Instructional Sequence Matters
Explore-Before-Explain
I am Pat Brown. You can find me at

**Twitter:** @brownpatrick8

**Email:** patbrown@fz.k12.mo.us, plbtfc@gmail.com
Presentation overview

- What is explore-before-explain?
- How can I transform my lessons?
- How can I better address the NGSS?
What is explore-before-explain?

- Engaging prior ideas
- Constructing evidence-based claims
- Explaining underlying scientific principles
Model Lesson

Grades 3-5:
Thermal Energy Transfer
Have you ever been told “shut the refrigerator door, you’ll let the cold out” or in the winter “shut the front door, you are letting the heat out?” Which way does heat transfer-- Hot to cold, cold to hot, or both?
Melinda filled two glasses of equal size half-full with water. The water in one glass was 50 degrees Celsius. The water in the other glass was 10 degrees Celsius. She poured one glass into the other, stirred the liquid, and measured the temperature of the full glass of water. What do you think the temperature of the full glass of water will be after the water is mixed? Write down your prediction (Keeley, Eberle, & Tugel, 2007)

A. 20  B. 30  C. 40  D. 50  E. 60

“Average” “Subtraction” “Overriding” “Addition”
Sticky Charts: “what patterns exist in student ideas”

Q’s?: Is it worth exploring the idea?

Yes! As a group we are not sure what the answer is
Preconceptions

- Average
- Subtraction
- Overriding
- Addition
- Other

- 21% Elementary
- 33% Middle Level
- 30% Elementary Methods
- 32% Secondary Methods
- 68% Elementary
- 57% Middle Level
- 55% Elementary Methods
- 13% Secondary Methods
- 13% Other
- 8% Overriding

- Elementary
- Middle Level
- Elementary Methods
- Secondary Methods
### Class Data

<table>
<thead>
<tr>
<th>Group</th>
<th>Cold</th>
<th>Hot</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>84</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>84</td>
<td>48</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>85</td>
<td>53</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>80</td>
<td>47</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>88</td>
<td>51</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>92</td>
<td>49</td>
</tr>
<tr>
<td>7</td>
<td>27</td>
<td>82</td>
<td>52</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>88</td>
<td>51</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>90</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>90</td>
<td>56</td>
</tr>
</tbody>
</table>
Explore - Before - Explain

- Drawing and building on prior experience
- Learning by doing science
“We know that when two different temperatures of water are mixed the end result is the average temperature... but how does energy transfer? “
It was a hot summer day. Mattie poured herself a glass of lemonade. The lemonade was warm, so Mattie put some ice in the glass. After 10 minutes, Mattie noticed that the ice was melting and the lemonade was cold. Mattie wondered what made the lemonade get cold. She had three different ideas. Which idea do you think best explains why the lemonade got cold? Circle your answer.

A. The coldness from the ice moved into the lemonade.

B. The heat from the lemonade moved into the ice.

C. The coldness and the heat moved back and forth until the lemonade cooled off.
Use colors and arrows to draw your prediction

- Red = Hot
- Blue = Cold
Student’s predictions

“Cold to Hot”

“Hot to Cold”

“Hot to Cold” and “Cold to Hot”
Teacher Preconceptions

- Cold to Hot: 22%
- Hot to Cold: 44%
- Both Ways Simultaneously: 33%
Translating Student’s Predictions to Models

Translating opens up more possibilities for student ideas
Use colors to draw your prediction
Red=Hot
Blue=Cold

Questions:
• How does the assessment probe relate to our model (i.e., the picture)?
• Which component represents the ice?
• Which component represents lemonade?
Translating Student’s Predictions to Models
EXPLORE-BEFORE-EXPLAIN

- Developing Conceptual understanding
- Evidence-based claims
- Promoting transfer learning (patterns, model based reasoning)
We have data that serves as evidence that thermal energy transfers from “hot” to “cold” but what is the underlying explanation?
DEVELOPING EXPLANATIONS AND REASONING

Time

<table>
<thead>
<tr>
<th>hot object</th>
<th>cold object</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

![Diagram](image3.png)
CONVECTION
the transfer of heat through a fluid (liquid or gas) caused by molecular motion

CONDUCTION
the transfer of heat or electric current from one substance to another by direct contact.

RADIATION
energy that is radiated or transmitted in the form of rays or waves or particles
Explore - Before - Explain

- Allowing students to explain underlying ideas
- Introducing academic vocabulary (DCIs)
How can you transform your Lessons?
Lesson Study: Cultural Phenomenon

Explain
Tell ideas

Investigate/Observe
Verify Ideas

Practice
Rehearse Ideas

K-16 Apprenticeship of Observation
Thinking about Our Cultural Lesson Model?

What understandings do students have to incorporate ideas?

Is telling enough to overcome misconceptions?

What will students be able to do with ideas in later grades?

- Explain
  - Tell ideas

- Investigate/Observe
  - Verify Ideas

- Practice
  - Rehearse Ideas

Will verifying and practice develop conceptual understanding?

