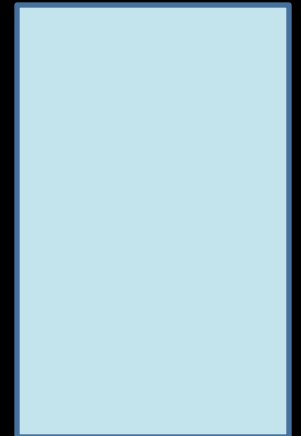
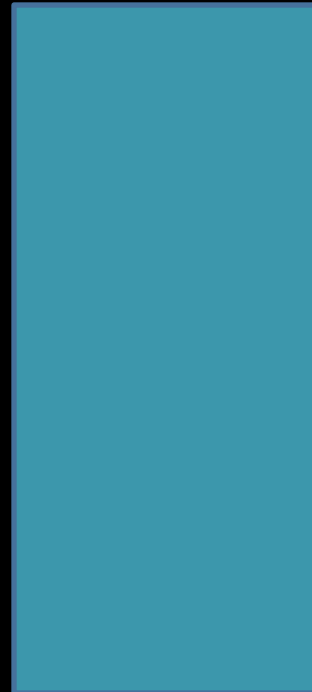


**Online Inquiry Learning:
Making Inquiry Easy with
Online Units Featuring
Visualizations, Debates,
and More**



Online Inquiry Learning

Promoting Integrated Understanding

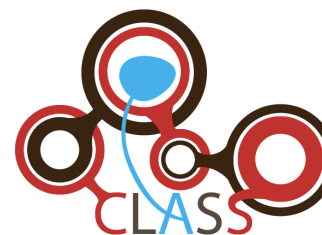
Marcia C. Linn

University of California, Berkeley

STEM Smart Conference

University of Nevada, Las Vegas

September 19, 2012



Web-based Inquiry Science Environment

The screenshot displays the WISE v4 interface. At the top, a navigation bar includes 'Full Screen', 'Ideas (0)', 'Add Idea', 'My Work', 'Flagged', and 'Home / Sign Out'. The main content area is titled 'What makes a good medicine?: Investigating mitosis and cell division processes [EB]'. It features a central image of a plant cell labeled 'A' and a section titled 'MAKE SOME OBSERVATIONS' with instructions to press 'PLAY' to watch an animation of mitosis. A 'Hints' button is visible in the top right. A callout box labeled 'Inquiry Map' points to a sidebar menu with items like 'What is cancer?', 'The Phases of Cell Division', 'Trade offs, side effects', and 'Investigating Plant A'. Another callout labeled 'Hints' points to a 'Hints' window showing a panda icon and the text: 'To keep your basket organized, type "Plant 1" as a tag for each new observation you make from this animation.' A third callout labeled 'Embedded Assessments' points to a 'Reflection Note: Would you recommend Plant A?' window with a 'QUESTION' field containing the text 'What are your recommendations for this plant as a possible medicine? Give reasons for your recommendations.' and a 'RESPONSE' text area. A fourth callout labeled 'WISE Evidence' points to a diagram of a chromosome with a red circle around it, located within an animation player that has 'Back', 'Stop', and 'Play' buttons. The bottom of the reflection window shows 'SAVE CHANGES' and 'SAVE & CLOSE' buttons, along with the text 'This is your first revision.'

Elicit Ideas

Add ideas

Distinguish Ideas

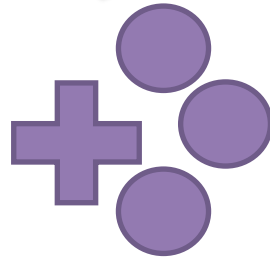
Sort Ideas

WISE Units Follow Knowledge Integration Framework

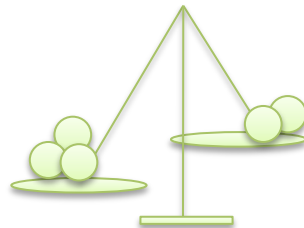
Elicit Ideas



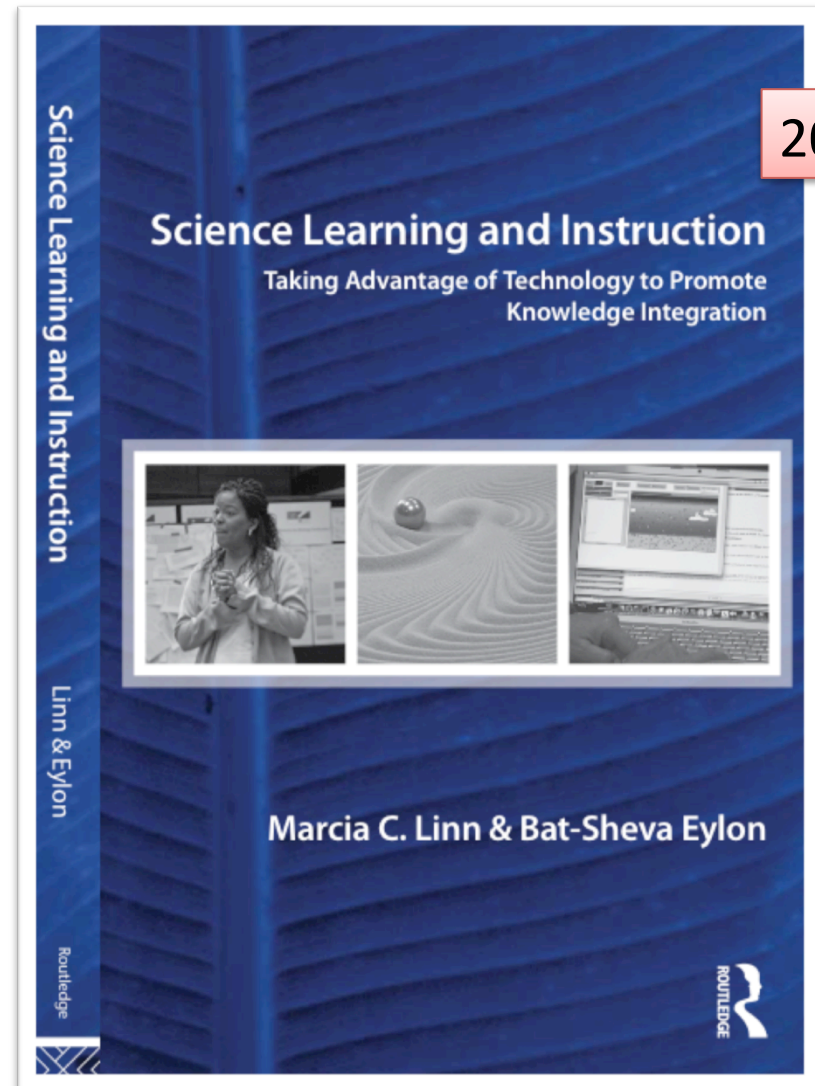
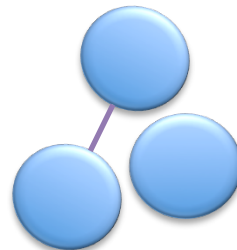
Add ideas



