

**Digital and Hands-On Solutions  
that Meet Your Students' Needs  
and Current Science Standards**

**CAST21**

## HS-PS3-4 Energy

Students who demonstrate understanding can:

- HS-PS3-4.** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). *[Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]*

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

### Science and Engineering Practices

#### Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

### Disciplinary Core Ideas

#### PS3.B: Conservation of Energy and Energy Transfer

- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).

#### PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

### Crosscutting Concepts

#### Systems and System Models

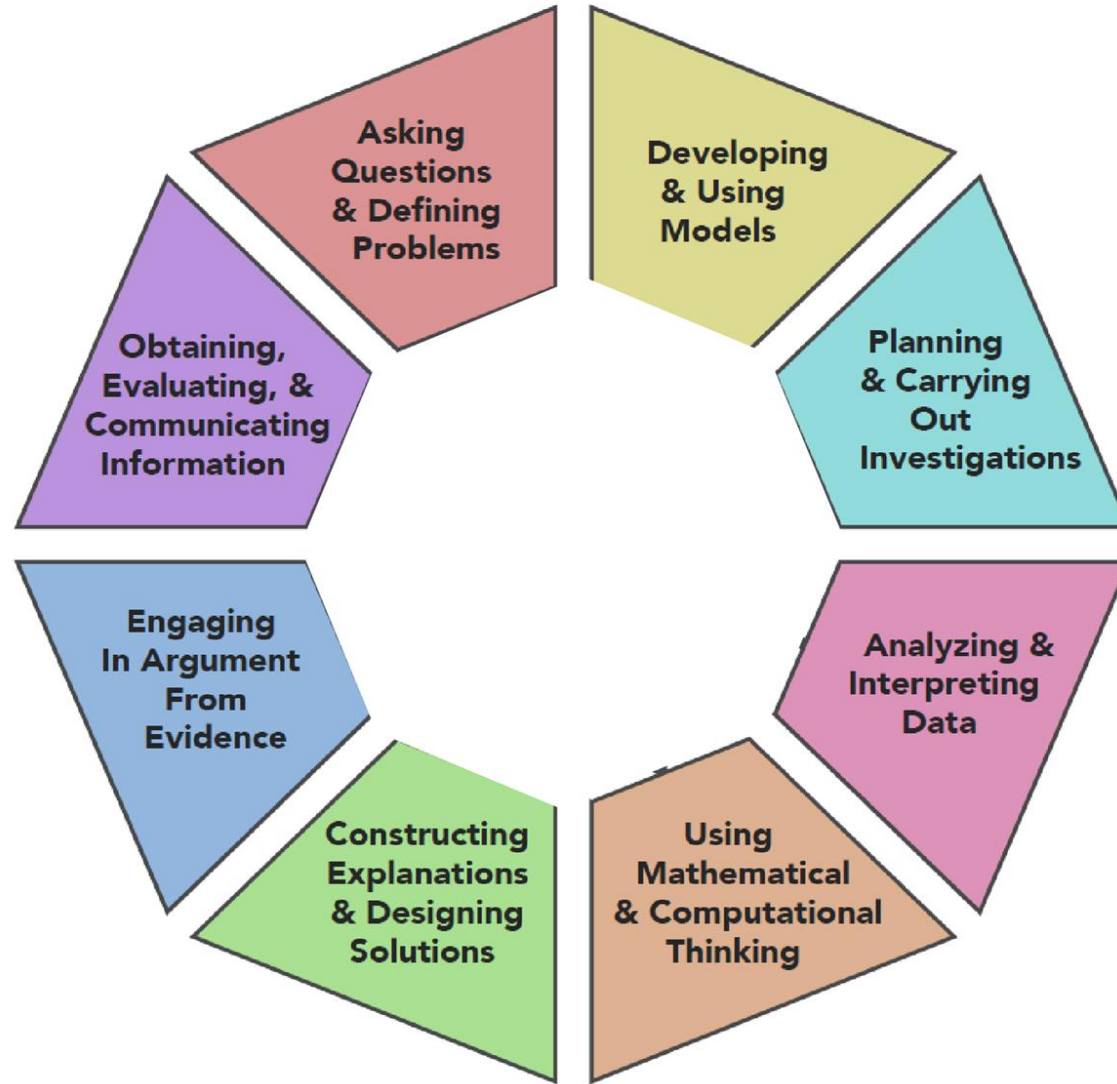
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

## TEKS Examples

**112.35. Chemistry (C)(2)(E):** Plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting equipment and technology, including graphing calculators, computers and probes, electronic balances, an adequate supply of consumable chemicals, and sufficient scientific glassware such as beakers, Erlenmeyer flasks, pipettes, graduated cylinders, volumetric flasks, and burettes.

**112.35. Chemistry (C)(7)(B):** The student knows how atoms form ionic, covalent, and metallic bonds. The student is expected to write the chemical formulas of ionic compounds containing representative elements, transition metals and common polyatomic ions, covalent compounds, and acids and bases.

Schwarz, C. V., Passmore, C. M., & Reiser, B. J. (2017). Moving beyond "knowing" science to making sense of the world. In C. V. Schwarz, C. M. Passmore & B. J. Reiser (Eds.), *Helping students make sense of the world through next generation science and engineering practices* (pp. 3-21). Arlington, VA: NSTA Press.

