Redesigning Curricular Materials to Encourage Student Sensemaking of Phenomena in High School Chemistry Learning Environments
Adam G. L. Schafer4, Thomas Kuborn, Megan Y. Deshaye, Ryan L. Stowe
Department of Chemistry, University of Wisconsin - Madison
*agschafer@wisc.edu

Background

Next Generation Science Standards (NGSS) and the framework from which they are based place substantial emphasis on students making sense of the world by building and critiquing atomic-/molecular-level models of chemical phenomena.1,2

Materials intended to focus instruction on scaffolded, interconnected sequences of core ideas, building in complexity as students make sense of increasingly complex chemical phenomena.

Cycle of Material Development

Preliminary Findings

Teachers submitted regular reflections of “what works” when implementing HS-CLUE materials. Investigating the reflections revealed:

The materials often supported student engagement in scientific practices:

- Students collected data about magnitude of charge and distance between particles to make an argument using our Claim, Evidence, Justification structure.
- But mostly conveyed emphasis on “stuff to know” and skill repetition
- It was a nice, concise start to the atom unit where students are expected to understand the evidence that lead to each model of the atom as well as interpret the visual models of the atom.
- Students also worked on the scientific skill of modeling by drawing Rutherford models of specific isotopes (i.e., carbon-12 and ions). Some students struggle with modeling isotopes and ions but with practice most catch on.

Research Questions

1. To what extent did our curricular materials center making sense of phenomena?
2. What sorts of design principles should underpin a chemistry learning environment to promote making sense of phenomena?

Methods

Each lesson in HS-CLUE materials coded according to scheme modified from Lowell, Cherbow, McNeill.3

3 raters divided coding so each lesson was coded by 2 raters (Cohen’s kappa = 0.88)

Results

<table>
<thead>
<tr>
<th>Unit</th>
<th>Lesson</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenomena</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Dimensional</td>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3-Dimensional</td>
<td></td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Teacher- vs Student-Centered</td>
<td></td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Coherent</td>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Conclusions

Use of Phenomena

Often phenomena are:

1) employed as examples, not as the focal point of knowledge construction
2) inconsistently present throughout units, mostly near end

3-Dimensional learning opportunities are often:

3) present but inconsistent from lesson to lesson
4) not well scaffolded throughout materials
5) provided with little guidance to support the teacher

Use of Student Ideas

Opportunities for knowledge construction are often:

6) centered on the teacher
7) provided with little guidance to support the teacher

Coherent

Connecting knowledge between experiences often:

8) is conducted by the teacher
9) does not account for students’ prior knowledge
10) does not facilitate student processes for connecting multiple knowledge sources

Implications

Phenomena should:

1) be the focus of what is “figured out” throughout knowledge development
2) anchor knowledge development throughout unit

3-Dimensional learning opportunities should:

3) be emphasized throughout learning experiences
4) be developed over time with appropriate scaffolding
5) be accompanied with purposeful guidance in the teacher materials

Opportunities for knowledge construction should:

6) elicit and employ student ideas
7) be accompanied with purposeful guidance in the teacher materials

Connecting knowledge between should:

8)–10) allow for students to connect their knowledge gained and applied from prior experiences to the current learning activity

References and Acknowledgments


Current & Future Work

Transition to Chem-LEAP (Chemistry Learning Environments Anchored in Phenomena)

Chem-LEAP Feature: Anchoring Phenomena

Initiate Learning with Phenomena

Multiple structural opportunities for peer support and knowledge development

Continued Experiences Through Phenomena

Teacher materials include guidance for feedback and facilitation

Chem-LEAP Feature: Early, frequent scaffolding of practice development

Model Generation

Guided Peer Feedback

Model Revision

Chem-LEAP Feature: Frequent, scaffolded opportunities to communicate and revise models

Model Generation

Guided Peer Feedback

Model Revision

Chem-LEAP Feature: Tools and practices that allow students to connect experiences

Students Experience Phenomena

Student Ask and Categorize Questions to Address Learning Activities

Revise the Driving Questions Board. How do the driving questions on the current activity board facilitate the current learning activity? How do the driving questions on the current activity board facilitate the current learning activity?

Revise the activity summary board. What themes have we addressed so far?