Redesigning Curricular Materials to Encourage Student Sensemaking of Phenomena in High School Chemistry Learning Environments

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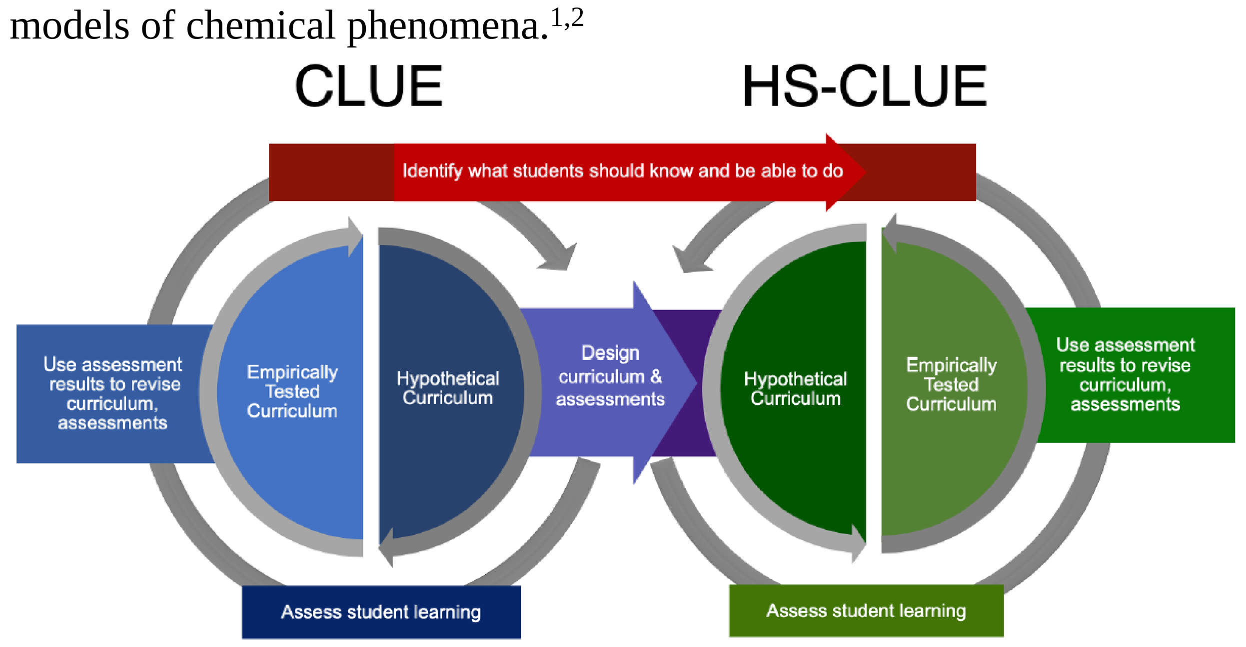
Background