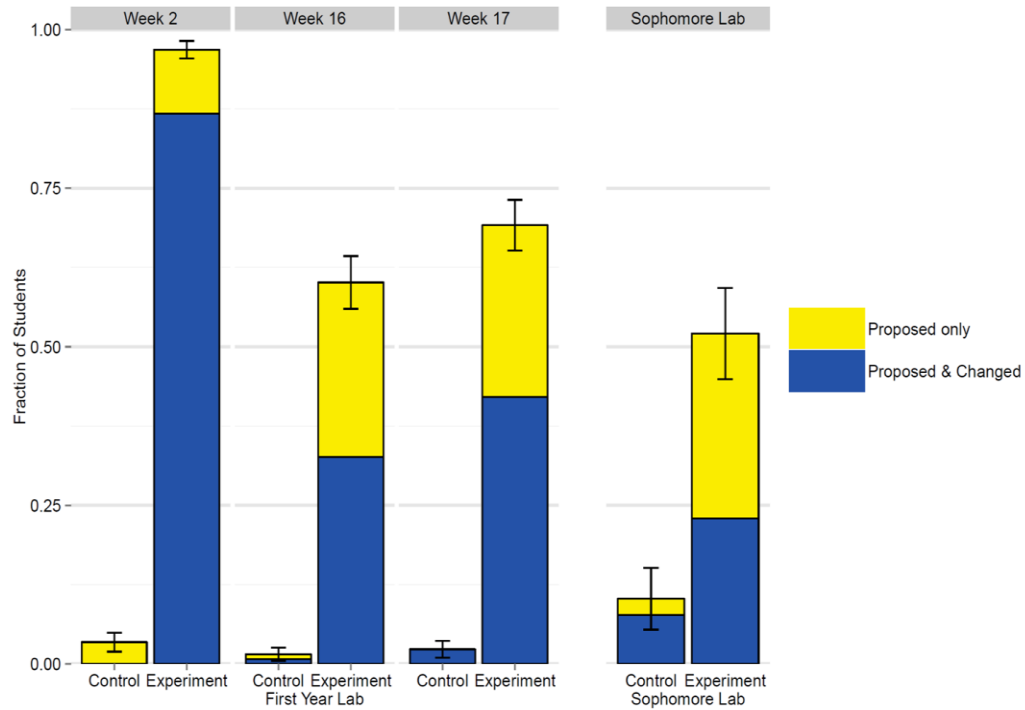


## SEPs

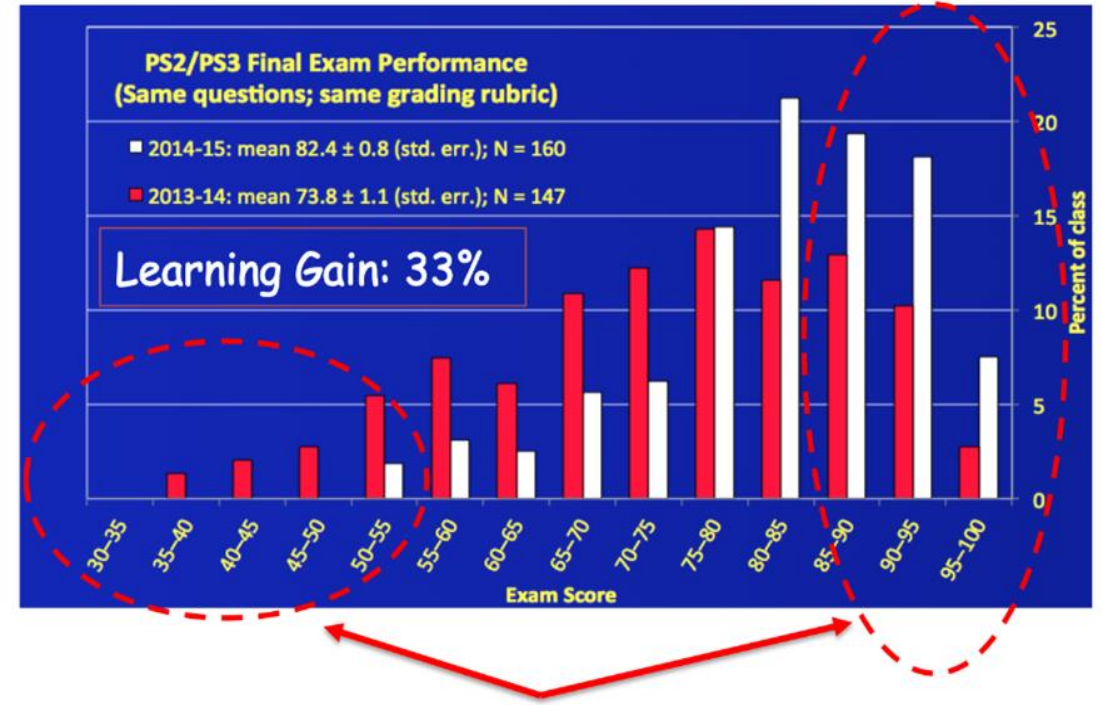
“Developers need to recognize that **most traditional approaches to curriculum materials**, in which teachers or expository texts present new ideas first, and then students apply them in labs or exercises, **do not reflect the three dimensions of NGSS**, in which students engage in **science and engineering practices** to develop and use the **disciplinary core ideas** with guidance from teachers.”

*Guide to Implementing the Next Generation Science Standards, 2018,  
National Academy of Sciences*

## Active vs Passive Learning

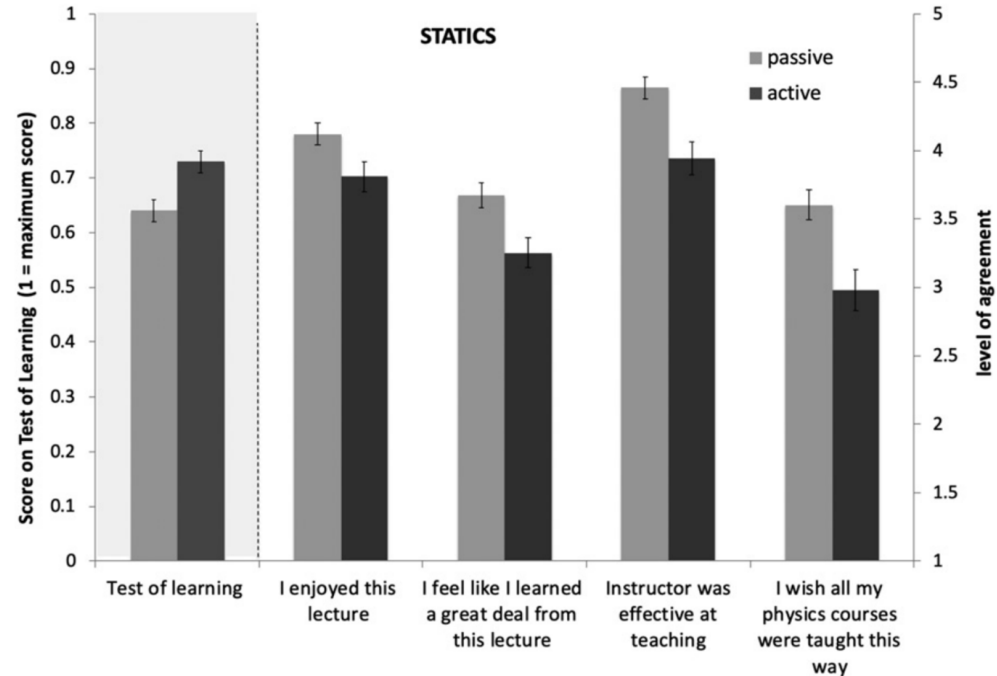


Holmes, N.G. et. al. "Teaching Critical Thinking" *PNAS* 112(36), **2015**, 111999-11204.



Deslauriers, L. et. al. "Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom" *PNAS* 116(36), **2019**, 19251-19257.

## Challenge: *Learning More but Feeling Like Learning Less*



- ❖ Cognitive fluency misleads students
- ❖ Novices are ill-equipped to judge how much they have learned
- ❖ Students are unfamiliar with intense active learning

Deslauriers, L. et. al. "Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom" *PNAS* 116(36), 2019, 19251-19257.

