Modeling Instruction in High School Chemistry -2

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REQUIRED TEXT:

- There is no required text for this course

SUPPLEMENTAL READING:

The articles listed here will be provided electronically to the teachers.

- Ashkenazi, Guy and Weaver, Gabriela. "Using lecture demonstrations to promote the refinement of concepts: the case of teaching solvent miscibility" *Chemistry Education Research and Practice*, 2007, 8(2), 186-196

- Bronsted, J.N. Some Remarks on the Concept of Acids and Bases (excerpt), *Recueil des Travaux Chimiques des Pays-Bas.* Vol 42. 1923

- Cooper, Melanie and Klymkowsky, Michael. "Lost in Lewis Structures: An Investigation of Student Difficulties in Developing Representational Competence", *Journal of Chemical Education,* Vol. 87 No. 8 August 2010

- Cooper, Melanie and Klymkowsky, Michael. "The Trouble with Chemical Energy: Why Understanding Bond Energies Requires an Interdisciplinary Systems Approach" *CBE—Life Sciences Education* Vol. 12, 306–312, Summer 2013

- Dukerich, Larry. "Applying Modeling Instruction to High School Chemistry To Improve Students' Conceptual Understanding." *J. Chem. Educ.*, 2015, 92 (8), pp 1315–1319

- Gillespie, R.J, Robinson, E.A. "Gilbert N. Lewis and the Chemical Bond: The Electron Pair and the Octet Rule from 1916 to the Present Day", *J Comput Chem* 28: 87–97, 2007

- Harrison, Allan and Treagust, David. "Secondary Students' Mental Models of Atoms and Molecules: Implications for Teaching Chemistry", *Science Education* 80(5): 509-534, 1996 (print)

- Megowan-Romanowicz, Colleen. "Whiteboardong: A tool for Moving Classroom Discourse from Answer-Making to Sense-Making, *The Physics Teacher*, Vol. 54 February 2016.

- Michaels, Sarah and Cathy O'Connor. "Talk Science Primer", TERC 2012
- Shusterman, Gwendolyn and Alan. "Teaching Chemistry with Electron Density Models" *Journal of Chemical Education*, Vol. 74 No. 7 July 1997

COURSE PREREQUISITES:

In-service teacher of chemistry or physics, or instructor approval. Students must have completed a Modeling Instruction (preferably Chemistry 1) workshop prior to this course.

COURSE DESCRIPTION:

Secondary-level chemistry teachers will participate in 60 hours of training in Chemistry: Modeling Instruction. The workshop will focus on an evidence-based approach to the internal structure of the atom, periodicity and covalent bonding, intermolecular forces, equilibrium and acids and bases. The name *Modeling Instruction* refers to making and using conceptual models of real systems and processes (both natural and artificial) as central to learning and doing science and engineering. Instruction is organized into modeling cycles rather than traditional content units. This promotes an integrated understanding of modeling processes and the acquisition of coordinated modeling skills. The two main stages of this process are model development and model deployment. The modeling cycle addresses the deficiencies of traditional instruction by assisting students to construct understanding from observations, by confronting student preconceptions, by examining student thought processes through the process of "whiteboarding" and Socratic dialoguing. Participants will receive both printed and electronically stored versions of the course manual, as well as ancillary materials.

COURSE TOPICS:

The course addresses both content and pedagogy used to teach the core concepts in an honors or AP high school chemistry course. The specific units are listed below:

- **Unit 10 – Models of the atom**
  From an examination of the radiation emitted by hot metals and atomic gases, we conclude that atoms must have internal structure not explained by Thomson's model.
- **Unit 11 – Periodicity and bonding**
  We extend the Bohr model to many-electron atoms, using it to provide a structural explanation for the organization of the Periodic Table, and to examine ionic and covalent bonding in compounds.
- **Unit 12 – Intermolecular Attractions and Biological Macromo**lecules
  We use an electron density model to account for the attractions between molecules and their effect on physical properties. Then we move to an investigation of organic molecules important to life.
- **Unit 13 – Equilibrium**
  Various equilibria in processes (liquid-vapor, solute-solution, partition) and reactions are modeled by the exchange of particles between "containers". This exchange explicitly models rates of opposing processes.

