

Choosing Classroom Resources: What Our Research Shows

A Guide for High School Science Teachers from
Molecules & Minds at NYU's CREATE Lab

Consortium for Research and Evaluation of Advanced Technologies in Education

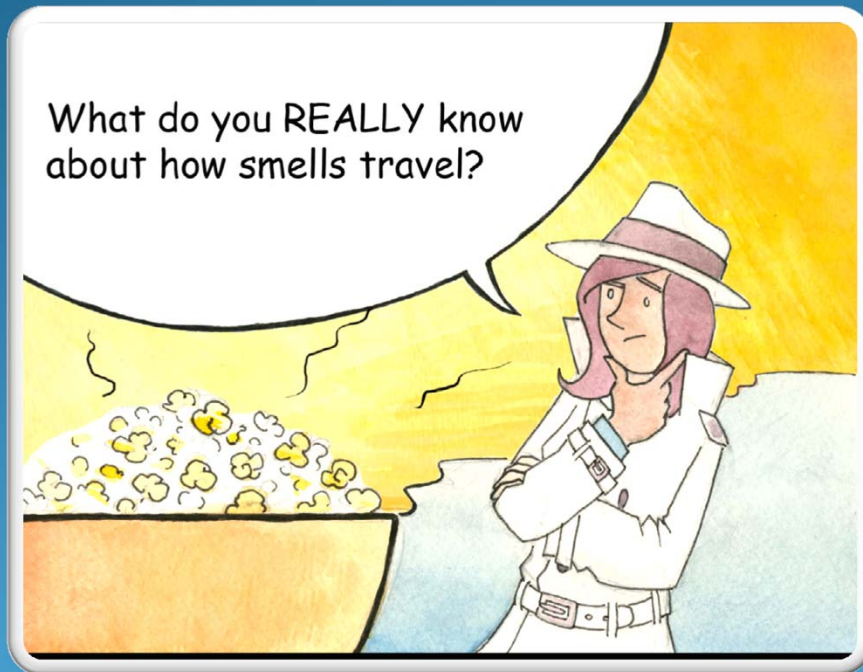


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Some Key Questions



- Who are my learners?
- What is the learning context?
- What strategy will be most helpful?

- We grappled with these questions as we designed the *Molecules and Minds* simulations

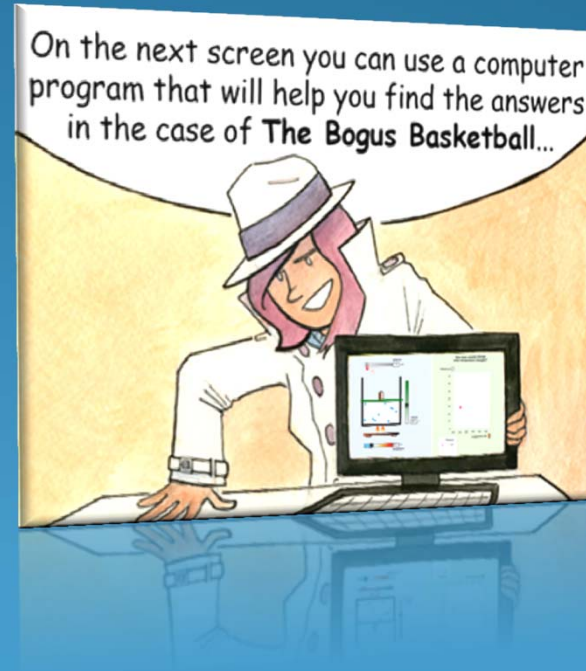


- As you make your own judgments about what resources to use, here are some things we learned through our research