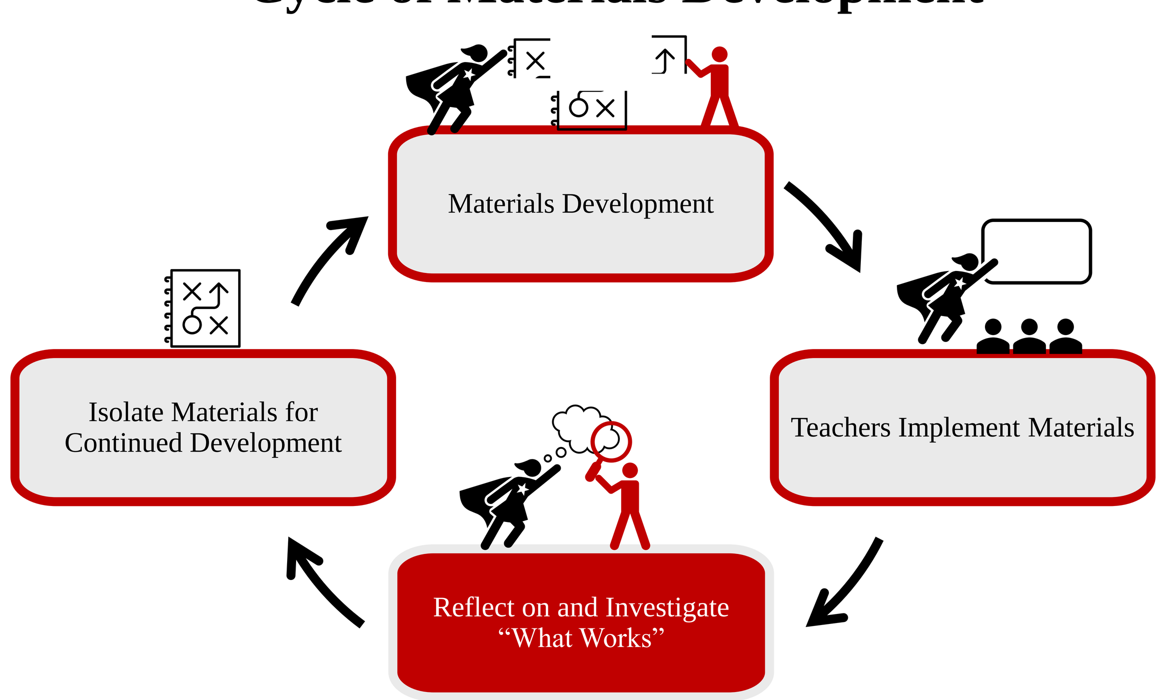
Next Generation Science Standards (NGSS) and the framework from which they are based place substantial emphasis on students making sense of the world by building and critiquing atomic- / molecular- level models of chemical phenomena.[1,2]



To support high school chemistry teachers in designing learning environments with opportunities for students to make sense of chemical phenomena, a suite of curricular materials was co-developed by a team of chemistry education researchers and high school chemistry teachers using the evidence-based CLUE curriculum as a scaffold.[3,4]

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 Materials 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 atoms 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.[5]

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

Category	Description
Use of Phenomena	Is there an event or phenomenon to provide context to knowledge construction?
3-Dimensional	Are Cross-Cutting Concepts, Scientific and Engineering Practices, and Disciplinary Core Ideas integrated throughout the learning experience?
Use of Student Ideas	Are students positioned as knowers and active co-constructors of knowledge?
Coherent	Are students provided opportunities to connect learning activities while sensemaking?

Results

Results address the question proposed for each category:

2 = Yes 1 = Partially 0 = No

Unit	Unit 4										Unit 7								
Lesson	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9
Phenomena	0	0	1	0	1	2	0	0	0	0	0	0	0	1	0	2	2	1	2
3-Dimensional	0	0	2	0	0	1	0	0	0	0	0	0	0	1	0	2	1	0	1
Teacher- vs Student- Centered	0	1	2	0	1	1	0	0	0	0	1	1	0	1	0	1	1	1	1
Coherent	1	0	0	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1

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

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[6, 12]
2) anchor knowledge development throughout unit[5, 7]

3-Dimensional learning opportunities should:

3) be emphasized throughout learning experiences[2, 7, 8]
4) be developed over time with appropriate scaffolding[2, 8]
5) be accompanied with purposeful guidance in the teacher materials [9, 10]

Opportunities for knowledge construction should:

6) elicit and employ student ideas[1, 2, 11, 12, 13]
7) be accompanied with purposeful guidance in the teacher materials [9, 10]

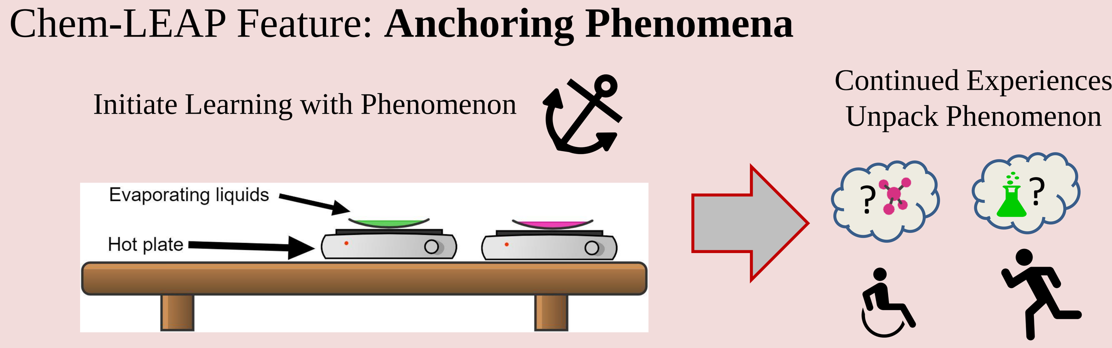
Connecting knowledge between should:

8) -10) allow for students to connect their knowledge gained and applied from prior experiences to the current learning activity[2, 7, 11, 12, 14, 15]

Current & Future Work

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

Chem-LEAP Feature: **Anchoring Phenomena**

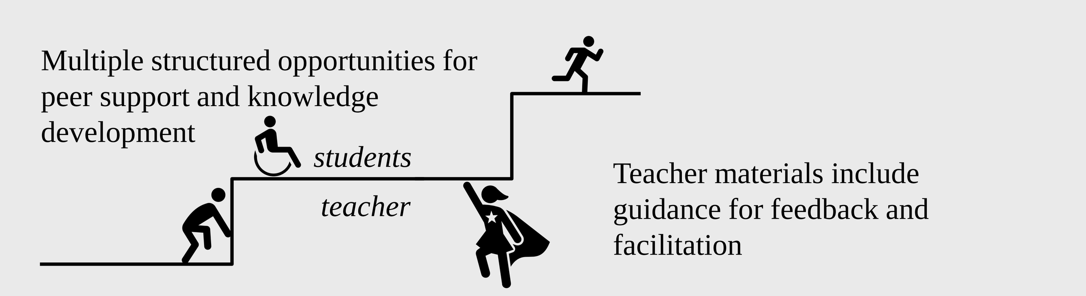


Example Item: Unit 1 Lesson 1

…try to generate as many questions as possible about these substances boiling. Be prepared to share.

While generating questions…
1) Ask as many questions as you can.
2) Do not stop to judge, discuss, edit, or answer any question.
3) Write down every question as asked.
4) Change any statements into questions.

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



Example Item: Unit 1 Lesson 3

Do your observations from the demonstration support a "continuous" model of matter or a "particle" model of matter? Provide evidence from the demonstration to support your claim and reasoning that links your evidence to the claim.

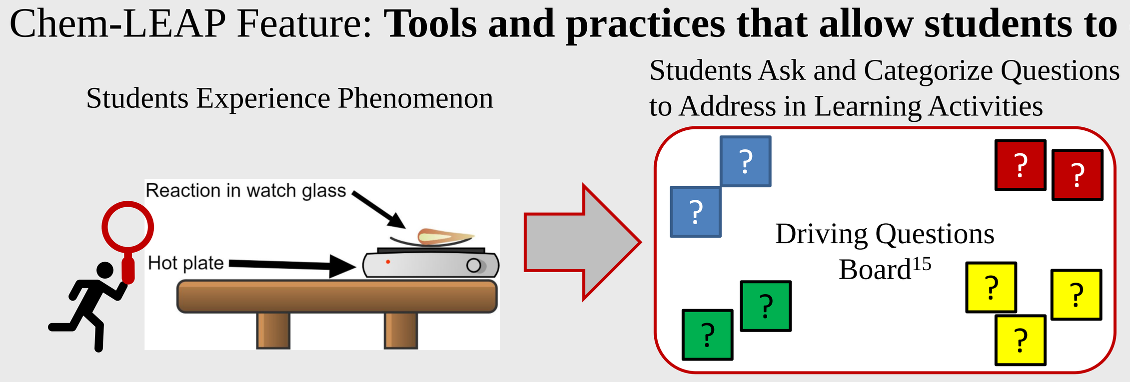
Claim: My observations support a continuous/particle (circle one) model of matter.
Evidence:
Reasoning:

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

Example Item: Unit 1 Lesson 5

When you have completed your claim about what the "temperature" of a substance describes, pair with another group to compare similarities and differences between your arguments. Use Table Z to organize your comparisons. For any differences observed, ask the group why the argument was crafted in that way.

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



Example Item: Unit 1 Lesson 7

Review the driving questions board. What question(s) from the driving questions board will be addressed in this experiment?

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

References and Acknowledgments

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