- Use and think with idea
- State in own words
- Create a model with it
- Find a metaphor or analogy for it
How important is foundational understanding?
Planning Step 1

• Pinpoint the evidence-based experience you will use with students
Focus on learning by doing (Think --Backwards Design)
- Demonstration or simplified lab (use what you have and know works)
- Talk with students about data→ evidence→ claims (help students formulate clear lines of arguments)
- Allows students to make a evidence-based claim
  - Blend of DCIs, SEPs, and CCs (NGSS-minded)
  - Creates a conceptual framework for understanding
  - Models the Nature of Science (accumulation of data serves as evidence for sense making)
What evidence-based experience can students have?
Planning Step 2

• Elicit student ideas around an observable phenomenon
Planning Step 2: elicit student ideas about phenomenon

Create a need to know situation with students
• Use an Understanding Student Ideas (USI) probe (see Keeley) or create your own
  • Selected response: Correct answer and typical incorrect ideas
• Have students make a prediction before a demonstration or investigation (“what do I wonder?”)
• Celebrate variation in ideas as a worthwhile topic for exploration (Do not grade!)
How can I better know students incoming ideas?

Mixing Water
Melinda filled two glasses of equal size half-full with water. The water in one glass was 50 degrees Celsius. The water in the other glass was 10 degrees Celsius. She poured one glass into the other, stirred the liquid, and measured the temperature of the full glass of water.

What do you think the temperature of the full glass of water will be after the water is mixed? Circle your prediction.

A 20 degrees Celsius
B 30 degrees Celsius
C 40 degrees Celsius
D 50 degrees Celsius
E 60 degrees Celsius

Explain your thinking. Describe the "rule" or reasoning you used for your answer.

Ice-Cold Lemonade
It was a hot summer day. Mattie poured herself a glass of lemonade. The lemonade was warm, so Mattie put some ice in the glass. After 10 minutes, Mattie noticed that the ice was melting and the lemonade was cold. Mattie wondered what made the lemonade get cold. She had three different ideas. Which idea do you think best explains why the lemonade got cold? Circle your answer.

A The coldness from the ice moved into the lemonade.
B The heat from the lemonade moved into the ice.
C The coldness and the heat moved back and forth until the lemonade cooled off.

Explain your thinking. Describe the "rule" or reasoning you used for your answer.
Planning Step 3

- Sophistical understanding
- Readings, discussions, simulations
- Academic vocabulary
Planning Step 3: EXPLAIN

Connect students evidence-based claims with underlying principles.

• Readings (textbook and trade books), discussions, and lectures introduce academic vocabulary in light of students firsthand experiences.

• Computer simulations can allow for exploration not easily accessible from firsthand (think subatomic).
How can students Explain Underlying Principles?
## Explore-Before-Explain Priority Planning

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
<th>Example</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select evidence-producing experience</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Macroscopic observation and data that thermal energy transfers from hot to cold and when combining two different temperature of water, the result is the average temperature.</td>
</tr>
</tbody>
</table>
| 2     | Choose or adapt a USI probe to initiate the evidence-based experience | - “Mixing Water” (Keeley, Eberle, and Tugel 2007)  
- “Ice-Cold Lemonade” from Uncovering Student Ideas in Science, Volume 2 (Keeley, Eberle, and Tugel 2007) | Elicit students ideas about transfer of energy from place to place. |
| 3     | Select explanations that can help students explain underlying principles | ![Image](image2.png) | Provides explanation-type experiences so students can visualize energy transfer on the molecular level. |

### Big Idea 1
Cohesion and Construction = Conceptual Understanding
## Iteration vs Invention

### Transformation Checklist

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>USI format (see Keeley)</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Student predictions</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Demos and investigations</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Underlying Principles:</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>• Readings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Discussion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Simulations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Big Idea 2:
- Facilitate a growth-mindset for teachers!
- Iteration-changing something that already exists
How can I better address the NGSS?
<table>
<thead>
<tr>
<th>Dimension</th>
<th>NGSS dimension</th>
<th>Thermal Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEPs</td>
<td>Asking questions and defining problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analyzing and interpreting data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developing and using models</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Planning and carrying out investigations</td>
<td>♦ 4-PS3-2</td>
</tr>
<tr>
<td></td>
<td>Constructing explanations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obtaining, evaluating, and communicating information</td>
<td></td>
</tr>
<tr>
<td>CCs</td>
<td>Patterns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Systems and system models</td>
<td>♦ 4-PS3-2</td>
</tr>
<tr>
<td></td>
<td>Energy and matter</td>
<td>♦ 4-PS3-2</td>
</tr>
<tr>
<td>DCIs</td>
<td>PS3.A: Definitions of energy</td>
<td>♦ 4-PS3-2</td>
</tr>
<tr>
<td></td>
<td>PS3.B: Conservation of energy transfer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PS4.B: Electromagnetic radiation</td>
<td></td>
</tr>
</tbody>
</table>
### Key Takeaways

<table>
<thead>
<tr>
<th>Session Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What is explore-before-explain?</td>
</tr>
<tr>
<td>• Creating conceptual coherence and asking students to do the hard intellectual work</td>
</tr>
<tr>
<td>• How can I transform my lessons?</td>
</tr>
<tr>
<td>• Flipping the instructional script to focus on conceptual understanding</td>
</tr>
<tr>
<td>• How can I better address the NGSS (and MLS)?</td>
</tr>
<tr>
<td>• The best learning occurs at the nexus of science practices, logical thinking, and concepts</td>
</tr>
</tbody>
</table>

Engaging prior ideas  
Constructing evidence-based claims  
Explaining underlying scientific principles
Thank you! Reach out to me at:

**Twitter:** @brownpatrick8

**Email:** patbrown@fz.k12.mo.us, plbtfc@gmail.com