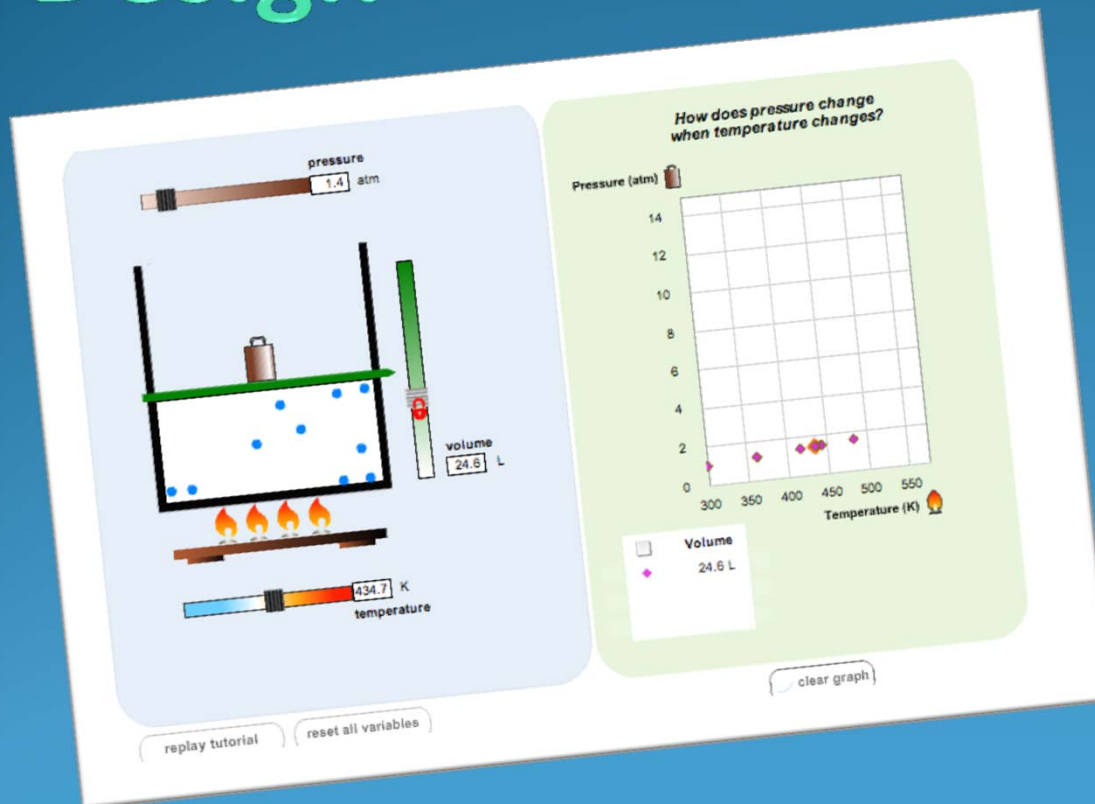
Levels of Representation

What does the resource look like?

- Simulations are more effective than pictures
- But what should they look like?
- We found that:



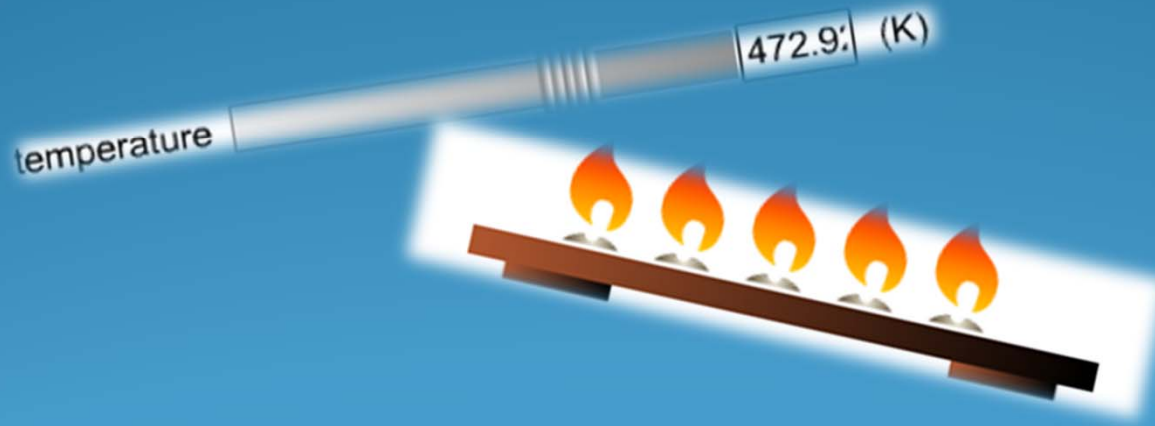
1. Big Ideas Need a Simple Design



- Why? Because bombarding the learner with unnecessary information inhibits learning.

