing a professional development program and students using a series of Molecular Workbench activities embedded in courses showed statistically significant improvements in content knowledge on a Molecular Concept Inventory (MCI).

• Though students had broad exposure to many topics within the courses overall, student gains on the MCI were related to the number and content of the Molecular Workbench activities they completed.
Your challenge: Find which flower box each Mystery Plant grows best in. When you see flowers click the Make graph button. Then, take a picture. Your picture will be saved in your Lab Book.
Evolution Readiness Research

- Cohorts 2 and 3 had a more complex understanding of evolution than the pre-implementation Cohort 1.
- Students in Cohort 2 and Cohort 3 performed statistically significantly higher on the CIER* than students in pre-implementation Cohort 1 (Effect sizes .46 and .33 SD)

* Concept Inventory for Evolution Readiness
Planning & Carrying Out Investigations
Temperature of mixing water (revised)

Introduction/Discovery Question

In this activity, you will investigate how to predict the temperature when two cups of water at different temperatures are mixed.

How do I mix water in a fish tank to adjust the temperature?

A cold mountain stream flows into a large, warm lake. What effect does the cold mountain stream have on the temperature of the lake?

A pet store manager adds a liter of cold water to a warm 50-liter fish tank to replenish the water supply. What effect does the added water have on the temperature of the tank water?

Try to write a rule for predicting the resulting temperature when two quantities of water at different temperatures are mixed.

Place answer here!

Materials
Designing Solutions
Analyzing & Interpreting Data
The TEEMSS 2 curriculum was found to have potentially positive effects on general science achievement for elementary school students in grades 3–4.

Listed as an effective curriculum in the prestigious What Works Clearinghouse.
The Problem

• Graphs are central to teaching and learning in many STEM courses
• However, many students, at all ages, have difficulty *understanding* graphs and the concepts represented in graphs

SmartGraphs is designed to help students understand graphs and the concepts they represent.
Research Questions

1. What do teachers using SmartGraphs physical science activities believe about the software, including its match to important learning goals for the motion unit of study?

2. Do students who use SmartGraphs activities learn more than comparison students studying the same topic from the same textbooks, but who do not use SmartGraphs activities?
# SmartGraphs Results for Q2
## Pre/Post Gains

<table>
<thead>
<tr>
<th></th>
<th>Experimental</th>
<th>Control</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>5.07</td>
<td>4.30</td>
<td>p = .008</td>
</tr>
<tr>
<td>Multiple-Choice</td>
<td>1.16</td>
<td>1.07</td>
<td>p = .049</td>
</tr>
<tr>
<td>Open-Response</td>
<td>4.19</td>
<td>3.64</td>
<td>p = .043</td>
</tr>
</tbody>
</table>

n=1,686
Maria's Run

Now you that you've had a chance to create position versus time graphs from your own motions, let's look at some graphs that were created by someone running.

Maria ran practice laps around the school track. Her coach recorded the distances she ran after each minute. These data are shown in the graph and the table at right. Remember that the time was recorded in minutes rather than seconds.

Click the point in the graph that shows when and where Maria might have first stopped to talk to her coach.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Pos (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>400</td>
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<tr>
<td>3</td>
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<td>8</td>
<td>1550</td>
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<tr>
<td>9</td>
<td>1800</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Constructing Explanations
Red is temperature change from the starting temperature.

Green is CO2 in air (in ppm)
Blue is CO2 in oceans
Red is temperature rise from the starting temperature. Blue indicates the amount of water vapor in the air.

Green is CO² in air (in ppm) Blue is CO² in oceans
How might the trend shown in the graph affect Earth's temperature in the year 2100?

○ It will increase the temperature.
○ It will decrease the temperature.
○ There will be no effect on the temperature.

Explain your prediction.

On a scale from 1 to 5, how certain are you about your temperature prediction for the future?

○ (1) Not at all certain
○ (2)
○ (3)
○ (4)
○ (5) Very certain

Explain what affects your level of certainty about your prediction for temperature change.
The most urgent issue facing climate modelers today is the effect of humans on Earth's temperature.

Run the model and adjust the "Human-emission" slider to determine how much humans would need to change their CO₂ emissions (as compared to 2010 emissions) to significantly reduce global temperature.

**How much did you need to change human emissions to reduce the average global temperature?**


**Explain your conclusion by describing the experiments that you have run and their outcomes.**


High-Adventure Science Research

- Students significantly improved their scientific argumentation ability before and after all three investigations. The improvement occurred in all four elements of scientific argumentation, i.e. claim, explanation, uncertainty rating, and uncertainty rationale.

  Total effect sizes across all argumentation elements: 0.56 SD, 0.75 SD, 0.81 SD for the three investigations.

- Students retained or even further improved their scientific argumentation after HAS investigations were finished.
Engaging in Argument from Evidence
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This Way To…
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Thanks to our many collaborators, including: Parkland College, NANO-LINK, BIO-LINK, MATEC, OP-TEC, Center for Engineering Education and Outreach at Tufts University, the Boston Museum of Science, Purdue University, Hofstra University, Boston College, BSCS, MMSA, University of California, Berkeley, University of Toronto

And above all thanks to the National Science Foundation.
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ACTIVITY SPOTLIGHT!
Solubility
Explore molecular views of solvents and solutes to explain how substances dissolve, the differing properties of the solid, liquid, and gas phases of matter, and the process of dissolution.

NEWS FROM THE CONCORD CONSORTIUM
Obama Praises Educational Technology at School Piloting Geniverse
President Obama praised the virtues of educational technology during a March 8 visit to TechBoston Academy, one of six schools in the New England area participating in the Geniverse Project.
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