Distinguish
Ideas



Sort Ideas

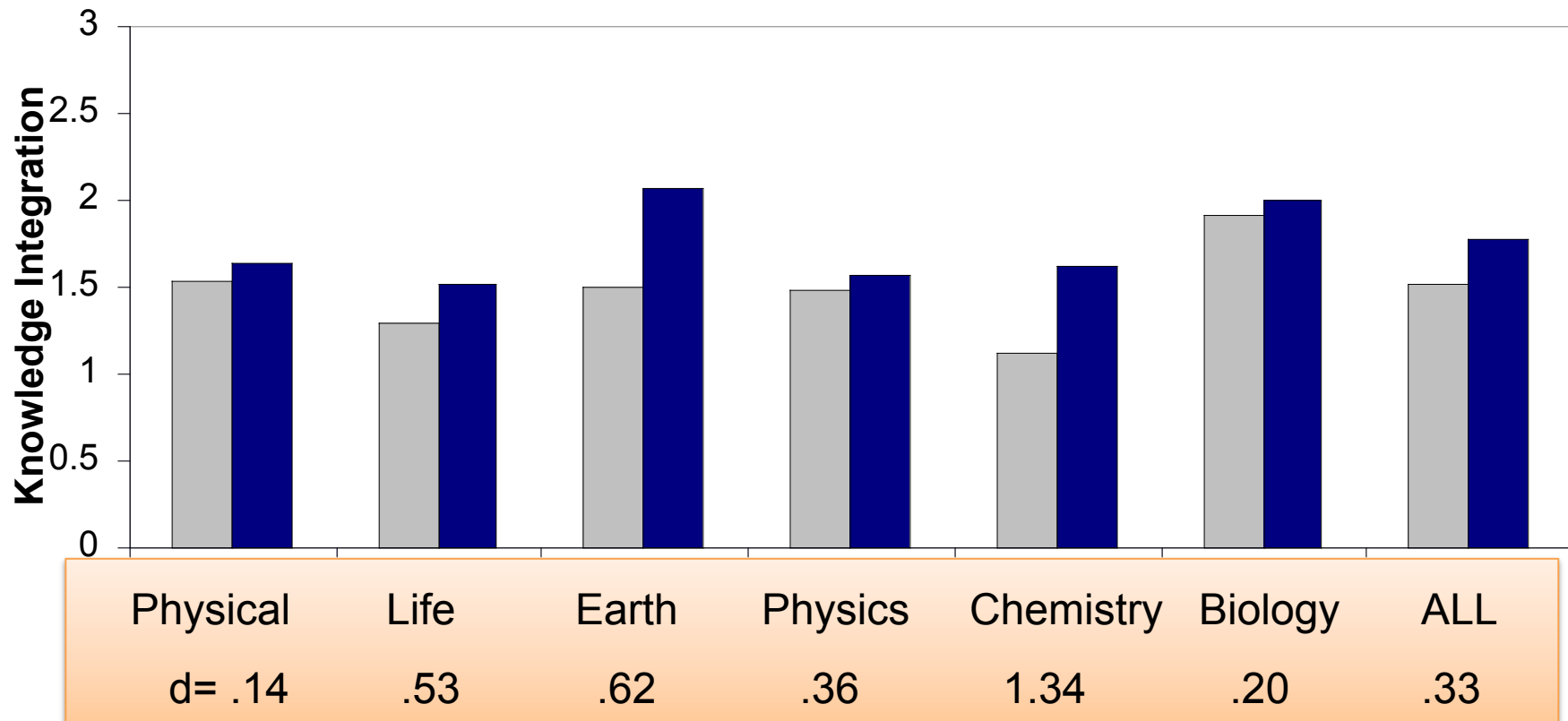


WISE Versus Typical Cohort

100s of teachers and 1000s of students benefit from WISE Inquiry Units



Hee Sun Lee



Linn, M. C., Lee, H.-S., Tinker, R., Husic, F., & Chiu, J. L. (2006). Teaching and Assessing Knowledge Integration in Science. *Science*, 313, 1049-1050

Standardized Assessments Fail to Measure Integrated Understanding

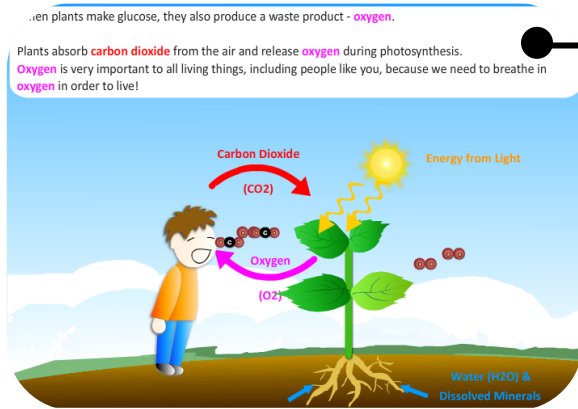
1. What is the main function of chloroplasts in a plant cell?
 - A. absorb light energy and manufacture food
 - B. remove waste from the cell
 - C. manufacture chemical energy from food
 - D. control the shape of the cell

ItemID DD.1005641
Correct A
Standard(s) SCI.7.LS.1.d (7)

**Standard
measured
by the
item**

1d Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.

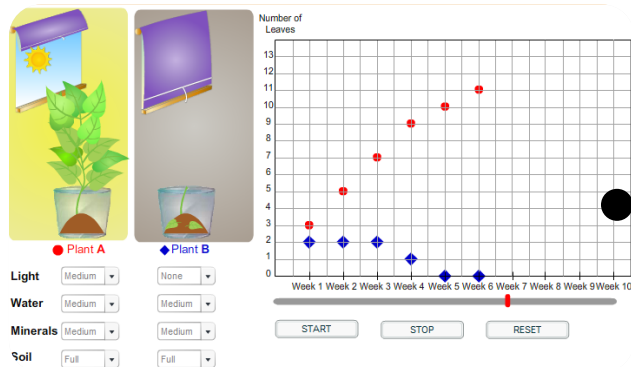
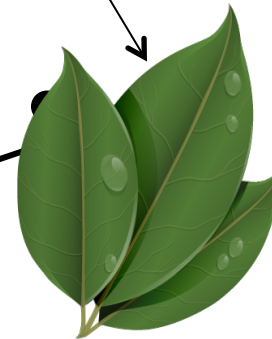
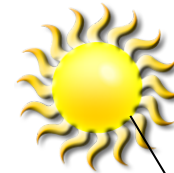
WISE Units Use Inquiry to Promote Knowledge Integration: Photosynthesis



Activity 1:
Where Does Energy
Come From?

Activity 2:
How Is Energy
Transformed?

Activity 3:
Where Does Energy
Go?



Light Energy

Carbon Dioxide (CO₂)

Water (H₂O)

Oxygen (O₂)

Glucose

Chlorophyll

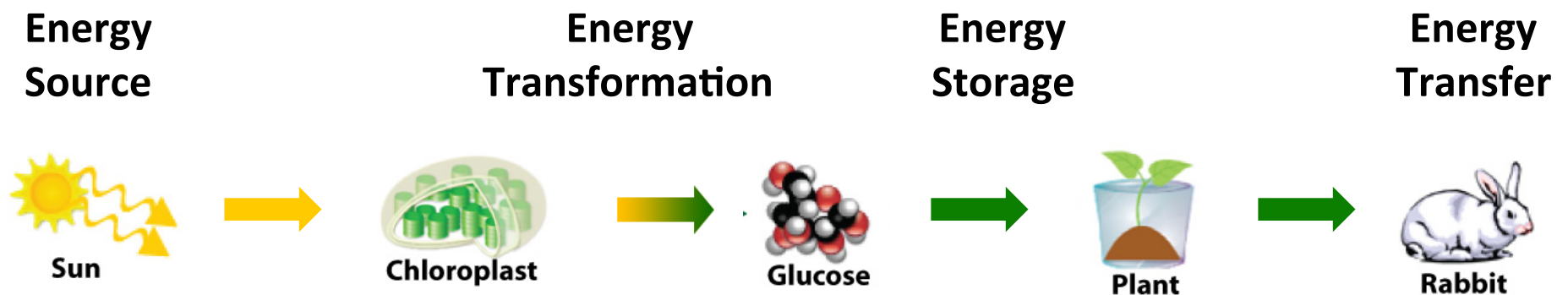
Chloroplast

Energy Stories and Concept Maps

Measure Knowledge Integration

Write a story about how the rabbit gets and uses energy from the sun.

- Where does energy come from?
- How does energy move?
- Where does energy go?
- How does energy transform/change?



Energy Stories

- Sophisticated Response

The energy comes from carbon dioxide water and light energy. The light energy breaks apart the carbon dioxide and the water molecules to form glucose and oxygen. That means it changes to chemical energy from light energy. The glucose is what makes the plant grow and live. When the rabbit eats the plant it is eating the nutrients that the sun helped the plant make.