- When you look for resources, think about clear and uncluttered!

How is the information represented?



- We found that:

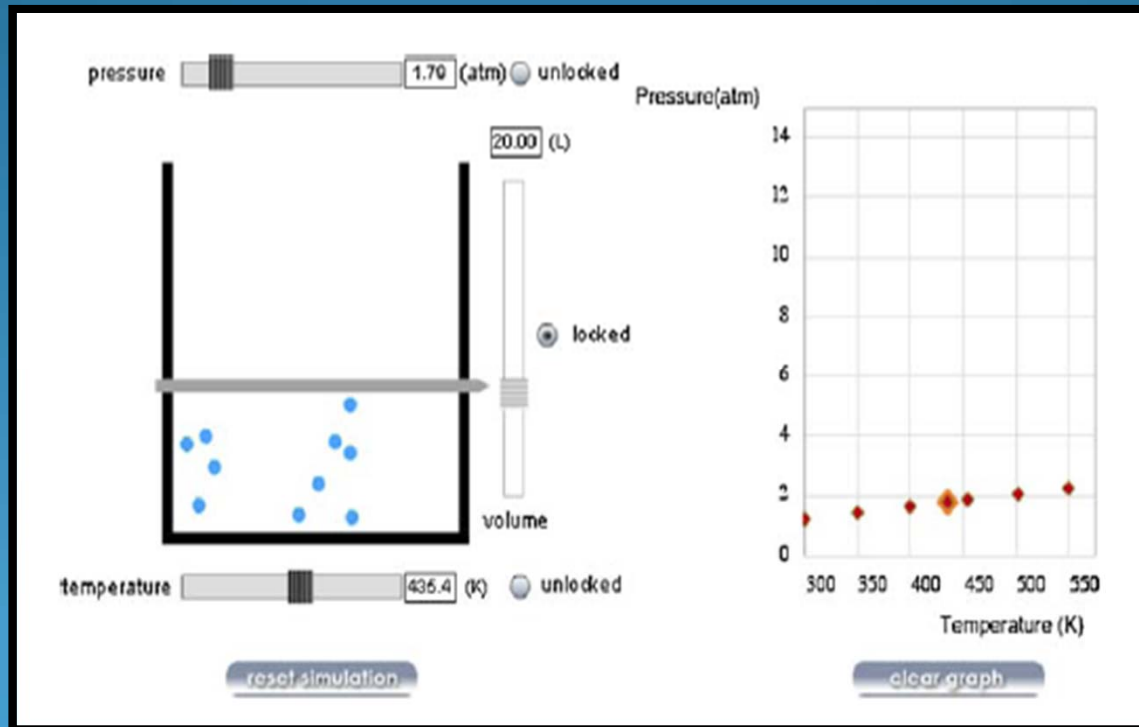
2. Icons Work Better than Symbols

- Why?
- Because icons have culturally accepted meanings.