## **How to create a successful and active classroom/lab?**

- ❖ Improve student perceptions of their learning
- ❖ Provide supports to increase feelings of fluency
- ❖ Connect learning to meaningful things, i.e. phenomena
- ❖ Assess students' abilities to practice science as well as master disciplinary core ideas
- ❖ Present information on the benefits of active learning



## Impediments

- ❖ Time
- ❖ Range of student readiness
- ❖ Students are not used to this kind of learning, it frustrates

# Connect to Students' Interests – Phenomena





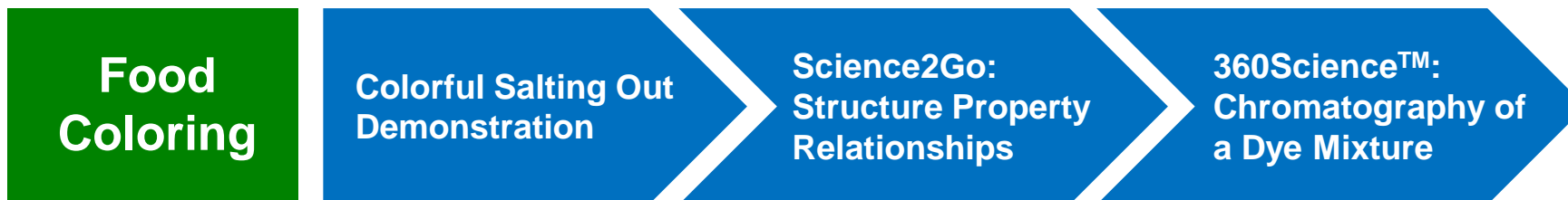
**Which dyes can be added to food?  
What's the molecular structure of food dyes?  
How do dye molecules interact with food?  
Intermolecular forces?**



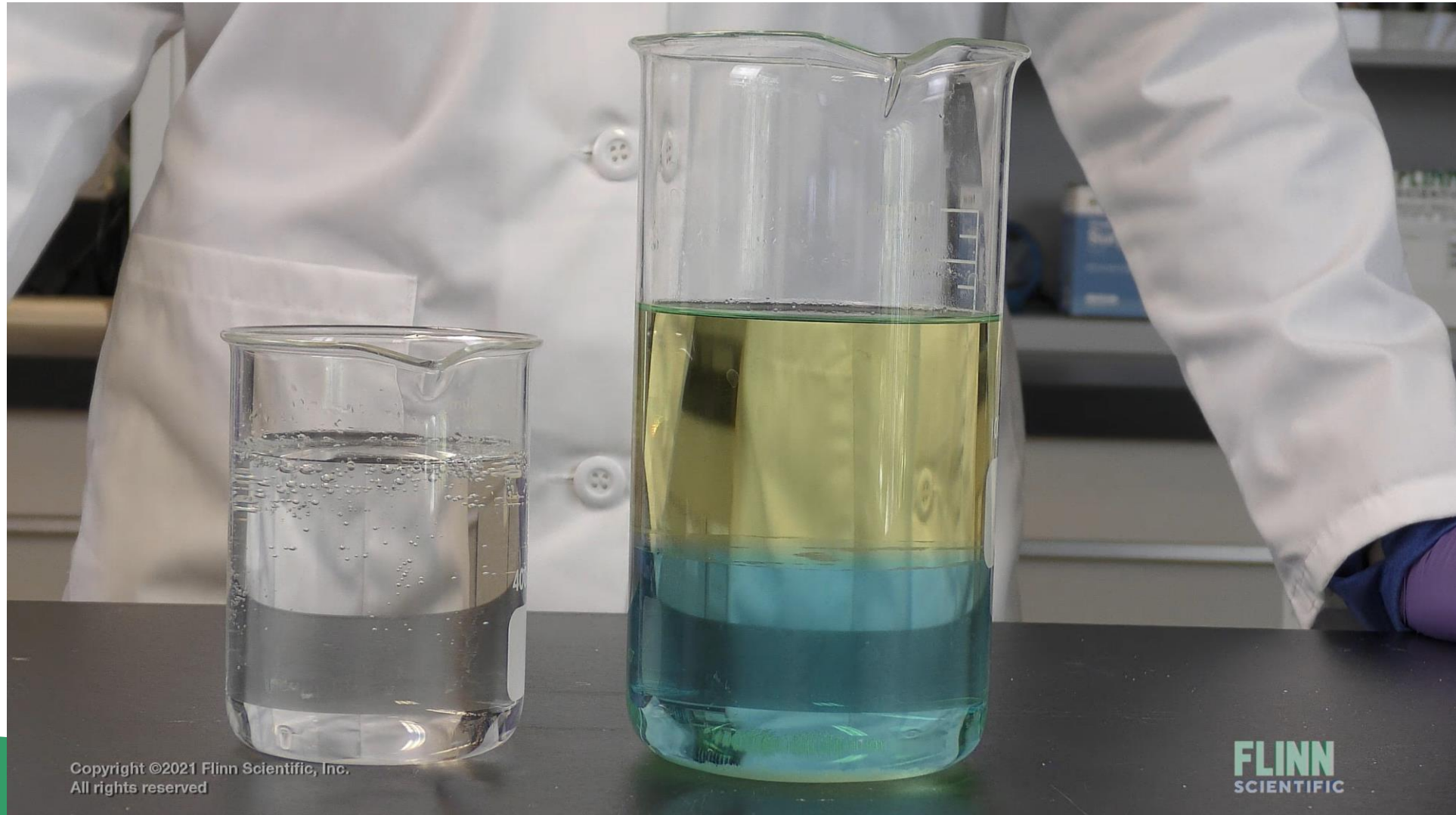
## Connect to Students' Interests – Phenomena

