Moving from Description to Explanation: Professional Development and Research on Molecular Visualization for High School Chemistry Teachers

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Background

Conceptual understanding in chemistry is at the heart of the Next Generation Science Standards (NGSS):[1]

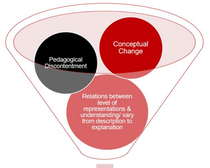
- Science and Engineering Practices
  - developing & using models
  - constructing explanations
- Disciplinary Core Ideas
  - matter & its interactions
  - motion & stability: forces & interactions
  - energy

Current pedagogical practices and professional development are not aligned with the conceptual rigor of the NGSS. Why?

- nature of the disciplinary knowledge of chemistry
- how chemistry has been traditionally taught[2,3]

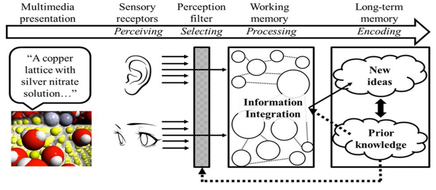
Visualization can support conceptual burden of learning chemistry.
High school chemistry ready for visualization and reform with appropriate PD.

Theories of Change and Action



PD on the VisChem Approach

VisChem Cognitive Learning Model[4]



Weaving Together PD & Research

VisChem Institute Aims (PD)

1. Improved teacher & student conceptual understanding
2. Improved PD model (VisChem Institutes)
3. National NGSS alignment

4-Day Intensive Institute

Overarching Research Questions

1. How do the VCIs change teachers' understanding of chemistry concepts?
2. In what ways do teachers afford and constrain students' use of explanatory frameworks with particulate-level models when implementing the *VisChem Approach*?
3. To what extent and in what ways do students' ideas about molecular-level behavior underpinning chemical and physical phenomena change when their teachers use the *VisChem Approach*?

Sampling

- Target teachers of disadvantaged and underrepresented minority students (NCES)
- Target ideal characteristics for change & effectiveness (application)

	2020	2021
Applicants	166	156
Candidates	70	94
Finalists	34	40
Participants	20	20

Applicants
- Teaches chemistry at Public US high school
- Has 2-29 years of teaching experience
- Is willing to do virtual PD

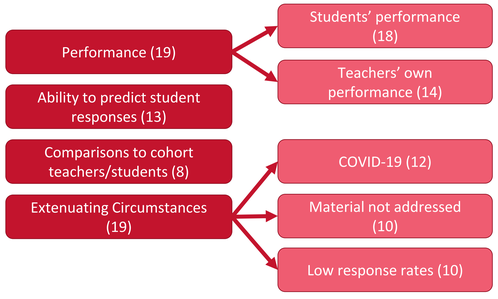
Candidates
- Weighted ranking system
  - Economic need (school)
  - Minority population (school)
  - Years Experience (teacher)
  - Number of chemistry students (teacher)
- Essay responses rated & ranked according to student centeredness

Finalists
- Categories into two pools: Participants & Alternates
- Aiming for geographic diversity
  - 1 teacher/school
  - 1-2 teacher(s)/state

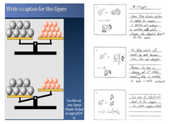
PD Teacher Preparatory Work

Goals:
- Prepare teachers to change their classroom practices
- Generate pedagogical discontentment to promote growth

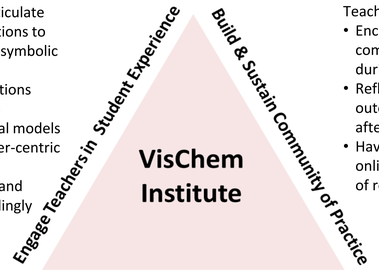
Method:
- Teachers & students complete a molecular-level assessment
- Teachers reflect on their & their students' performance
  - Unguided reflection – 1 week prior to VCI
  - Guided reflection – end of VCI Day 1
- Reflection Themes (Number of Teachers)