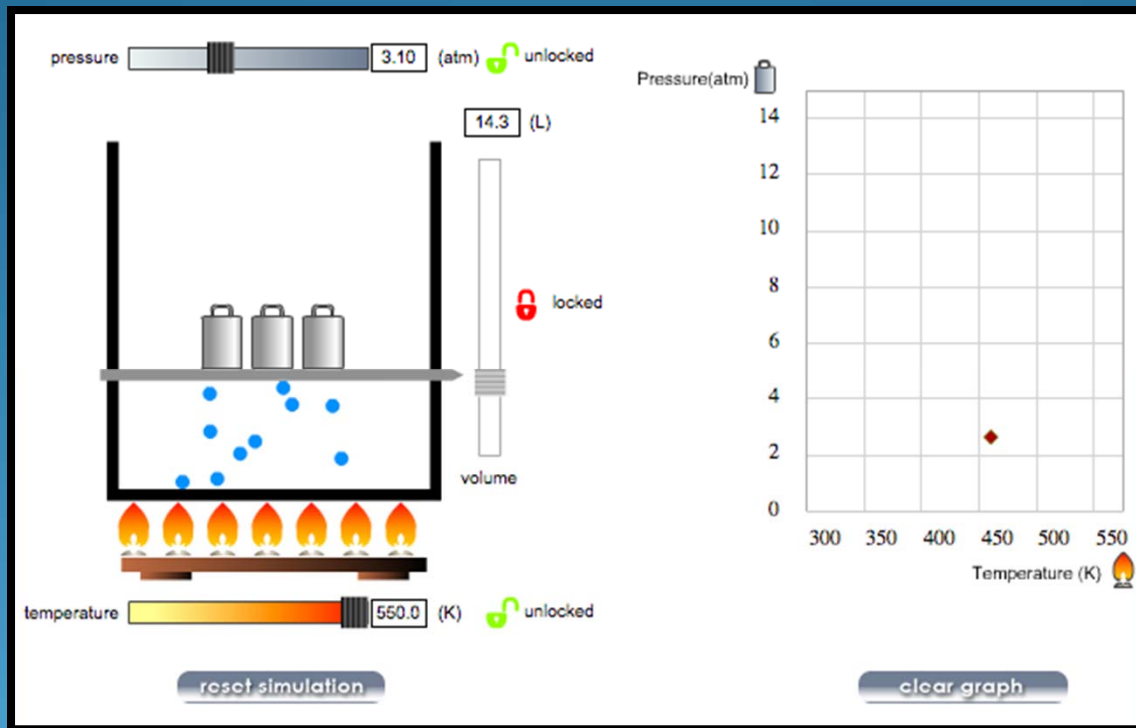
Symbolic

- Words are complex symbols that must be decoded



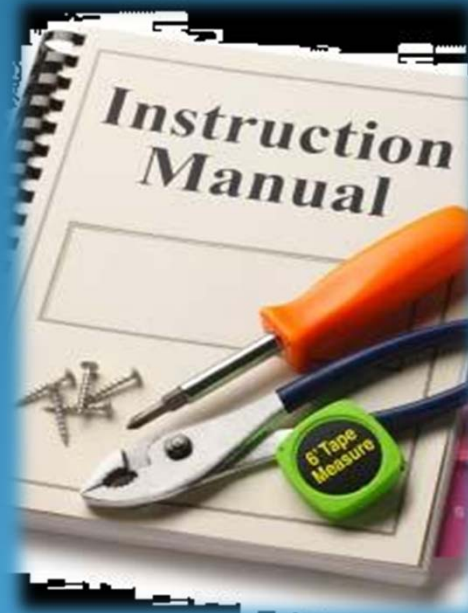
Iconic

- Icons are culturally understood representations



- When you look for resources, consider iconic representation!