**HS-PS1-3:** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

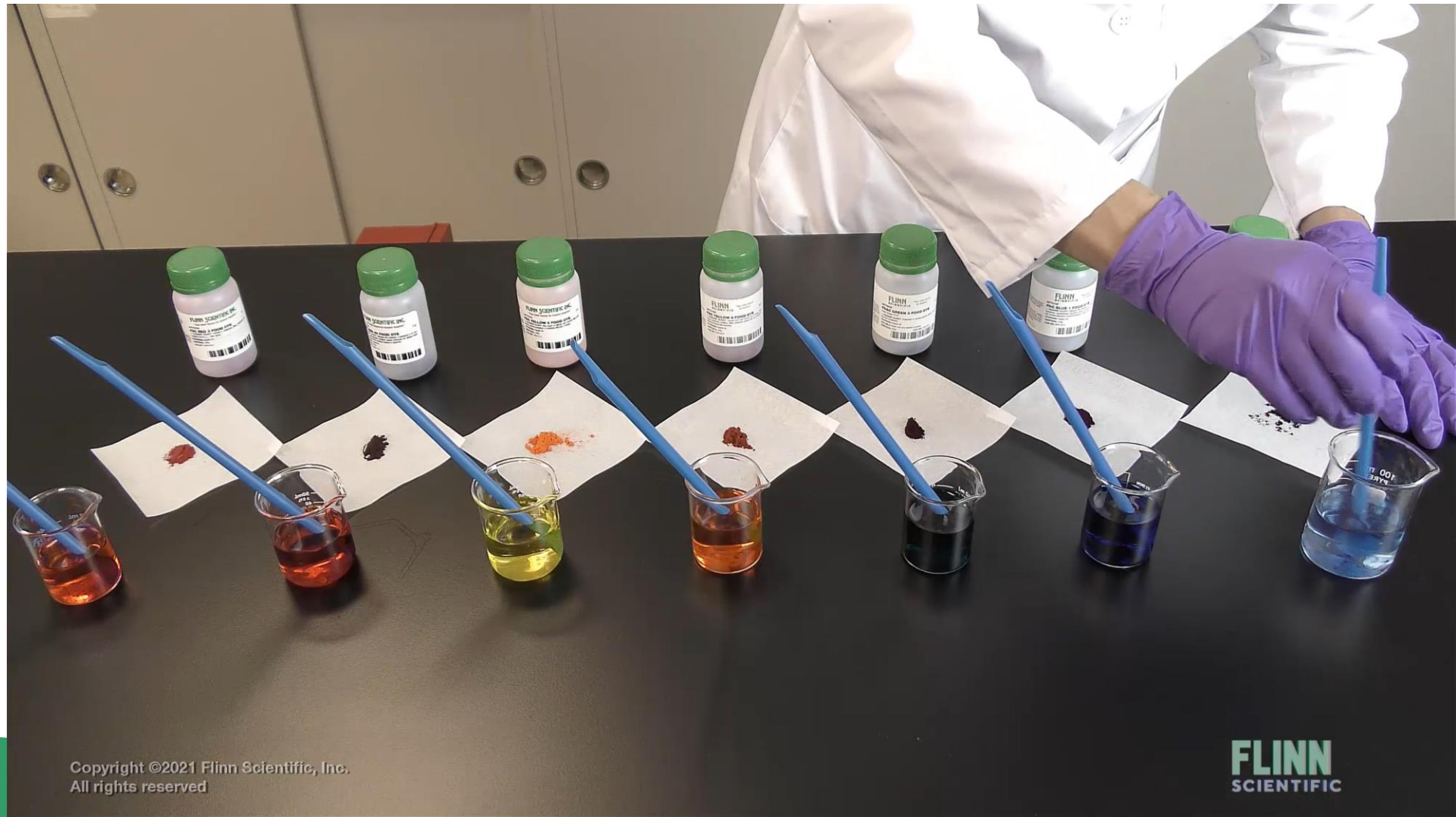
**HS-PS2-6:** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.



## Demonstrations to Spark Interest and Discussion



## Students Can Practice Science Outside of School



## Blur the Line Between In-School and At-Home Science

- ❖ Pair videos with prompts meant to elicit students' abilities to engage in the science practices

### Observe Part 1

From the video, which two properties can you observe for the different dyes when added to water in separate beakers?

SELECT

Done

The color of the dyes is a macroscopic property that you can observe without an instrument or specialized lab analysis. Looking at the chemical structures of the dyes showed in the video, what is the reason behind the different colors of the seven FD&C dyes?

- The dyes are molecular compounds that have distinct chemical structures.
- The dyes have different elements in their structures.
- The dyes are elementary substances that have distinct chemical structures.
- The dyes have different numbers of benzene rings in their molecular structures.

Done

### Identify an Experimental Design Limitation

The video shows a paper chromatography experiment. Paper chromatography is used to assess whether a sample is pure or can be separated into its individual components. What is one potential problem or limitation you can think of that would be associated with using paper chromatography to analyze a sample that contains more than one component?

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# Have Students Make Observations and Try Safe Demos at Home

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## Try It at Home

Design your own chromatography experiment at home using M&Ms or another type of colored candy, a glass of water, a paper towel, a plate, and a piece of tape.

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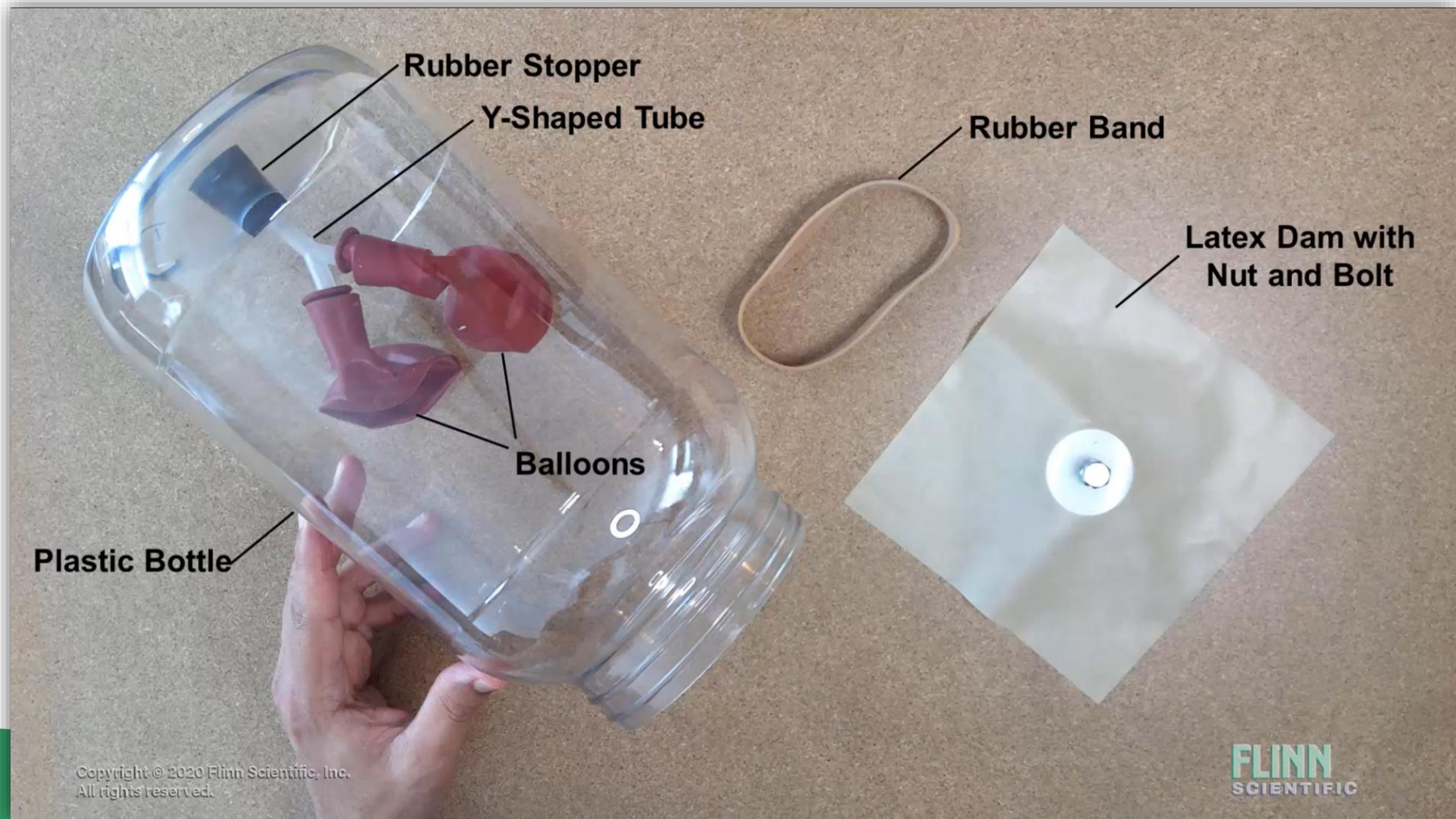
## Have Students Make Observations and Try Safe Demos at Home



