Teacher-Driven Partnership to Support Mid-Career Chemistry Teachers

NARST Presidential Symposium
April 1, 2019

Teamwork

Teachers: Rob Huie, Greg Banks, Scott Balicki, Michael Clinchot, Jen Lambertz, Becca Lewis (not pictured)
Graduate student: Raúl Orduña Picón
Postdocs: Vesal Dini (not pictured), Stephanie Murray (not pictured)
School district administrators: Pam Pelletier, Holly Rosa, Marianne Dunne (not pictured)
State administrator: Jake Foster

Teacher: Greg Banks
Postdocs: Stephanie Murray, Ira Caspari, Vesal Dini (not pictured)
Graduate students: Emma Vélez Avila, Raúl Orduña Picón, Clarissa Keen, Klaudja Caushi, Jessica Karch
Undergraduates: Daniliz Capellán Pichardo, Qausarat Ogunnaye
Visiting scientist: Edenia Amaral (visiting from Brazil)
Collaborator: Vicente Talanquer (at Univ. of Arizona)
Chemistry team


Theoretical perspectives

| Teacher leadership in professional development | • Metaphors of teacher leadership [6]  
|      | • Norms: facilitator-teacher discursive interactions [7] |
| Domain-general teaching and learning | • Formative assessment: “process used by teachers and students to recognize and respond to student learning in order to enhance that learning, during the learning” [4]  
|      | • Communicative approach: authoritative vs. dialogic [5] |
| Domain-specific teaching and learning | • Chemical thinking: applying chemical knowledge and practices to analyze, synthesize, and transform matter for practical purposes [3] |
| Classroom activity | • Design-based research: entanglement of design of learning environments & development of learning theory [1]  
|      | • Principled practical knowledge: systematic, coherent, explanatory, practical guidance [2] |

There is a lack of practical guidance for chemistry teachers in enacting formative assessment to support students’ sense making.

Guiding principles and 3 examples of collaborative work

- Merged community of practice
  - Teachers drive what is worth studying
  - Researchers support the research
  - Together we design and study
- Three examples of research-practice collaborations
  1) Developing chemistry formative assessment tools to study students’ chemical thinking
  2) Examining how experienced chemistry teachers evaluate student work
  3) Characterizing how chemistry teachers lead from the classroom in peer-led professional development

Szteinberg et al., 2014

Developing chemistry formative assessment tools to study students’ chemical thinking

**STUDY 1**
Chemical thinking

- What types of matter are there?
- What are the effects of using and producing different matter types?
- What properties of matter types change?
- How does structure influence reactivity?
- What drives chemical change?
- What determines the outcomes of chemical changes?
- What are the interactions between matter?

Consequences

- Assessing risk at various scales (hazard, exposure)
- Considering mechanism (toxicology), life cycle (fate and transport)
- Identifying classes of chemicals
- Compensatory reasoning (e.g., price-performance-safety, pick 2)

Benefits-Costs-Risks
What are the consequences of changing matter?

Activity: Sustainable action

Evaluation

Decision making
Benefits-costs-risks instrument

GoKarts cognitive interview

Fuel choice (assume for simplicity same price per gallon). Which one? Why?

- Gasoline (octane derived from petroleum)
- Gasoline (octane derived from wood pellets)
- Natural gas (methane)
- E85 (ethanol)

Gradual provision of new information:
- Phases
- Component elements
- Chemical structures (ball & stick)
- Goal of pollution reduction

Methods

<table>
<thead>
<tr>
<th></th>
<th>Middle school</th>
<th>HS regular or honors</th>
<th>HS Adv Placement</th>
<th>Univ freshmen</th>
<th>Univ sophomore</th>
<th>Univ senior</th>
<th>Graduate students</th>
<th>Practicing chemists</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>11</td>
<td>11</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>CR</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Evolution of benefits-costs-risks thinking

Familiarity
Natural vs. artificial

What is in it?
Judgments based on affective impressions about system components

How was it produced?
Organic vs. commercial

How does it interact with other chemicals in the environment?

What does it turn into?