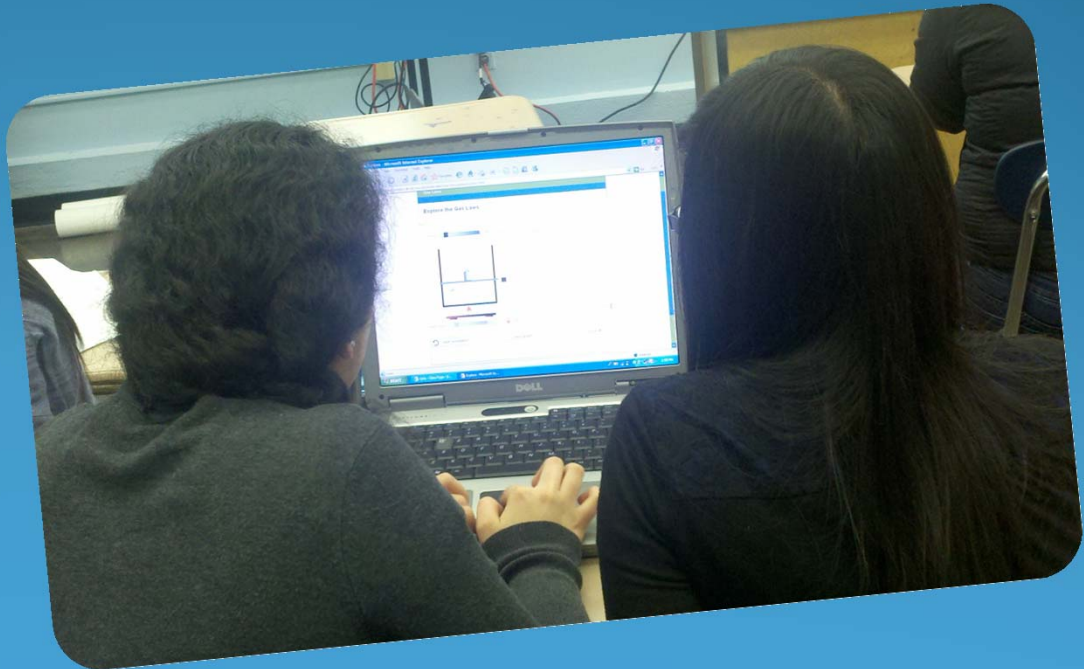
What learning strategies work best?



We found that:

3. Freedom to Explore Supports Learning and Engagement

- Why? Because all learners value the opportunity to explore in a safe environment (even if they are not aware of it).

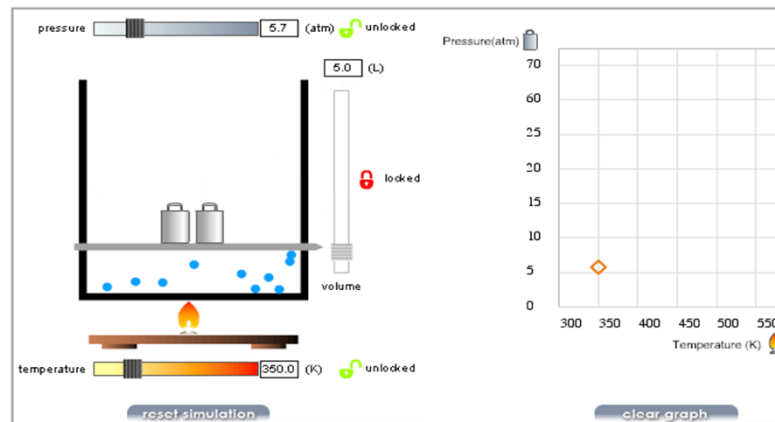


Worked-Out

- Learners follow step-by-step instructions

Suppose you wish to work out how the gas *pressure* changes when you change the *temperature*. In this case the volume of the gas remains constant. For each step in the simulation, click the numbered item to watch the video. Enter the result in your chart for pressure and temperature. You can watch the video again by clicking the text again.

- 1 Select a value for the volume and lock it.
Set the volume to 5 L and lock it.
- 2 Select a value for the temperature.
- 3 Check the value for the pressure.
- 4 Increase the temperature.
- 5 What happens to the pressure?
- 6 Increase the temperature further.
- 7 What happens to the pressure?
- 8 Decrease the temperature.
- 9 What happens to the pressure?



Exploratory

- Learners figure it out independently

When exploring a system with many variables, a good strategy is to change only one variable to observe its effects on another variable. Try locking one of the variables and explore how changing one variable affects the other unlocked variable.

For example, work out how the gas pressure changes when you change the volume (with constant temperature).

- How will it change if you double the volume? Record the results in your chart.
- Explore other relationships between other variables and record the results in your chart.

Feel free to explore the simulation. You can set as many values for the gas characteristics as you wish; remember that several values are needed for each chart to obtain a good graph.

Do not proceed to the test before you have explored the gas characteristics thoroughly and completed all the charts.