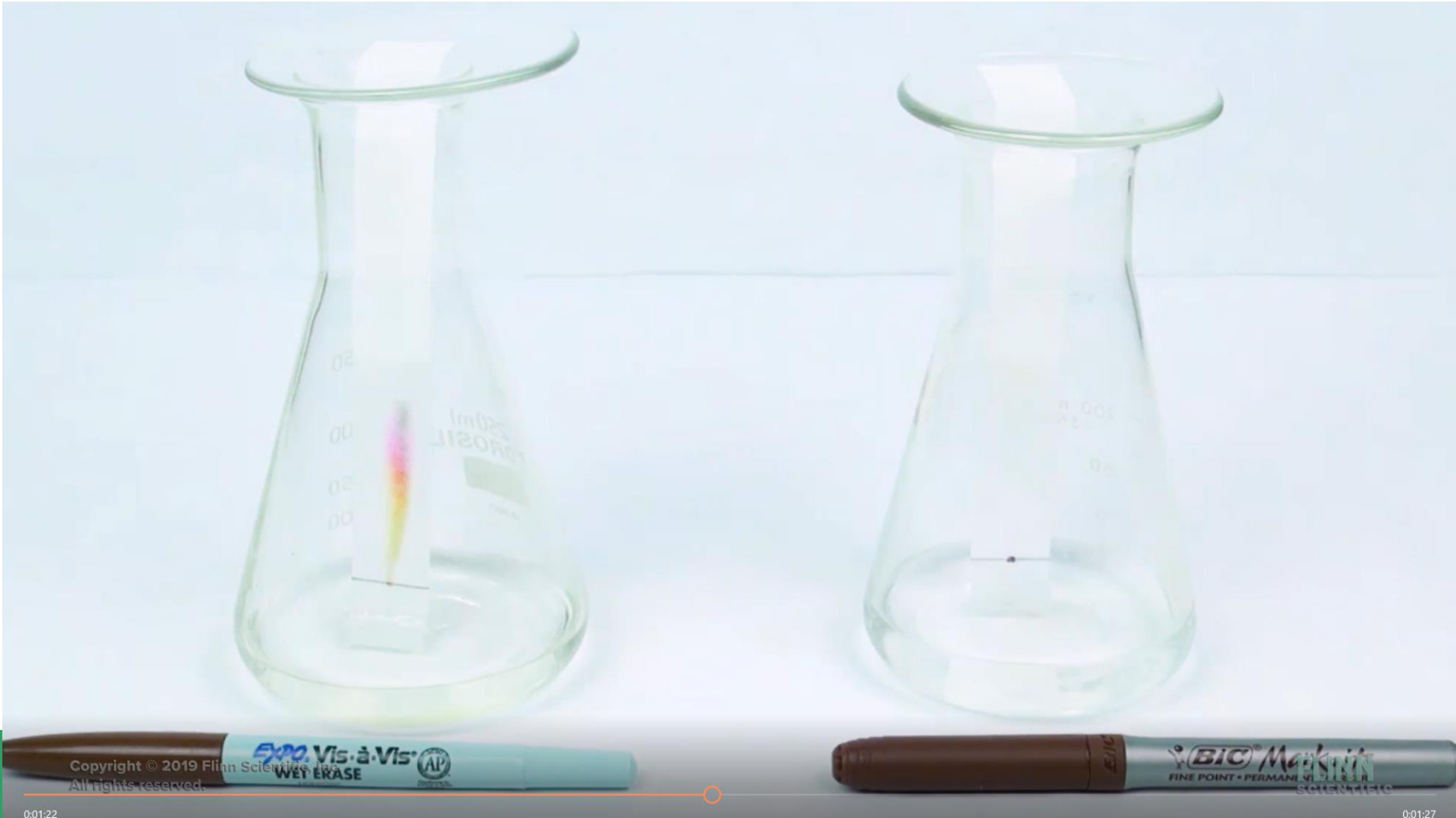
## Have Students Make Observations and Try Safe Demos at Home



## Have Students Make Observations and Try Safe Demos at Home



## Students Will be Better Prepared for In-School Science



# Activities Must Not Exceed Students' Abilities Early in the Year

## Short (Guided) Inquiry

1

### Procedure

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#### Part I. Preparation of Sodium Chloride Solution (Eluent)

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1. Use a graduated cylinder to measure 12.5 mL of 2% sodium chloride solution, and transfer to a 100 mL beaker.

5

2. Use a graduated cylinder to measure 37.5 mL of distilled water, and add it to the beaker containing the 12.5 mL of sodium chloride solution. Mix the solution and label this beaker as "0.5% NaCl."

6

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#### Part II. Chromatography of a Dye Mixture

3. Position the chromatography paper strip on a clean, flat surface so it is 152 mm long and 19 mm wide. Note: Handle the paper by the edges so the analysis area is not accidentally compacted or contaminated.

4. Using a ruler and a pencil, draw a faint line 15 mm from the bottom of the paper across the width of the strip. Measure 9.5 mm from the edge and place a dot on the line. This is the starting point for the sample.

## Open Inquiry

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### Procedure

#### Part I. Chromatography Pure Food Dyes

Pick three of the food dyes available to you in this lab. Weigh out approximately 0.1 g of each dye, transfer separately to clean 50 mL beakers, and dissolve the powders in 20 mL of distilled or deionized water. Follow the procedure below to properly conduct the chromatography of these dye solutions. Use a separate paper strip of each dye.

1. Position the chromatography paper strip on a clean, flat surface so it is 152 mm tall and 19 mm wide.  
Note: Handle the paper by the edges so the analysis area is not accidentally compacted or contaminated.

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17. **SEP Plan Your Investigation** Design and write a procedure to investigate the effect of concentration of the eluent on the quality of chromatography analysis of your coloring mixture. Prepare and use the two dilutions of stock eluent solution as the developing solvents. Perform two trials with each concentration of eluent if possible. Record your observations (i.e., name and concentration of eluent solution, solvent front distance, distance traveled by each dye on the paper strip) in a data table, and your calculated retention factors ( $R_f$ ) in a results data table.

The image shows a rich text editor interface. At the top, there is a toolbar with icons for Source, Cut, Copy, Paste, Undo, and Redo. Below the toolbar is a row of text formatting options: Bold (B), Italic (I), Underline (U), Strikethrough (S), Subscript (x<sub>2</sub>), Superscript (x<sup>2</sup>), Text Color (I<sub>x</sub>), Background Color, Bulleted List, Numbered List, Decrease Indent, Increase Indent, Quote, Link, Unlink, Table, Table of Contents, and Insert. Below the formatting options are dropdown menus for Styles and Format, followed by icons for Undo, Redo, and a Checkmark. The main area of the editor is a large, empty text box with a vertical scrollbar on the right side. At the bottom left of the text box, the word "body" is visible.