Typical Student Progress When Studying WISE Photosynthesis

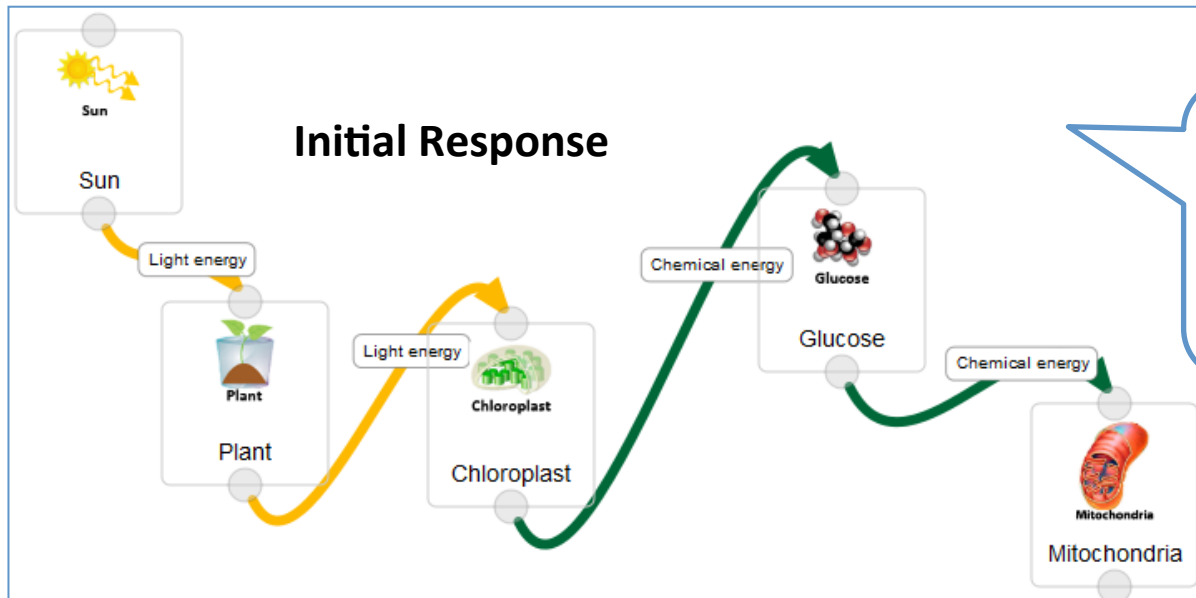
Pretest	The rabbit eats plants. Those plants got energy from the sun. The solar rays hit the chloroplasts, which converted it into glucose so that the plant could grow.
Photosynthesis Posttest	The energy comes originally from the sun. It comes to earth in the form of light energy. This energy is absorbed by the chloroplasts in the plant's leaves. Inside of these chloroplasts, the light energy combines with water and carbon dioxide from the roots and breaks them apart, in the meantime transforming into chemical energy. The atoms that previously made up carbon dioxide and water rearrange into glucose and oxygen. The chemical energy enters the glucose, and when the rabbit eats the plant, the glucose containing chemical energy is what the rabbit gets and uses.
Cell Respiration posttest	The energy originally comes from the sun, in the form of light energy. While it is in the chloroplasts, it breaks up CO₂ and H₂O molecules, and in the meantime converts into chemical energy. When glucose forms from the CO₂ and H₂O's atoms, the chemical energy then enters the glucose. In the mitochondria, the glucose molecules are broken up and this chemical energy is released to be used by the plant or stored. When the rabbit eats the plant, it is harvesting the chemical energy that has already been released, as well as the energy that is still in the glucose, all of which it can use to function and live.

Elicit Ideas

Add ideas

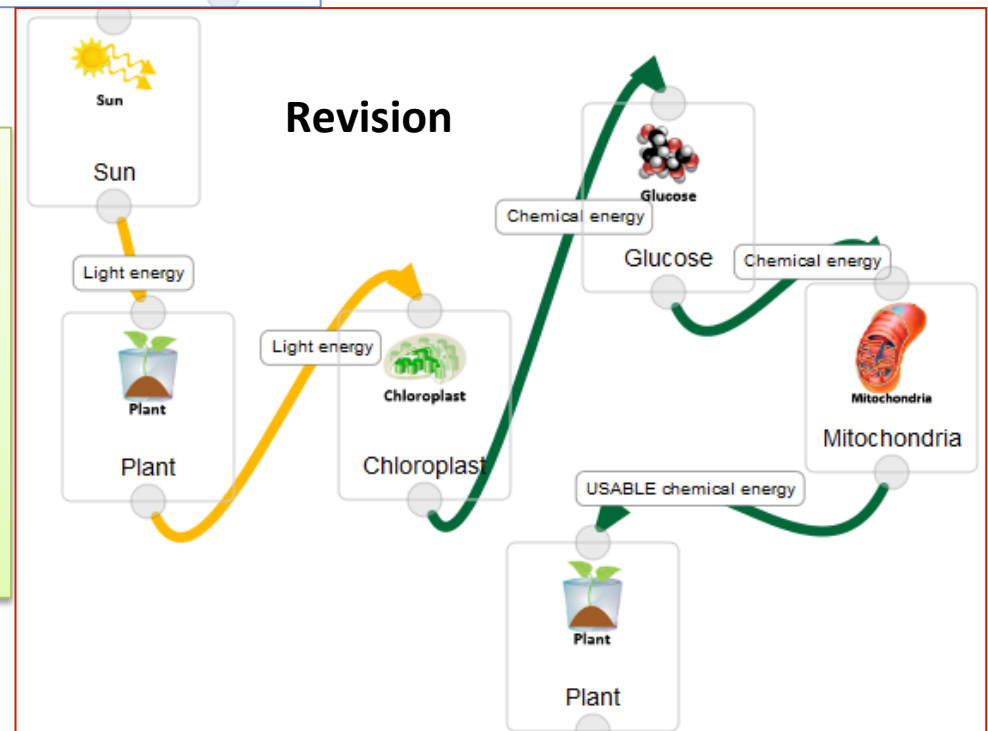
Distinguish Ideas

Sort Ideas



Good progress! Now review the visualization in **Step 3.9** to find out what mitochondria do during cellular respiration and improve your diagram.

My System Diagram and Knowledge Integration Guidance



Research Can Improve Inquiry Units

Are Dynamic Better than Static Visualizations of Photosynthesis?



Kihyun Ryoo



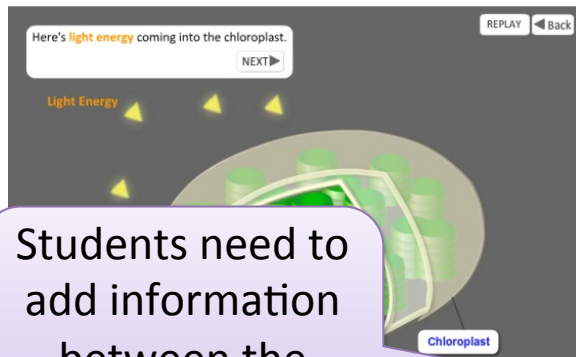
Ryoo, K. L., Linn, M. C. (2012). Can dynamic visualizations improve middle school students' understanding of energy in photosynthesis? *Journal of Research in Science Teaching*, 49(2), 218-243. doi: 10.1002/tea.21003

Static Pictures

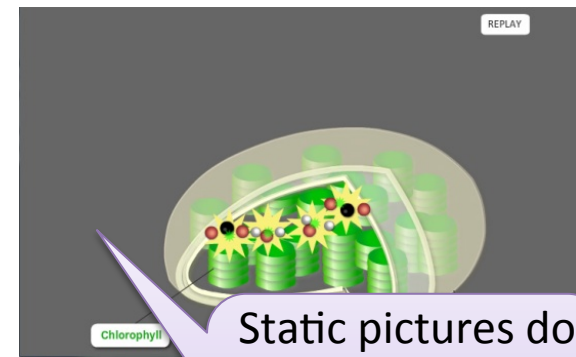
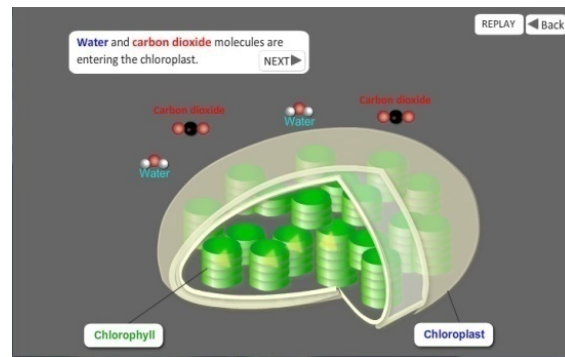