The simulation interface includes a central diagram of a gas cylinder with a piston, containing blue dots representing gas particles. A flame is shown below the cylinder, indicating heating. To the left of the cylinder are sliders for 'pressure' (set to 1.4 atm, unlocked) and 'temperature' (set to 350.0 K, locked). To the right is a 'volume' slider (set to 20.0 L, unlocked). On the far right is a graph with 'Volume(L)' on the vertical axis (0 to 70) and 'Pressure(atm)' on the horizontal axis (0 to 10). At the bottom are buttons for 'reset simulation' and 'clear graph'.

- When you look for resources, consider exploratory learning!

What sequence of topics makes sense?

D
C
A
B
E

B
A
D
E
C

C
E
B
A
D

A
B
C
D
E

We found that:

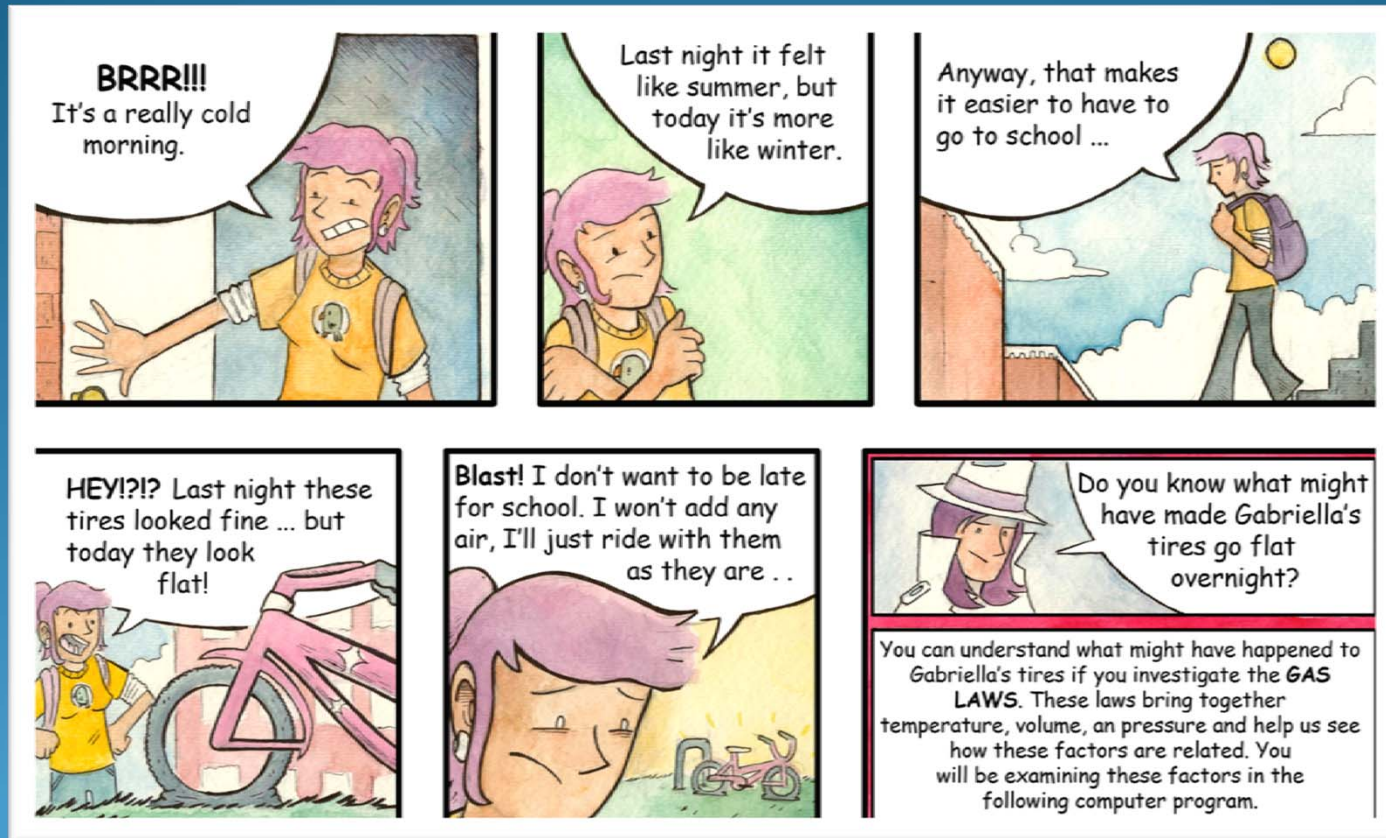
4. The Order of Topics May Be Important for Learning

Why? Because learning complex theories will be more effective if the learner understands the underpinning concepts.