## Advanced Inquiry

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### Part II. Effect of Concentration of the Eluent

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16. Based on your results from Part I, decide what eluent solution works best for separating the coloring mixture into its component dyes. Determine the amount of stock (2% or 20%) eluent solution required to prepare 50 mL of diluted eluent solutions of different concentrations, which you will use to investigate the effect of eluent concentration of the chromatography of a dye mixture. Show all your calculations.

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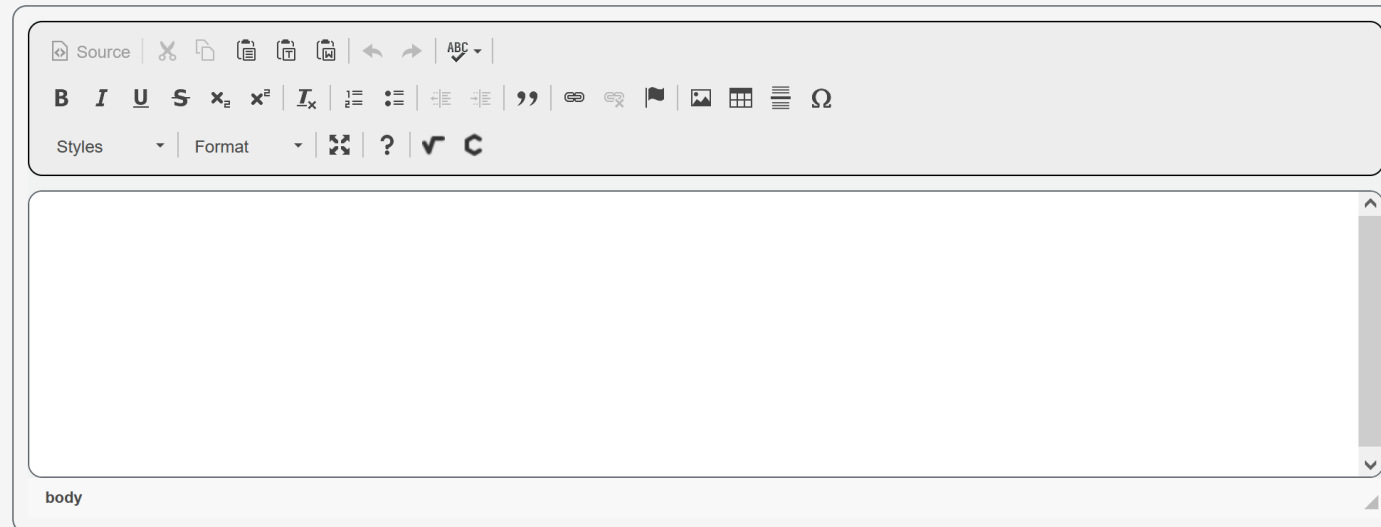
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## Advanced Inquiry

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17. Design and write a procedure to investigate the effect of concentration of the eluent on the quality of chromatography analysis of a coloring mixture. Prepare and use the two dilutions of stock eluent solution as the developing solvents. Perform two trials with each concentration of eluent if possible. Record your observations (i.e., name and concentration of eluent solution, solvent front distance, distance traveled by each dye on the paper strip) in a data table, and your calculated retention factors ( $R_f$ ) in a results data table.



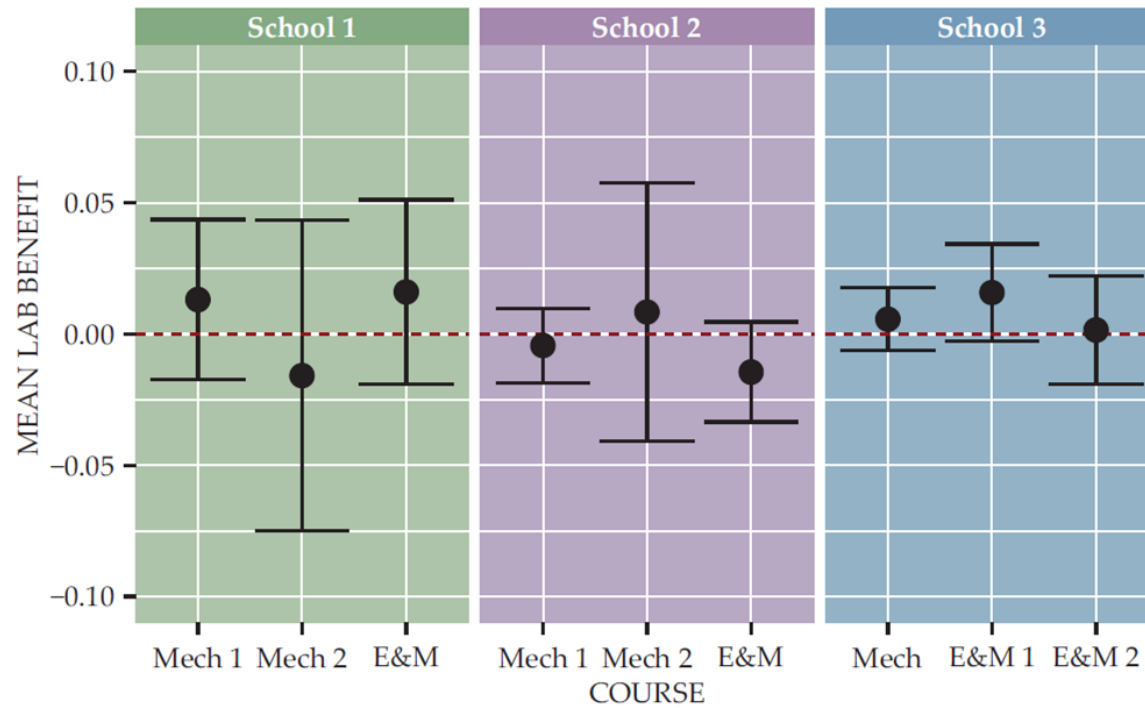
A rich text editor interface with a toolbar at the top. The toolbar includes icons for Source, Cut, Copy, Paste, Undo, Redo, and a font color dropdown. Below these are icons for Bold (B), Italic (I), Underline (U), Strikethrough (S), Subscript (x<sub>2</sub>), Superscript (x<sup>2</sup>), Text Color (I<sub>x</sub>), Bulleted List, Numbered List, Decrease Indent, Increase Indent, Quote, Link, Unlink, Flag, Image, Table, Horizontal Line, and Insert Link. Below the toolbar are dropdown menus for Styles and Format, followed by icons for Undo, Redo, and a checkmark. The main editing area is a large empty text box with a vertical scrollbar on the right. The word "body" is visible at the bottom left of the editing area.