Kihyun Ryoo

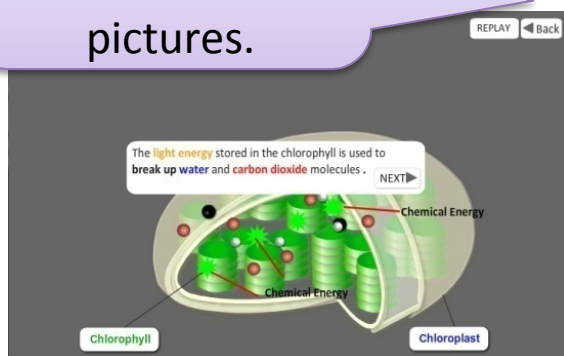
- Static Pictures Highlight Essential Information
- Static Pictures Draw on Skill in Using Text



Students need to add information between the pictures.

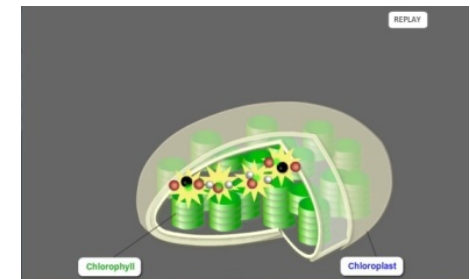
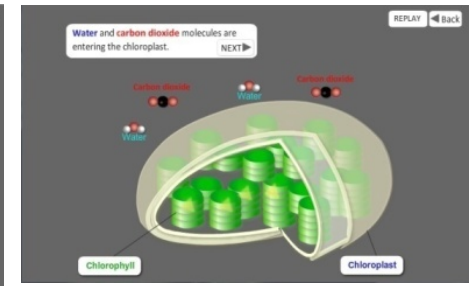
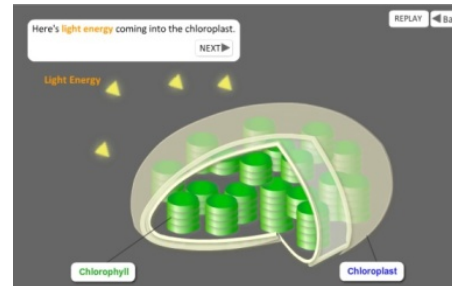
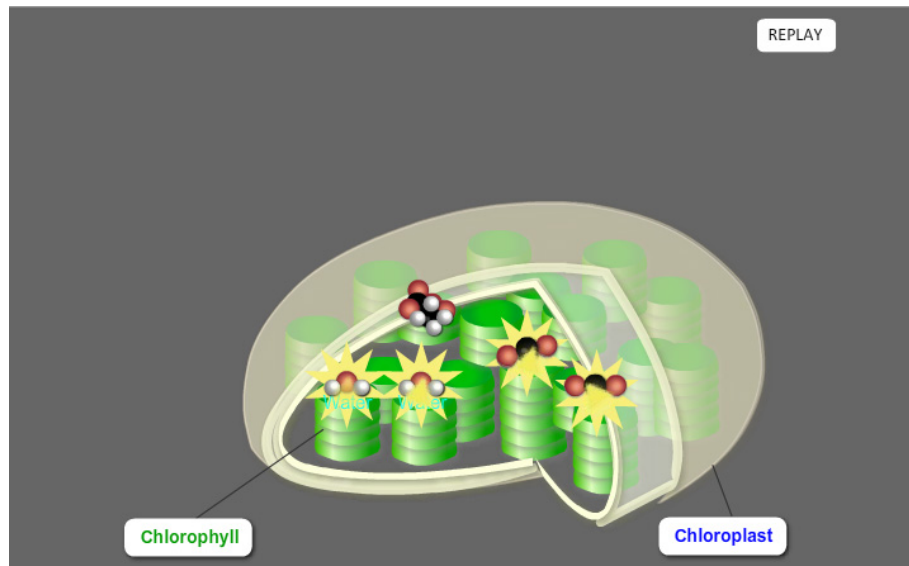


Static pictures do not show continuous movements.



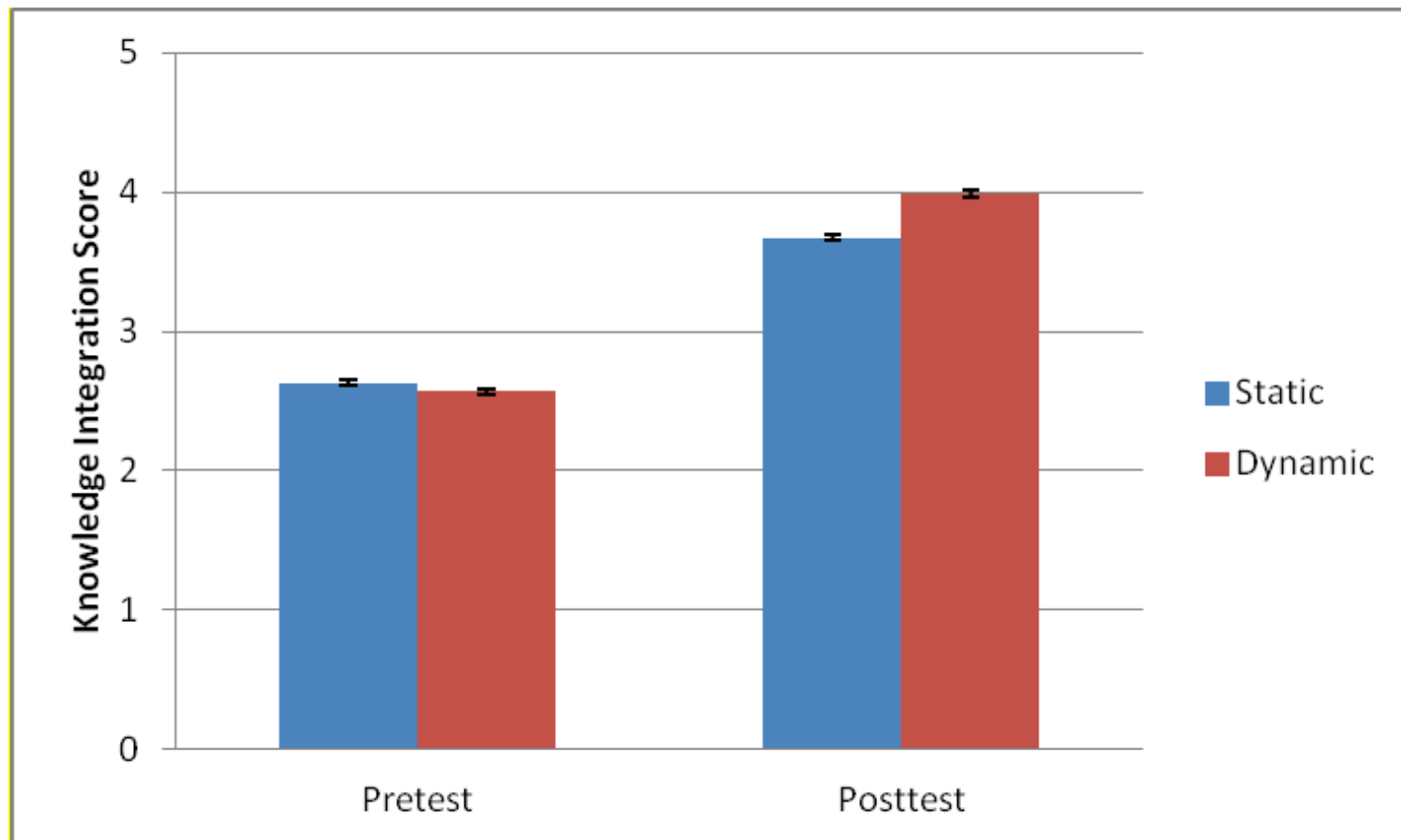
Both Visualizations Add New Ideas

- Both static and dynamic visualizations can add new ideas to students' repertoire of ideas.