1. Diffusion	2. Kinetic Molecular Theory	3. Gas Laws	4. Phase Change
Particles in gases and liquids move randomly and quickly	Temperature affects the motion of particles	The behavior of gases is affected by pressure, volume, and temperature	Intermolecular forces
Motion is affected by particle size and temperature	The number of particles affects the motion of particles	If you want to make an argument for the relation between variables, one must be held constant in order to explore the affect of one upon the other	When particles exist as solids and liquids, there are forces of attraction between the particles that must be broken by heat.

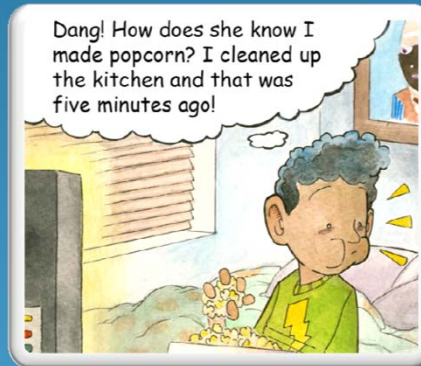
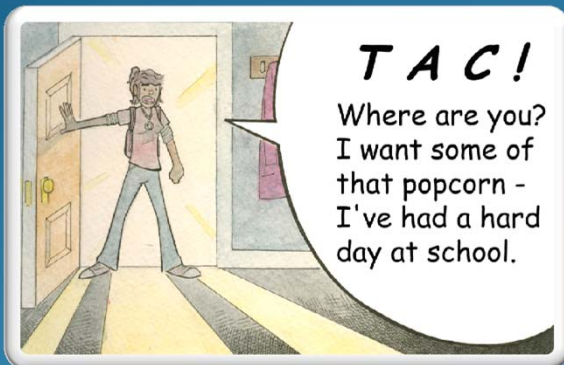
- When you look for resources, does the order of topics make sense?

How is the material contextualized?



We found that:

5. A Problematizing narrative leads to better outcomes



Why? Problematizing narratives create a motivation to learn and help expand science learning from the classroom/lab into the outside world

When you look for resources, consider a problematizing narrative that connects science concepts with students' real-life experience

References

Big Ideas/Simple Designs:

Lee, H., Plass, J. L., & Homer, B. (2006). Optimizing cognitive load for learning from computer science simulations. *Journal of Educational Psychology*, 98, 902-913.

Icons/Symbols:

Plass, J.L., Homer, B.D., & Hayward, E. (2009). Design factors for educationally effective animations and simulations. *Journal of Computing in Higher Education*, 21(1), 31-61.

References

Exploration/Worked-Out

Homer, B., Plass, J.L., Milne, C., & Jordan, T. (2009). Icons and exploration: How interactions between learner characteristics and instructional design features affect learning in chemistry simulations. In S.C. Kong et al. (Eds.) *Proceedings of the 17th International Conference on Computers in Education [CDROM]*. Hong Kong: Asia-Pacific Society for Computers in Education.

References

Order of Topics/Problematizing Narrative

Plass, J.L., Milne, C., Homer, B.D., Schwartz, R.N., Hayward, E.O., Jordan, T., Verkuilen, J., Ng, F., Wang, Y., & Barrientos, J. (2012). Investigating the effectiveness of computer simulations for chemistry learning. *Journal of Research in Science Teaching*, 49(3), 394-419.

Simulations Produce Better Learning:

Hoffler, T.N., & Leutner, D. (2007). Instruction animation vs. static pictures: A meta-analysis. *Learning and Instruction*, 17, 722-738.