Toxicity to people, animals, plants…

Interactions view (at different scales)

Judgments based on analysis of material and energetic consequences of production and use of materials

Objects view (all scales assumed same)

Practical results
Practical results

Journal of Chemical Education

Table 4. Assumptions That Constrain Students’ Thinking When Evaluating Fuel Choices, as Well as Stepping Stones That Are Conjectured Based on the Findings and May Facilitate Reconceptualizations toward More Advanced Thinking

<table>
<thead>
<tr>
<th>Intuitive Thinking</th>
<th>Stepping Stone</th>
<th>More Advanced Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits-over-risks thinking</td>
<td>Judgments based on affective impressions about system components</td>
<td>Recognizing and thinking about energy changes</td>
</tr>
<tr>
<td>Structure–property relationships</td>
<td>Direct association between explicit features of chemical representations and macroscopic properties of substances</td>
<td>Noticing implicit features of chemical entities</td>
</tr>
<tr>
<td>Additive view of properties of substances based on properties of components</td>
<td>Setting mechanisms at multiple causal links</td>
<td>Recognition of causal links based on interactions between different components of a system</td>
</tr>
</tbody>
</table>

Banks et al., 2015

Examining how experienced chemistry teachers evaluate student work

STUDY 2
Chemical thinking

1. What types of matter are there?
2. What cues are used to differentiate matter types?
3. What properties of matter types change?
4. How does structure influence reactivity?
5. What drives chemical change?
6. What determines the outcomes of chemical changes?
7. What interaction patterns are established?
8. What affects chemical change?
9. How can chemical changes be controlled?
10. How can the effects be controlled?
11. What are the effects of using and producing different matter types?
12. How do we identify chemical substances?
13. How do we predict the properties of materials?
14. Why do chemical processes occur?
15. How do chemical processes occur?

Chemical Control
How do we control chemical changes?
Activity: Reaction control

- Classification of processes
- How to induce or control chemical processes (thermodynamic control, kinetic control)
- Internal and external factors that affect processes
- Stability, reactivity, reaction rates

Models of change
Control parameters

Clinchot et al., 2016
Chemical control formative assessment

(silent video shows a student creating a “volcano” for a demonstration for 4th graders)

Students are asked to answer the following:

• What are 3 different things she could do to make it more dramatic (bigger amount of bubbles)?
• Explain/justify why it would work

List of chemicals
- Various acids & bases
- Metals, sugars
- Alcohols, ketones

List of equipment
- Mass & volume
- Hot plate
- Flasks, containers

5 g citric acid  5 g baking soda  20 mL water
Focus group interviews

Why focus groups [1, 2]
- Synergy of group dynamics → Explore beliefs, behavior reasons
- Common experiences → own vocabulary & priorities

Questions [3]
1. What did you pay attention to in the students’ answers and why?
2. How do you make sense of [specific things noticed]?
3. What patterns did you see in students’ responses?
4. If these students were representative of a class before you, what’s the best action to help the class?
5. How can the probe be improved to do a better job of finding out what students are thinking?


Data analysis

Phase 1 Holistic
- Framework analysis (Rabinee, 2004)
- Uncover common themes inductively
- Overlapping cycles of analysis

Phase 2 Individual teachers
- Teacher’s stance within each episode of discussion
  - Noticing☆: descriptive or inferential
  - Interpreting☆: correcting or making sense
- Built Acting: prescriptive or responsive

Phase 3 Representative approaches
- Examine clusters in (N, I, A) space
- Identify commonalities and differences
- Build composite cases
Experienced teachers’ assessment approaches

- Authoritative approach characterized by prioritization
  - Correct > incorrect
  - Quantitative > qualitative
  - Chemistry > physics
  - Looked for specific vocabulary or numbers

- Dialogic approach characterized by interpretation
  - Inferred patterns in how students may be thinking
  - Paid attention to how students make sense of ideas

- Discomfort with open-endedness
  - With some teachers, the open-ended nature of the assessment elicited a more responsive stance
  - More often teachers recommended improvements to make the assessment more closed-ended

Formative assessment enactment model

Sevian & Dini, 2019
Characterizing how chemistry teachers lead from the classroom in peer-led professional development

**STUDY 3**

**Structure of the study**

**Data analysis**
- What is the focus
- Formative assessment practice
- Chemical thinking question
- Leadership metaphor
- Teaching practice dilemma