Pre-Posttest Performance

- Significant advantage of dynamic visualization: $F(1,148) = 10.30, p < .01$



Elicit Ideas

Add ideas

Distinguish Ideas

Sort Ideas

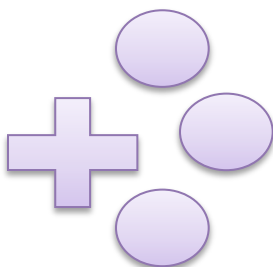
More Research on Inquiry Guidance

Draw versus Explore Visualization

Elicit Ideas



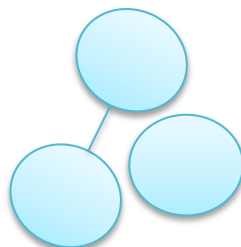
Add ideas



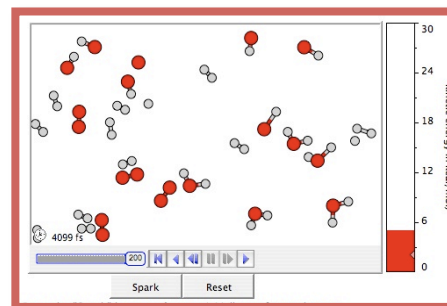
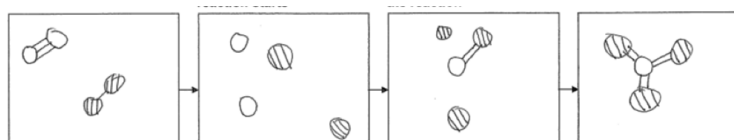
Distinguish Ideas



Sort Ideas



Students predict how chemicals will react.



Step 1: Before the reaction starts.



Draw versus Explore

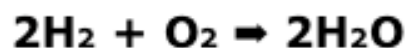
Based on what happened to the speed and temperature of the atoms in the simulation, what happens to atoms and molecules in an explosion?

In an explosion, atoms...

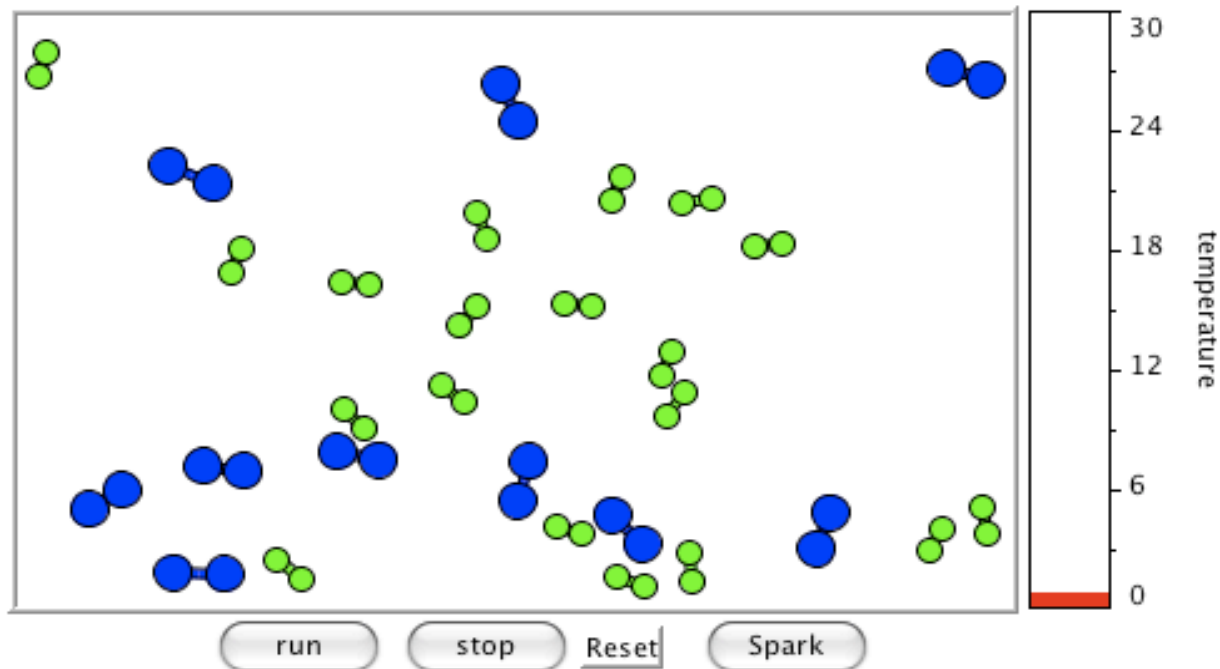
Molecular Visualization Should Students Draw or Explore?



Helen Zhang

**Instructions:**

1. Run the model.
2. Then press the spark button to initiate the reaction.

KeyHydrogen molecule  (H₂)Oxygen molecule  (O₂)Water molecule  (H₂O)

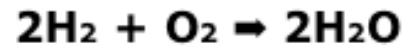
Molecular Workbench developed by the
Concord Consortium

Virtual Experiment



Jennie Chiu




Without the spark there is no combustion

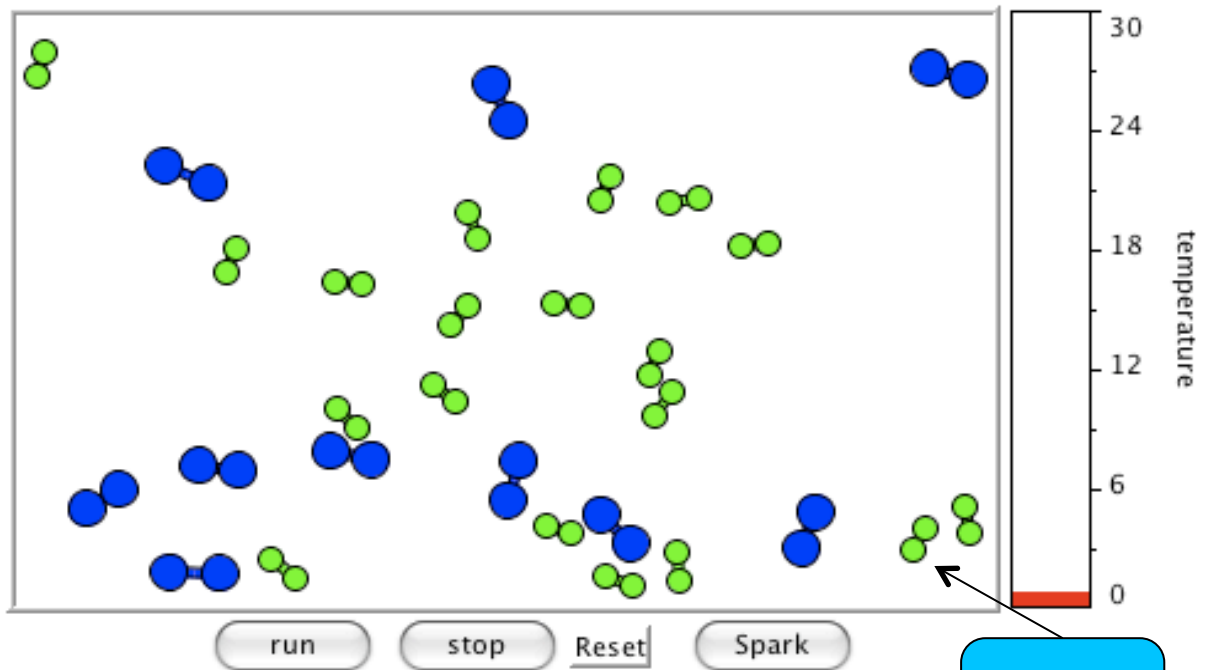


Instructions:

1. Run the model.
2. Then press the spark button to initiate the reaction.

Key

- Hydrogen molecule  (H_2)
- Oxygen molecule  (O_2)
- Water molecule  (H_2O)



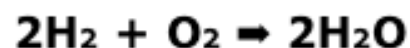
Kinetic Energy

Virtual Experiment



Jennie Chiu

With the spark there is combustion. What differences do you observe?