- **Unit 14 – Acids and bases**
  Exchange of the acidic proton between species in acid-base equilibria and relative strengths of acids and bases is viewed in terms of competition by bases for H_3O^+ ions.

Because these concepts are ones with which teachers have less direct experience, as much emphasis will be placed on deep discussion of this chemistry content as on pedagogy.

There is additional enrichment on entropy (for AP and honors courses) on the probable direction of change. We adopt a "probability" view to account for the spontaneity of processes involving both structural and thermal change. This approach puts the “dynamics” back into thermodynamics!

LEARNER OUTCOMES

Through successful completion of this course, teachers will

- Improve their instructional pedagogy by incorporating the modeling cycle, inquiry methods, critical and creative thinking, cooperative learning, and effective use of classroom technology,
- Deepen their understanding of content in 2nd semester high school chemistry,
- Experience and practice instructional strategies of model-centered discourse, Socratic questioning/whiteboarding, and coherent content organization,
- Strengthen local institutional support as school leaders in disseminating standards-based reform in science education,
- Increase their skill in all eight scientific practices recommended by the National Research Council in “A Framework for K-12 Science Education.”
  The development and use of models are at the core of the NGSS Science and Engineering Practices.

BIG IDEA:

To help participants learn to actively guide their students in the use of scientific models in order to develop experimental and analytical skills, including: experiment design, graphical analysis, mathematical, and diagrammatic model building.

The NGSS standards addressed in this course are:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Modeling Instruction addresses these NGSS Disciplinary Core Ideas

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium..

COURSE REQUIREMENTS:

Students are expected to do the following:

- **Keep a course notebook.**
  This should take the form of an electronic journal in Google Drive. Participants should record clear, focused comments and notes on how each lab and problem set is viewed from both the student and teacher perspectives. Entries should include any additional suggestions for implementation, changes, and questions for Socratic Dialogue and class discussion. Teachers can take notes via paper and pencil, then scan or take pictures of pages to enter into their course folder.
- **Keep a reflection journal**
  At the end of each unit, write a more detailed analysis of the unit, including strengths and weaknesses, how it is either resonant or dissonant with your own thinking about the content, how you might modify parts of the unit to fit your own style or teaching situation, etc. This ought to be 1-2 pages in Google Docs. Another option we'd like you to consider is to make at least one 10-15 min narrated screencast using Screencast-o-Matic* (or similar program) or Explain Everything** presentation for your unit reflection in place of the written reflection. This could include some clips of any experiment or demo you performed.
  * https://screencast-o-matic.com/
  ** https://explaineverything.com/download/

- **Participate actively and thoughtfully in lab whiteboarding sessions, discussion of readings, activities, and problem-solving whiteboarding.**

- **Read excerpts from chemical education research articles as assigned and participate in subsequent discussions**.

- **No later than the final day of class, write and submit a final paper** (at least 4 pages, double-spaced, 12 point font) demonstrating further evolution in your capacity to implement and enact chemistry modeling instruction methods in your classroom. You should focus on specific, content-related practices that have direct applicability in the classroom, and avoid empty generalities. The use and inclusion of "multiple representations" (as explained, demonstrated and promoted in the workshop) is encouraged wherever appropriate. You may wish to focus on one or more of the following questions:

  a) How can Modeling Instruction be implemented in your classroom? In particular, how could one or more of the teaching units in this workshop be used in your specific teaching situation? For example, to utilize a specific type of equipment available at your school, to focus on a particular reasoning skill, or to improve one or more of your own existing, successful classroom activities by incorporating some aspect(s) of Modeling Instruction.

b) Contrast the classroom procedures used in the modeling pedagogy with those typically used in a conventional teaching approach.

c) In what ways and to what extent does a non-modeling reformed pedagogy (like POGIL or Target Inquiry) differ from Modeling Instruction? Is it more inquiry-based than modeling? Less inquiry-based? This should be supported with examples, quotes from the materials, or other evidence

TENTATIVE COURSE SCHEDULE

* This syllabus is a tentative schedule of class activities which may be changed to meet student needs. Any changes will be announced ahead of time.