**Three types of videos**
- Planning meetings for the PD
- PD workshops
- Debriefs after each workshop

**Year-long PD**
- Meetings once per month
- Cohort model
- Experienced chemistry teachers
Example of what we analyze

- **Context**
  - The peer leaders are planning for the first PD session
  - They are anticipating a point in the PD when the teachers will have just spent an hour in the lab doing the Pringles lab
  - Some teachers probably will have made some of the common student actions that are shown on the screen at this point in the PD
  - In this way, the teachers participating in the PD are proxies for the students, and using this, they can work on interpreting the meanings underneath students’ actions
- **Bruno (a new peer facilitator)**
  - Wants to focus teachers’ attention on how three common actions of students in the Pringles lab activity can be interpreted in terms of how students are thinking about how to control chemical reactions
  - She is struggling to figure out how to transition the teachers from talking about the value of the open-endedness of the lab activity, to paying attention to typical student actions

What have we learned, and where can we go from here?

**SUCCESSES, CHALLENGES, & LESSONS LEARNED**
Successes

- Merged community of practice
  - Teachers identify what it is important to study
  - Researchers provide rigor in research approaches, and funding
  - Together design research & development work in a design-based approach with the goal of creating principled practical knowledge
  - Model of peer teacher leadership that leverages formative assessment to support teachers’ attention to the substance of students’ chemical thinking
- Chemical thinking
  - Resource map of accumulation of resources along 6 questions of chemical thinking
  - Identification of stepping stones that teachers can use in advancing students’ chemical thinking
- Formative assessment enactment
  - Model of formative assessment enactment that is useful to teachers in planning instruction
  - Language that mediates teachers’ planful noticing
- Teacher leadership
  - Approach to studying leadership development

Challenges

- Professional development program
  - Finding the best balance among domain-general (formative assessment practices), domain-specific (chemical thinking), and challenges (dilemmas)
  - Supporting a wide range of where teachers are
- Resources for scaling
  - Facilitator guide
  - Capacity building
Lessons learned

- **It works because it is a joint enterprise**
  - My perspective changed dramatically and quickly. I found it quite interesting that the criteria for the research had not fully been developed. As a matter of fact, our input was an integral part of the process which guided the way the research was to develop.... Our input was not only about our opinions about students’ learning and thought processes, but also used to determine new goals for our collaboration. We came up with new directions for the papers and for the training planned for our colleagues. (high school teacher)

- **Community of practice aspects are necessary**
  - **Boundary objects**
    - I would like to think that bringing researchers and practitioners together to collaborate on a project would work under any conditions but I can’t negate the fact that there was already an existing familiarity and respect among the teachers and one of the principal researchers. I think this enabled trust to be quickly established and empowered individuals to be open and honest about ideas, concerns, and lack of chemistry, pedagogical, or statistical knowledge. (middle school teacher)
  - **Brokers**
    - Personally, I think the presence of both middle school and high school teachers had a big impact on the success of the project. I feel that the high school teachers provided a bridge between the middle school teachers and the researchers. (middle school teacher)

- **Rigorous qualitative work is helpful to teachers in growing their practice**
  - I had never done qualitative research before. And while I did not need to be convinced of its value, I did have a learning curve to master the practices that quantify student understanding beyond the ‘test grading’ metrics I was used to using… The big revelation for me… was the idea that that some student ‘misunderstandings’ are better thought of as stepping stones, and that there may be a pattern and progression in the stepping stones.
  - I believe that the act of being involved in developing these tools has given me new perspectives about ways in which I could use lessons from interviewing and coding to revise and re-design lesson plans in a manner that encourages students to explain their thinking, models, and assumptions in a more complete and detailed way.

Dedication

This presentation is dedicated to the memory of Julio Lopez-Ferrao
Program Officer, Division of Research on Learning, NSF
May he rest in peace
Thank you! And if you would like further information

If you would like to download this presentation
- [https://acctproject.org/publications](https://acctproject.org/publications) (this NARST presentation is 3rd bullet under 2nd heading), or go to: bit.ly/narst-2019-acct

- We are recruiting Boston area teachers now for Cohort 3 in AY 2019-20 (grades 6-12 teachers of chemistry with 3+ years’ experience teaching) (see PD section of website)

Selected references