Professional Development (PD)



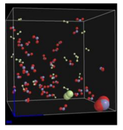
- Emphasize particulate level & connections to macroscopic & symbolic levels
- Focus on limitations inherent within representational models
- Facilitate learner-centric sensemaking
- Elicit feedback and respond accordingly

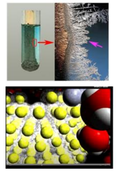


Teachers will…
- Encourage communication during and after PD
- Reflect on learning outcomes before & after institute
- Have access to an online repository of resources

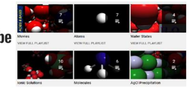
zoom
Keeping channels open for informal discussions

slack
Ensuring its longevity via literature circles and coffee-talks





YouTube



Google Drive

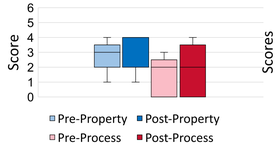
Model Evidence-Based Teaching Practices

- Use the research literature to prime the attention filter
- Reduce cognitive load with learner-centered organization
- Facilitate the linking of new ideas to existing ideas using a variety of technologies & approaches

Research

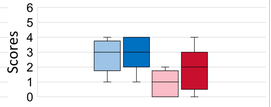
- Developed Property & Process Tool (scan corner QR code) to evaluate quality of participants' descriptions and explanations in
  - Storyboards
  - Learning designs
- Visualized scores into radar plots
- Organized radar plots into profiles from most ideal (dark) to least ideal (light) for each participant (18/20) in Cohort 1

Property & Process Scores for Dissolution Storyboards Before & After Viewing an Animation



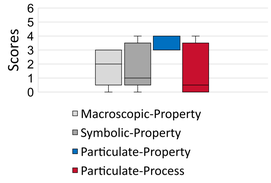
- 19/20 dissolution storyboards collected on Day 1
- Higher property scores (pre & post)
- Lower median post-process score with greater variability

Redox Storyboards Before & After Viewing an Animation

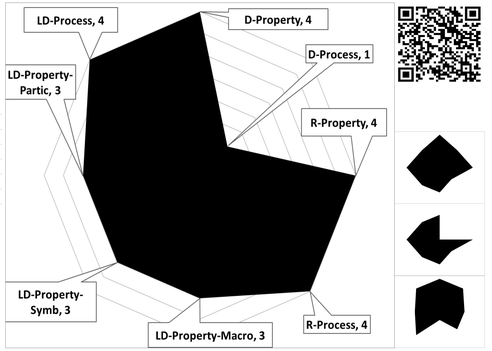


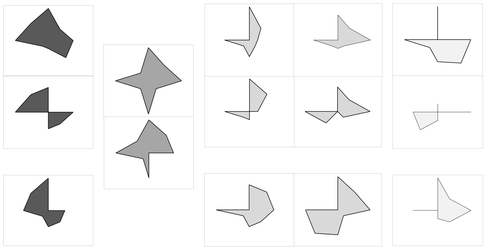
- 19/20 redox storyboards collected on Day 4
- Higher property scores
- Improved pre-post process score, but low median value

Precipitation Learning Designs



- Note change in legend from above
- 20/20 precipitation learning designs collected on Day 2
- Higher property scores (especially on the particulate level)
- Lower median process score with greater variability





Project Status

- Recruitment, Sampling, and Selection Methods (designed and tested)
- Diagnostic Instruments to Support Measuring of Student Learning for Teachers and Project Team
- VisChem Resource Development and Dissemination (e.g., VCI YouTube Channel and Google Drive folders)
- Professional Development Design
- Professional Development Implementation
- Human Resource Development
- Community of Practice (informal professional gatherings)
- Interaction with Advisory board (annual group and individual meetings)
- Research on Professional Development
- Dissemination of Work (six conferences, paper in progress)
- Research on VisChem Implementation
- Follow Up Simulation Professional Development

References

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