Instructions:

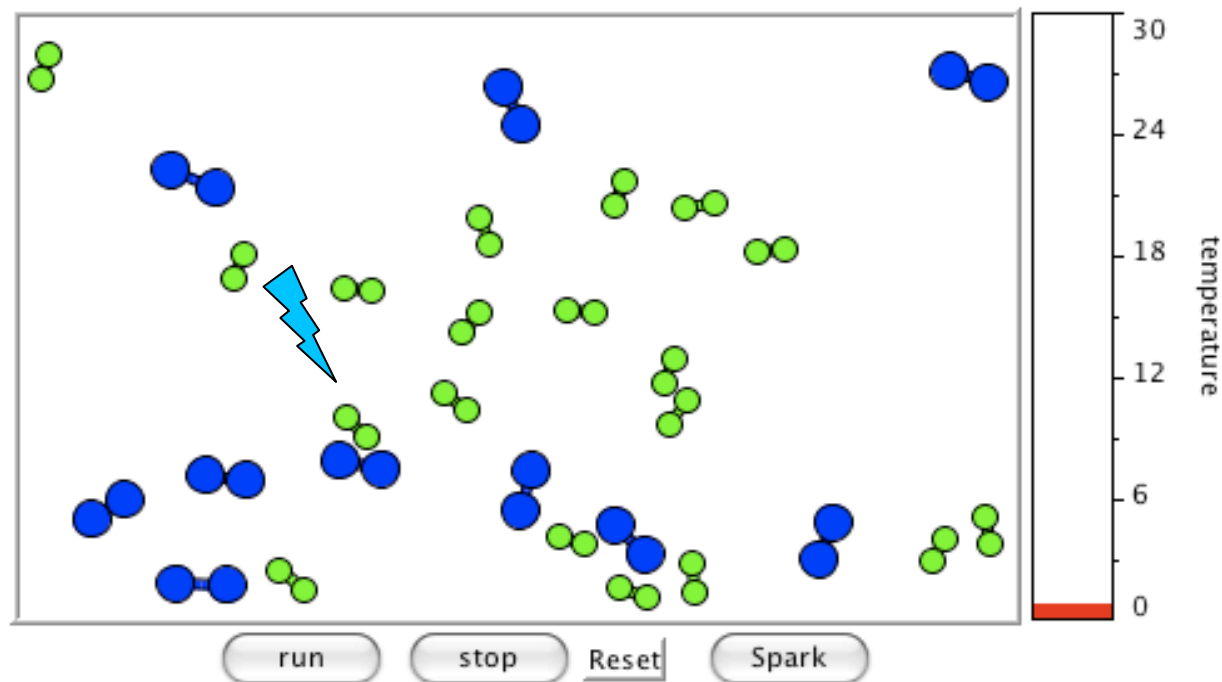
1. Run the model.
2. Then press the spark button to initiate the reaction.

Key

Hydrogen molecule  (H₂)

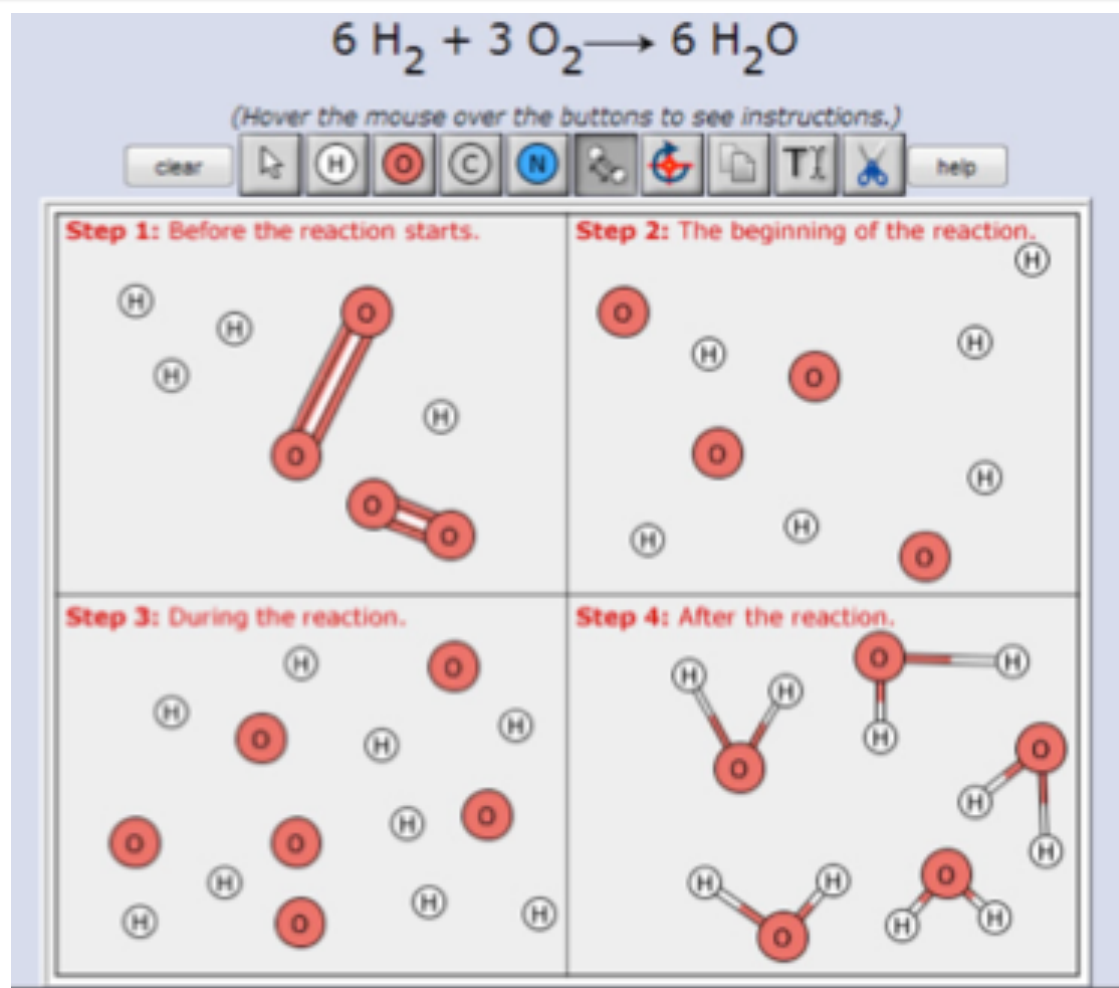
Oxygen molecule  (O₂)

Water molecule  (H₂O)