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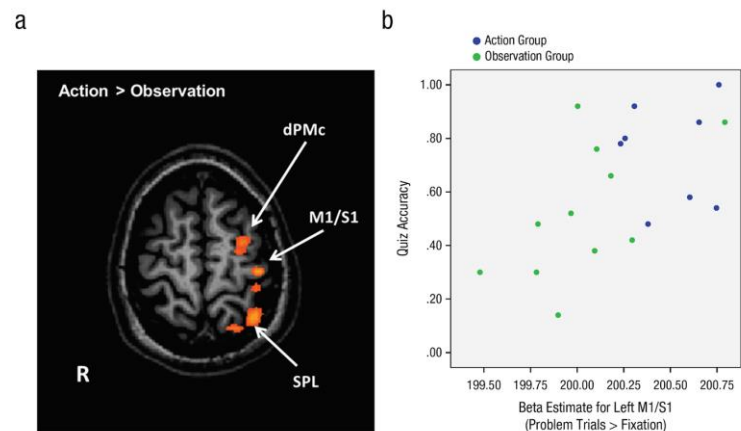


## Get Students Comfortable with Less Prescriptive Lab Work



Holmes, N.G. and Weimann, C.E. "Introductory physics labs: We can do better" *Physics Today* 71, 1, 38 (2018)

# Pair Videos with Hands-On Activities for Better Outcomes



**Fig. 4.** Imaging results from the posttest in Study 3. The brain image (a), an axial slice at  $z = 57$ , shows a subset of neural regions in which the activation difference between problem trials and fixation was greater in the action group than in the observation group, for the 19 subjects who completed both the scanning and the online quiz. dPMc = dorsal premotor cortex; M1/S1 = primary motor/somatosensory cortex; SPL = superior parietal lobule; R = right. The scatter plot (b) shows the relation between accuracy on the online quiz and  $\beta$  weight for activation within the left M1/S1 region from the group contrast (problem trials > fixation); each plotted point represents a subject.

Kontra, C. et. al. Physical Experience Enhances Science Learning. *Physiological Science* (2015).

## Online Prelaboratory Videos Improve Student Performance in the General Chemistry Laboratory

Mike Stieff,<sup>\*,†,‡</sup> Stephanie M. Werner,<sup>†</sup> Bill Fink,<sup>‡</sup> and Dianne Meador<sup>§</sup>

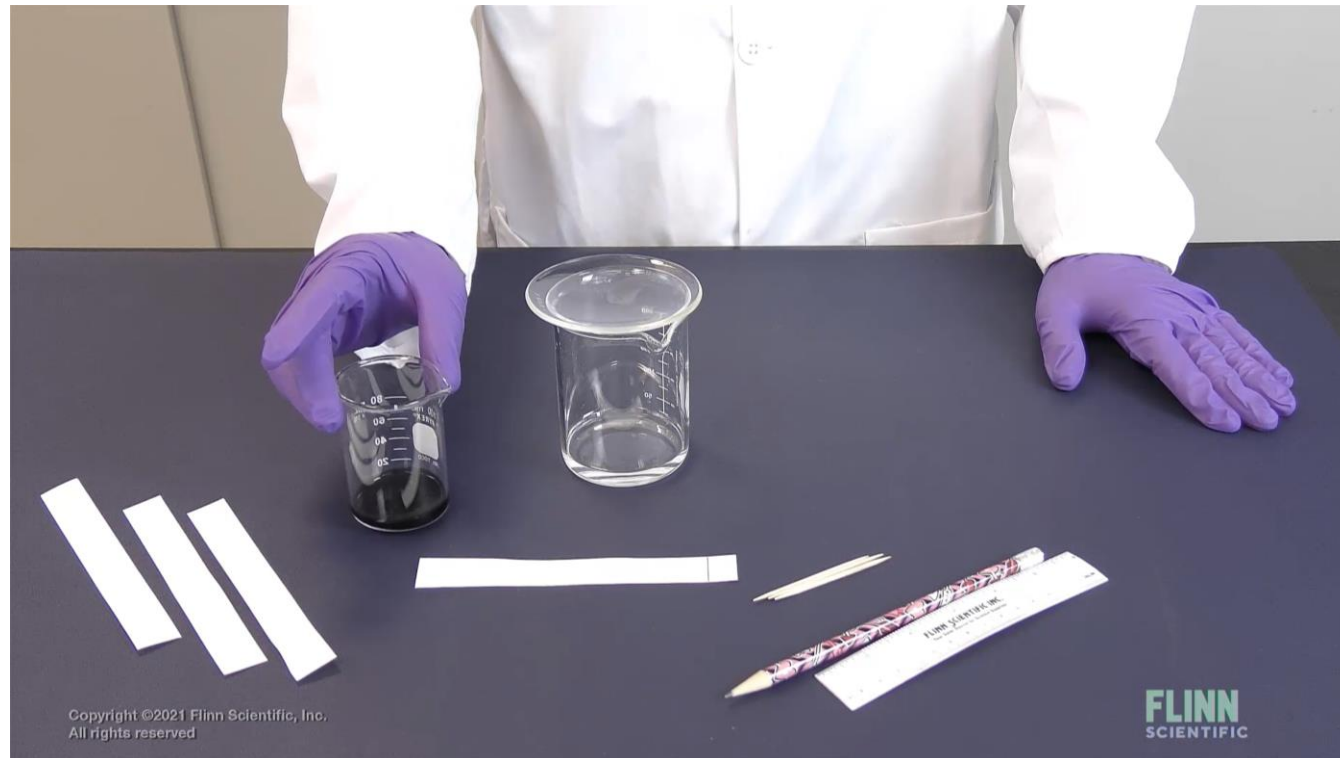
<sup>\*</sup>Department of Chemistry, University of Illinois—Chicago, 845 West Taylor Street Room 4376, Chicago, Illinois 60607, United States

<sup>†</sup>Department of Chemistry, University of California, Davis, California 95616, United States

<sup>‡</sup>Department of Chemistry American River College, 4700 College Oak Drive, Sacramento, California 95841, United States

**“Students were more efficient and demonstrated a greater understanding of the rationale for the two procedures that used online prelaboratory videos...”**

- ❖ Analyze videos individually or collectively
- ❖ Investigate the questions videos bring up...



