Modeling Instruction™
Pedagogy and Practice
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Goals of Science Education
Goals of Science Education

- Cultivate a love of science
- Instill a desire to understand “why”
- Help students develop critical thinking and problem solving skills
- Guide students in developing the ability to analyze and draw conclusions – and support their ideas with facts and data
- Produce a scientifically literate population
Traditional Pedagogy and Practice
Traditional Instruction

Sit and Get

- A classroom environment where teachers are asking all the questions
- Students view their teachers as the distributors of knowledge
- More emphasis is placed on arriving at the correct answer than on understanding the problem-solving process
Traditional Instruction

Teaching by Telling

- Requires little engagement from the learner\textsuperscript{1}

- Does not improve student problem-solving skills\textsuperscript{1,2,3}

- Assumes students will see the underlying structure and context of the content (sequence and why it’s important)\textsuperscript{3}
Traditional Instruction

Teachers Know Too Much

- Courses are often organized in a way that makes sense to people who already understand chemistry
- Terminology is presented ahead of relevance or need
- Use of algorithms shortcut problem solving without a need for conceptual understanding of why it works
- Students see little connection between curriculum and lab activities
Modeling Pedagogy and Practice
Modeling Instruction™

- An inquiry-based constructivist approach to science education
- Immerses students in the process of doing science
- Provides opportunities for students to act like scientists
- Builds a classroom culture where teachers act as guides to help students construct knowledge
The Tenets of Modeling Instruction™

- Using multiple representations to communicate scientific ideas
- Using scientific questioning to guide investigations
- Designing investigations for data collection
- Analyzing and evaluating data
- Working with scientific theories and explanations
- Connecting and relating content across domains
Modeling Cycle

Model Development: The paradigm lab

Model Limitations: The model no longer explains the data

Model Deployment: Testing the model in new situations
How Students Model

- Particle representations of matter and change
- Collaborative whiteboarding
- Students present their ideas to classmates for evaluation, analysis, and revision
- Student models begin simple, and evolve to greater complexity as observations require further explanation
- Proportional reasoning in favor of algorithmic procedures
Johnstone’s Triangle

Macroscopic:
Laboratory Experiments
Demonstrations

(Sub)Microscopic:
Particle-Level Illustrations

Symbolic:
Chemical and Mathematical Formulae
Whiteboarding Sessions

- Uncover misconceptions in student thinking
- Provide a starting point for meaningful peer-to-peer conversations
- Make students’ thought process visible
- Build and strengthen understanding through employing multiple representations of concepts
Whiteboard Examples

- **Pressure vs. Volume**
  - Graph showing pressure and volume relationship.
  - Points labeled: 231, 47, 231, 47, 198, 42.
  - Mathematical relationship explained:
    - If the volume goes up, the pressure goes down.
    - If the volume goes down, the pressure goes up.

- **Energy vs. Temperature**
  - Graph showing energy and temperature relationship.
  - Points labeled: 100°C, E_p, E_f, E_s, E_f, E_s.
  - Energy is absorbed or supplied.

- **Dissolving Sugar in Water**
  - Diagram showing sugar dissolving in water.
  - Before and After images.

- **Burning of Steel Wool**
  - Chemical change diagram.
  - Before and After images showing mass change.
  - Oxygen molecule and steel wool molecule.
  - Our group's data: mass change.

- **Conservation of Mass**
  - Diagram showing mass conservation.
  - Before and After images.
Algorithms Vs. Understanding

What does it mean if students can solve quantitative problems, but can’t answer the following?

Nitrogen and hydrogen gas react to form ammonia according to the following equation:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

The box at the right shows a mixture of nitrogen and hydrogen before the reaction begins.

Which box accurately represents the reaction mixture when the reaction is complete?
Next Steps
Next Steps Toward Modeling

- Download sample gas behavior lesson plans at: 

- Check out these resources on whiteboarding: 

- Need more evidence? - AMTA Website 
  - [www.modelinginstruction.org](http://www.modelinginstruction.org)

- Participate in a Modeling Workshop 
Thank You!

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Works Cited


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