Students Explore the Visualization or Draw their Ideas using WISE Draw

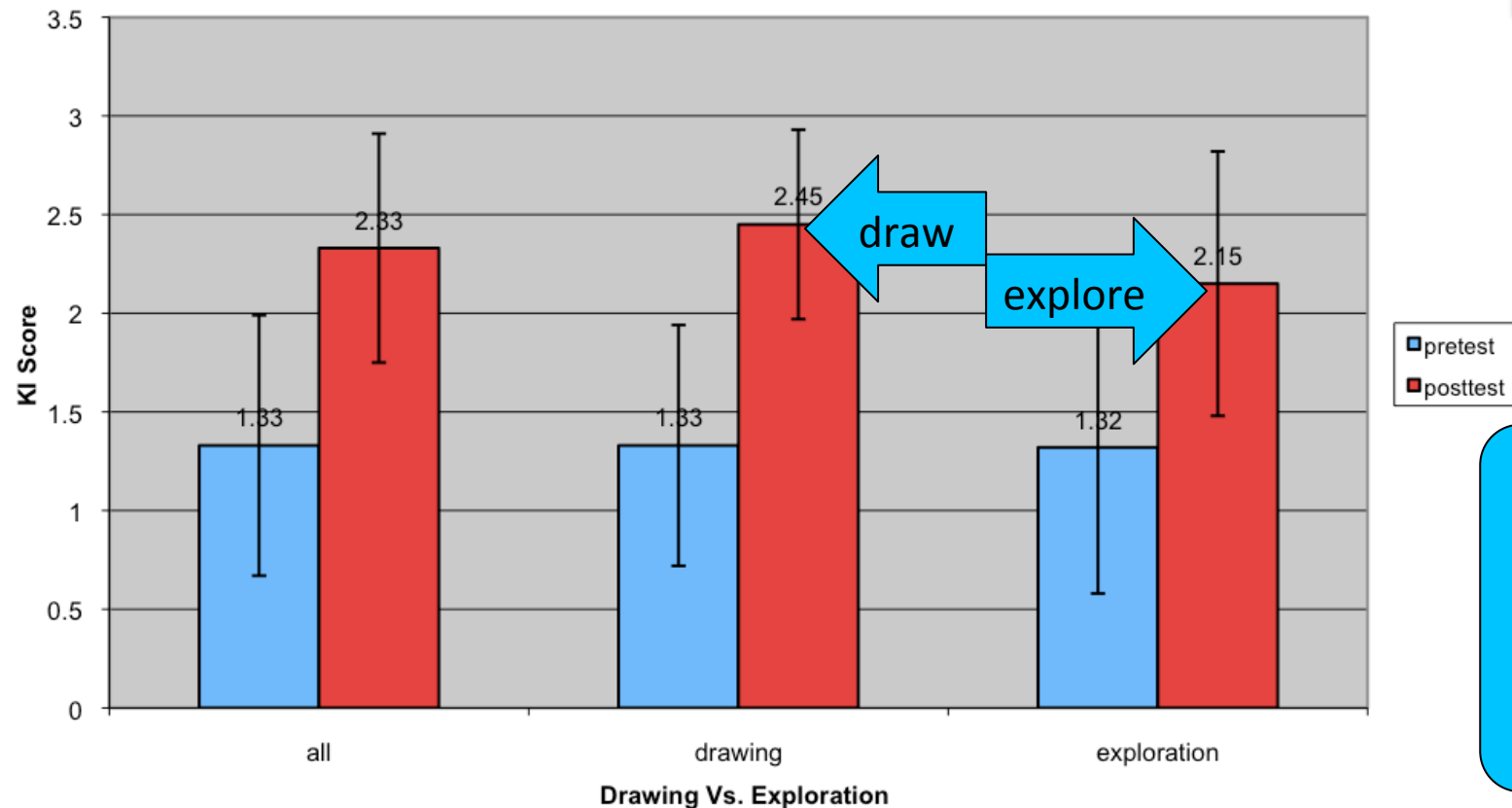
Draw four pictures to show combustion of SIX hydrogen gas molecules



Research Shows Drawing More Effective than Exploring



Helen Zhang



Zhang, Z., & Linn, M. C. (2011). Can Generating Representations Enhance Learning with Dynamic Visualizations? *Journal of Research in Science Teaching*, 48(10), 1177-1198.

Conclusions

- Inquiry Instruction Promotes Integrated Understanding
- Current Standardized Assessments Send the Wrong Message! Encourage Memorizing not Reasoning!
- Design of Inquiry Instruction Benefits from Research
 - Knowledge Integration Pattern Effective
 - Dynamic Adds Value to Static Pictures
 - Drawing Adds Value to Exploring a Visualization
- WISE Offers Free, Classroom Tested Inquiry Units
 - Enable Teachers to Diagnose Student Difficulties and Tutor Individuals or Small Groups

Start Now at: WISE.berkeley.edu

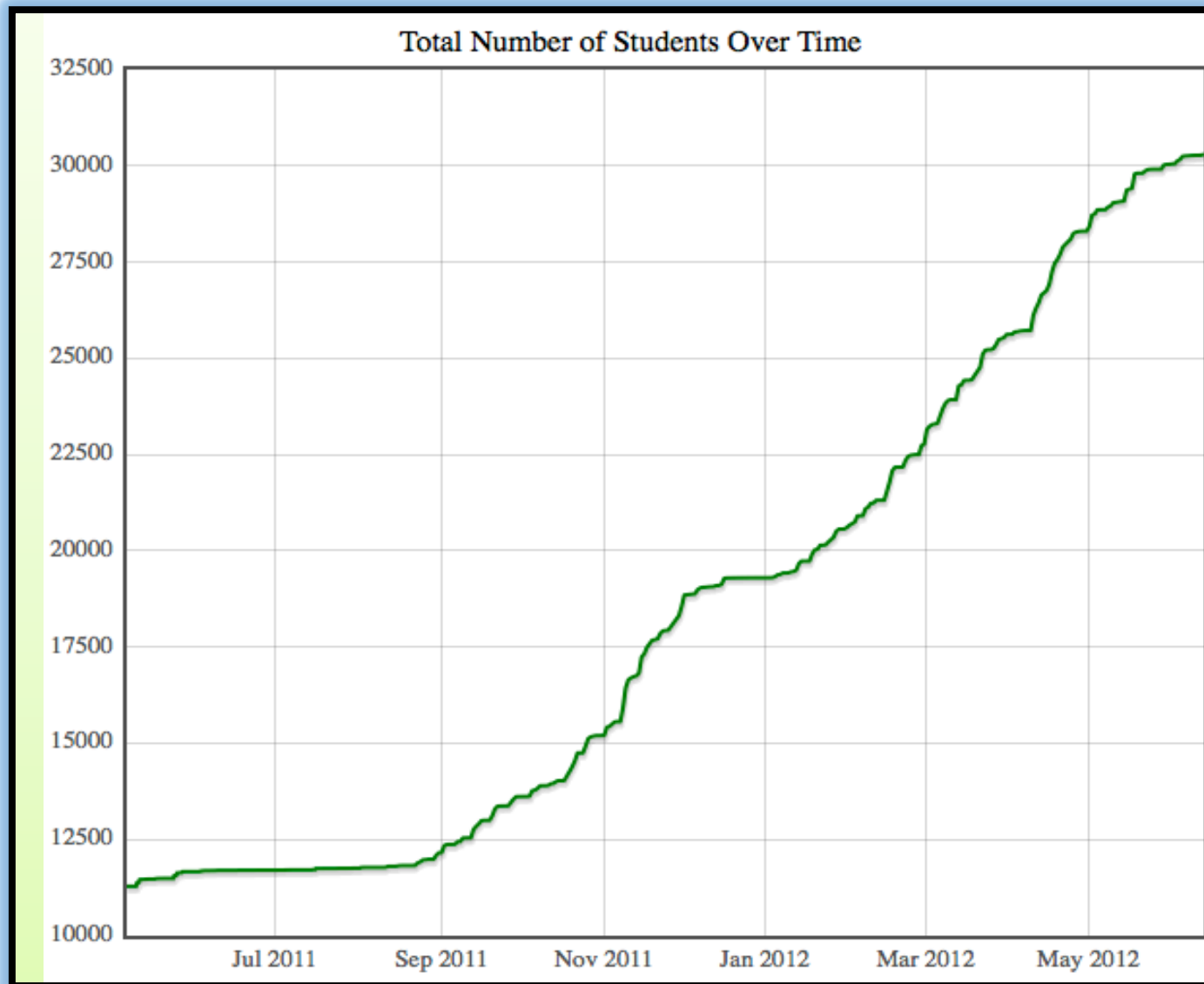
The image shows a screenshot of the WISE v4 website homepage. At the top, there is a navigation bar with the WISE logo, a login form with fields for Username and Password, and buttons for 'Sign In', 'Forgot Username', and 'Create WISE Account'. Below the navigation bar, there are several content blocks: 'Free & Open Source' with a sub-header 'WISE v4' and a paragraph describing the platform; 'What's New?' with a news item about WISE being included in the STEMworks Database; 'WISE Features' with a list of links: 'Learning Environment +', 'Teacher Tools +', 'Getting Started +', and 'Check Compatibility +'; 'WISE Projects' with a featured project 'Genetics: Simple Inheritance' for Grades 6-8; and three smaller sections: 'The WISE Advantage', 'WISE In Action', and 'Research Technology'. Three callout boxes with black backgrounds and white text point to specific features: 'Free & Open Source' points to the 'Free & Open Source' section; 'Inquiry Projects for 4th-12th grades' points to the 'Genetics: Simple Inheritance' project; and 'Tools for Teachers to Monitor Progress and Assign Grades' points to the 'Teacher Tools +' link.