## How to Prepare Students

- ❖ Benefits of active learning
- ❖ Show real data
- ❖ Discuss feeling of learning (FOL) vs actual learning
- ❖ Include a discussion on negative correlation: students in active classrooms feel like they learn less but actually learn more than students in passive classrooms
- ❖ Students need time to adjust but once adjusted enjoy active learning much more than passive learning



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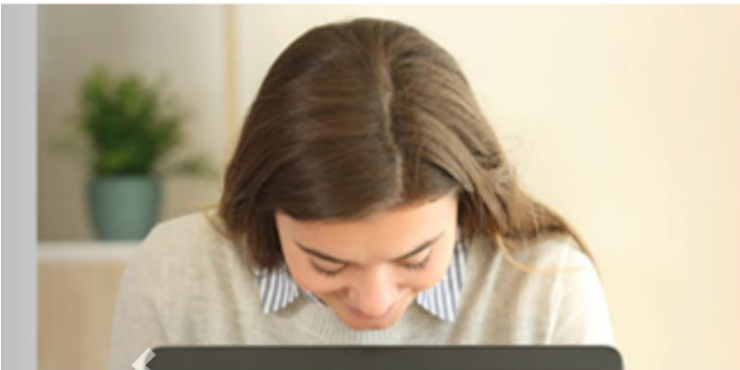
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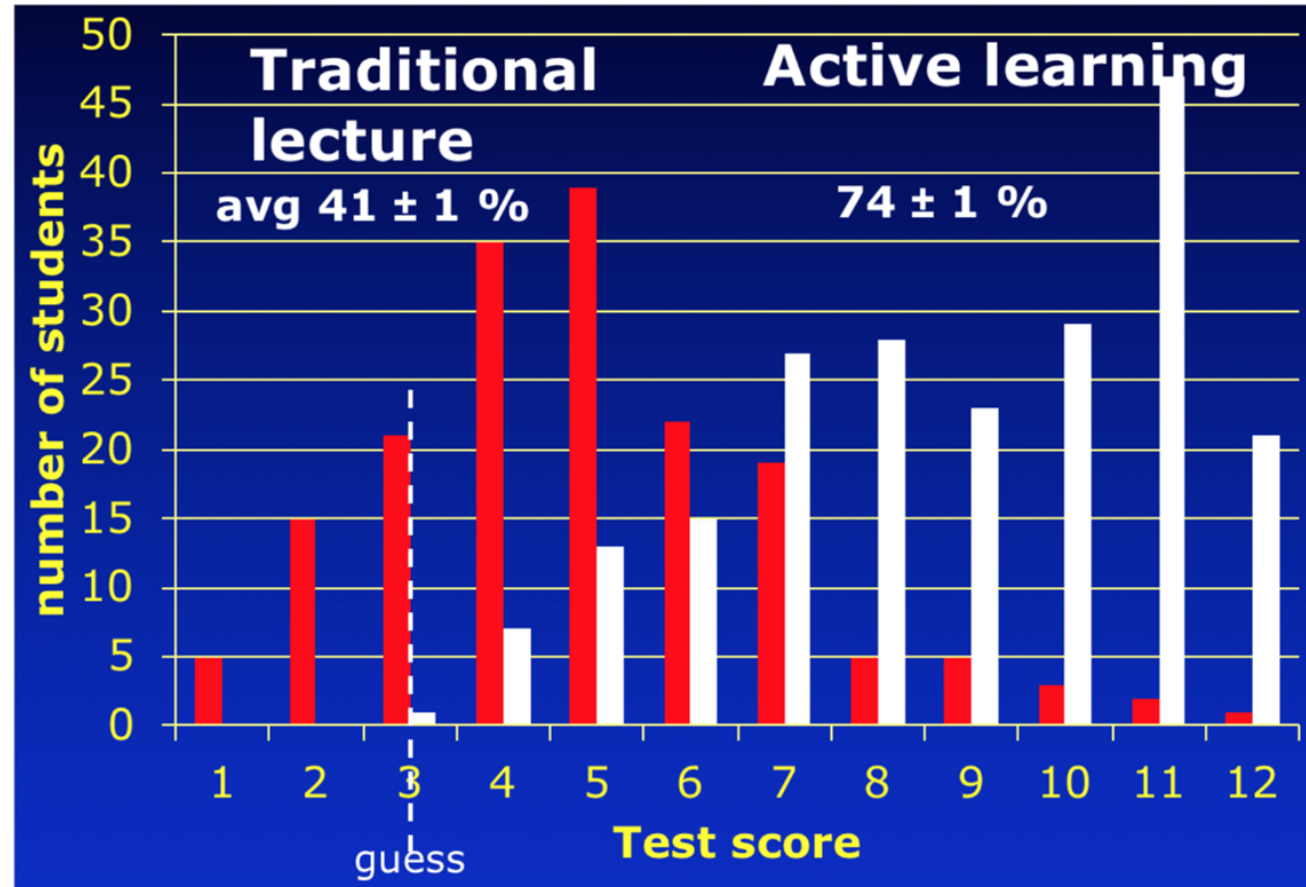


"Constructing" Mitosis the 5E Way



3-D Magnetic Field Jar





Deslauriers, L. et. al. "Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom" *PNAS* 116(36), 2019, 19251-19257.



## Why do passive methods persist?


- ❖ Insufficient time
- ❖ Limited resources
- ❖ Lack of support
- ❖ Concerns about content coverage
- ❖ Concerns about teaching evaluations

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- My Labs**
- Certificates
- Classrooms
- Planner
- Reporting
- Discussion
- Messages
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Abrasive Compounds



Acid-Base Titrations



Acidity of Beverages



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## Planner

Nov 08, 2021 - Nov 14, 2021 [List Day](#) [List Week](#)

Monday	<a href="#">Add Assignment</a>	Nov 08, 2021	▼	
Tuesday	<a href="#">Add Assignment</a>	Nov 09, 2021	▼	
Wednesday	<a href="#">Add Assignment</a>	Nov 10, 2021	▼	
Thursday	<a href="#">Add Assignment</a>	Nov 11, 2021	▼	
Friday	<a href="#">Add Assignment</a>	<a href="#">Nov 12, 2021</a>	▼	
360Science - Chromatography_Lab		View	Edit	Delete
Saturday	<a href="#">Add Assignment</a>	Nov 13, 2021	▼	
Sunday	<a href="#">Add Assignment</a>	Nov 14, 2021	▼	

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## Planner

### View Assignment

Start Date: 11/12/2021 Due Date: 11/19/2021

Assignment Title: Chromatography\_Lab

Select Learning Path: 360Science

Select Master Classroom: Master - Chromatography of a Dye Mixture

Select Classroom: Classroom - Chromatography of a Dye Mixture - Short-on-time Inquiry Lab

Select Master or Customized Versions: Master Copy

Selected Student Group(s): 2nd period

Upload Documents: No File uploaded

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## Planner

### Edit Assignment

Start Date: 11/12/2021 Due Date: 11/19/2021

Assignment Title: Chromatography\_Lab

32 Character(s) Left

Select Learning Path: 360Science

Select Master Classroom: Master - Chromatography of a Dye Mixture

Select Classroom: Classroom - Chromatography of a Dye Mixture - Short-on-time Inquiry Lab

Select Master or Customized Versions: Master Copy

Available Student Group(s): 2nd Block, 3rd Hour Chem, 4th Block, AP Chemistry, BT1, BT2, Group 1

Selected Student Group(s): 2nd period

Note - Control + Click and Drag it to Select Multiple Students.



If you have any  
questions, give us a call  
or  
send us an email!

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**Thank You!**