TENTATIVE COURSE SCHEDULE*

Date	Topic	Assignment
Day 1	Debrief experiences with implementation of MI in classrooms. Review storyline of units 1-9 Unit 10 – Demo/Discussion: light and spectra; what's going on in system when R is the mechanism? Atomic research project described; break into groups to look over the sites provided (assign pairs of atomic scientists from list to 3 groups - self-organize to research, view sites: Thomson + Millikan; Rutherford + Moseley; Bohr + Chadwick).	Continue work on the research project, be ready to make a presentation with colleagues after some time on Day 2.
Day 2	Make brief presentation on research project • *Describe experiment and key evidence,* • *change in model due to evidence,* • *change in model 'invented' for completeness* modify Rutherford model to account for isotopes, do worksheets Make-n-take on thermal energy and radiation apparatus Begin Unit 11 – Develop Men in the Well analogous model for arrangement of electrons in many-electron atoms, deploy model to account for periodic trends	Review Unit 10 Teacher notes, write unit reflection
Day 3	Use of MiW model to account for ionic bonding, failure to adequately represent covalent bonding – need for new model, Lego activity to represent bonding in compounds of C, N, O and H. Need for structural formulas to explain isomers. Discuss Lewis article - specifically, what convinced Lewis that a pair of valence electrons made a bond? how did the octet rule arise? Similarities and differences between MiW and Lewis models, evolution of Lewis cubical model to tetrahedral bonding model, discuss Cooper/Klymkowsky article on issues with Lewis structures	Read *Gilbert N. Lewis and the Chemical Bond: The Electron Pair and the Octet Rule from 1916 to the Present Day,* read Cooper-Klymkowsky article on Issues with Lewis structures.
Day 4	Begin Unit 12 – develop electron density model to explain London, dipole-dipole interactions, H-bonding, IMF and miscibility Apply model of IMF to biological molecules, functional groups Review of research project on carbohydrates, proteins and nucleic acids How organisms use energy (EBC's for biology)	Read Schusterman article: *Teaching Chemistry with Electron Density Models* (up to section on bond order). Journal entry, work on Unit 11 reflection. Read *TalkScience Primer*-part 1
Day 5	Begin Unit 13 – Equilibrium Observe, then model liquid-vapor equilibrium with "game" mid-course correction	*The trouble with chemical energy* reading – discuss tomorrow. Journal entry. Work on Unit 12 reflection

Day 6	Solubility equilibrium, worksheets Partition equilibrium, develop law of chem equilibrium from kinetics Quantitative treatment, worksheets	Read *TalkScience Primer-part 2,* begin reflection on unit 13
Day 7	Discuss reading, changes in a system at equilibrium: Demo/Discussion/Activity with FeSCN2+ system, Le Chatelier's Principle at the particle level. Review U13 test Begin Unit 14, Lab: properties of acids and bases, how to distinguish Features of and failures of Arrhenius model	finish Unit 13 reflection - challenges and/or benefits you see of using this unit in your setting, discuss final paper Bronsted reading
Day 8	Features of Bronsted-Lowry model, why superior to Arrhenius Relative strengths of bases lab Equilibrium expressions for weak acids worksheets	Read through Tnotes on relative strengths of bases activity – reflect on how this differs from usual treatment of acid strength, continue work on final paper, review Explain Everything video on this experiment
Day 9	Demo-discussion to investigate why $[H^+]$ doesn't go to 0, origin of pH scale, strong-acid-strong base titration, weak acid-strong base titration to determine K_a, worksheets	Unit 14 reflection, do Unit 14 test
Day 10	energy transfers between system and surroundings, Boltzman game, how entropy (S) is related to W, positional entropy, entropy in thermal and structural change, derivation of Gibbs free energy AACC test	