Free & Open Source

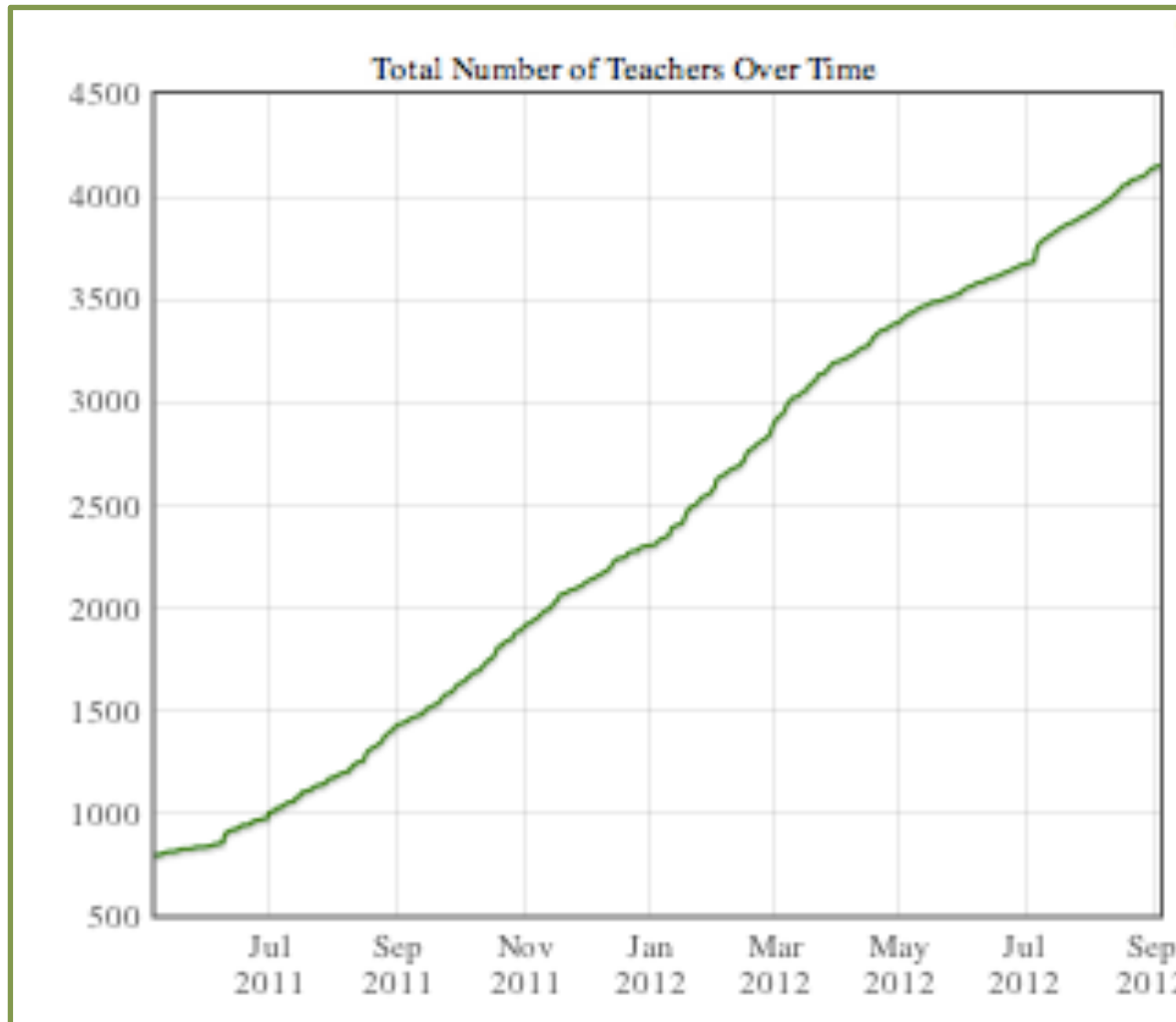
Inquiry Projects for 4th-12th grades

Tools for Teachers to Monitor Progress and Assign Grades

Over 30,000 Students Since July, 2011



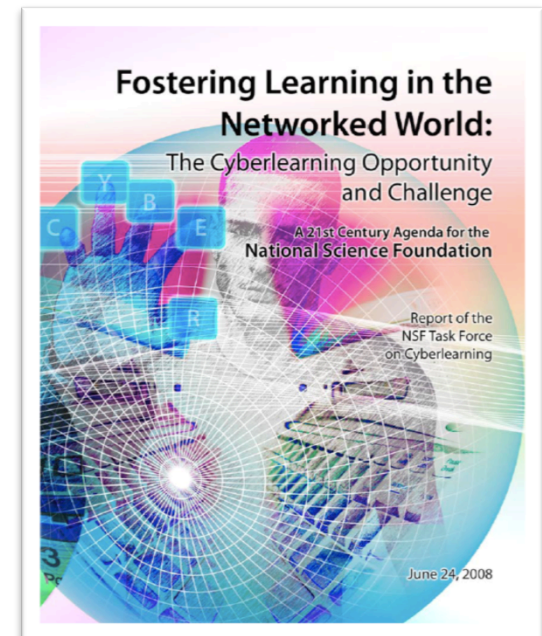
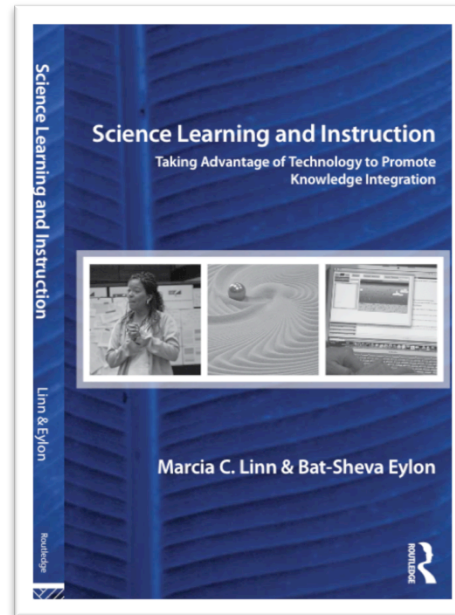
Over 4000 Teachers Since July, 2011



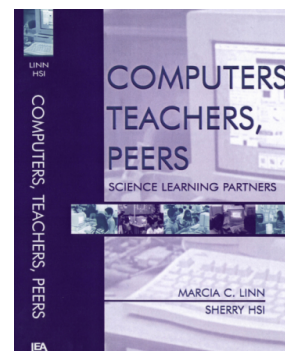
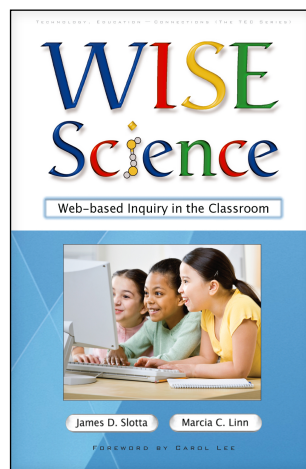
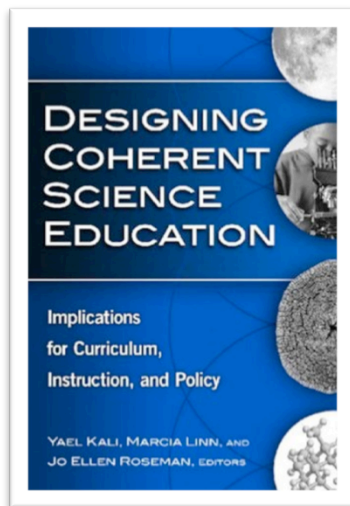
WISE is Free and Available



WISE.Berkeley.edu



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mclinn@berkeley.edu

