Middle and High School Teachers' Conceptions Regarding the Use of Models for Nanoscale Science Instruction

Shanna R. Daly and Lynn A. Bryan, Purdue University

Abstract

- The NCLT (National Center for Learning and Teaching Nanoscale Science and Engineering) Professional Development Work Circle hosted a two-week long workshop in Summer 2006.
- One component of this workshop probed and challenged teachers' conceptions of the use of models in science instruction.
- While teachers included student involvement and discovery activities in the use of models for science instruction, the majority of teachers did not choose models of nanoscale phenomena that allowed for inquiry activities.

Background

Models and Nano

- Use of physical representation models especially important for instruction of nanoscale phenomena
  - Nanoscale phenomena cannot be seen via
    - Photographs
    - Light microscopes
    - Demonstrations
  - Only resulting micro- or macroscopic effects or machine-generated image can be witnessed
  - Creation of two- and three-dimensional physical representation models relied upon to support students' building of nanoscale science conceptions

Defining Models

- Representations of ideas, objects, events, processes, or systems (Gilbert & Boulter, 2000)
- Boulter and Buckley (2000) Typology:

	Static	Dynamic: Deterministic	Dynamic: Stochastic
Concrete Material	3D model; Scale models	3D models that move; Working scale replicas	Physical simulations
Visual Pictorial	Diagram; Drawing	Sequenced diagrams; Animations; Video of live phenomena	Graphical displays
Gestural Bodily	Showing positions	Acting out set movements	Hand gestures

Research Design

NCLT Professional Development Workshops

- Purdue Univeristy PD Workshop
  - 2 Weeks, Summer 2006
- Goals
  - Education on nanoscale concepts
  - Support integration of nanoscale concepts
  - Facilitate and enhance teachers' understanding of models and modeling in the context of nanoscale science and engineering education

Research Design Con't

Research Questions

- What criteria do teachers consider when choosing models? How do these criteria compare when choosing models to represent nanoscale phenomena?
- What models of nanoscale phenomena do teachers find to potentially incorporate into their classrooms?
- How does the structure of the NCLT Professional Development Workshop support teachers' understanding and use of nanoscale phenomena models in their classroom?

Participants

	Chemistry	Physics	Chemistry and Physics	Biology	General Science
Middle School	0	1 Male	0	0	2 Male
High School	3 Female, 1 Male	2 Male	1 Female, 1 Male	1 Male	0

Frameworks

- Scope of Workshop
  - Design-based research framework of PD workshops: "Bring design and research activities into tight relation to advance understanding of learning-related educational phenomena" (Bell, 2004, p. 245)
  - Action Research: "A (usually cyclic) process by which change and understanding can be pursued at the one time, with action and critical reflection taking place in turn. The reflection is used to review the previous action and plan the next one." (Dick, 1997)
- Modeling research data contributes to iterative cycle of design, implementation and redesign of the intervention
- Scope of Science and Engineering Education Research
  - Explore teachers' experiences choosing models and what factors into those choices
    - Pedagogical understanding of models
    - Use of models in their classroom
  - Emphasis on models in the context of nanoscale education

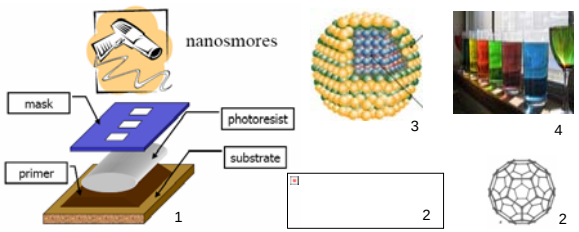
Eliciting Teacher Ideas

- **Initial Understandings** → (a) What is a model? (b) How can models be used in science instruction? (c) What criteria should be considered when choosing a model?
- **Model Ranking** → Ranking and justification of seven sets of models of the same science phenomena (e.g., three different models of a molecule, three different models of the solar system; three different models of a virus)
- **Finding and Evaluating Models of Nanoscale Phenomena** → (a) How do the criteria used to choose a science model compare to the criteria used to choose a model of a nanoscale phenomena? (b) Why are models so important in teaching nanoscale concepts? (c) How well do these example models of nanoscale phenomena support the understanding of nanoscale concepts?
- **Discussions** → (a) Initial Understandings (b) Model Ranking (c) Finding and Evaluating Models of Nanoscale Phenomena (d) Coll, France, and Taylor article

Results

Individual Responses Emphasized Model Accuracy and Logistics

- Prior to discussion, majority of responses regarding model criteria related to:
  - Accuracy
  - Physical attributes of models
  - Logistics of using models
- Discussion on an article of the role of models in science education
  - Incorporated of some potential form of student involvement into criteria (creation, critique, etc.)
  - Presenting science education research to teachers may promote classroom change



Model Criteria Generated by Teacher Group

Physical Attributes
- ❑ Clearly visible
- ❑ Aesthetics
- ❑ Labels on model explaining parts and pieces
- ❑ Size
- ❑ Color
- ❑ 3-D vs. 2-D

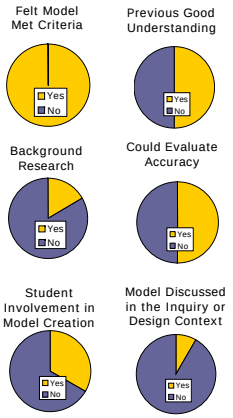
Concepts
- ❑ Accurate representation of the conceptual goal
- ❑ Illustrates main ideas
- ❑ Ease of understanding
- ❑ Spatial accuracy
- ❑ Information delivery
- ❑ Purpose within lesson
- ❑ Minimizes potential misconceptions/ discrepancies within model

Student Involvement
- ❑ Invites and directs manipulation and investigation
- ❑ Student-constructed
- ❑ Invites conversation or critique
- ❑ Level of possible student-interaction with model

Logistics
- ❑ Cost
- ❑ Time
- ❑ User-friendly
- ❑ Durability
- ❑ Spatial accuracy
- ❑ Grade-level of students

Other
- ❑ Clear and concise verbal component
- ❑ More than one model per concept
- ❑ Ability to manipulate
- ❑ Engaging

Trends in Teacher Conceptions and Decisions Related to Nanoscale Phenomena Model Choices



Teacher-Selected Models

	Static	Dynamic: Deterministic	Dynamic: Stochastic
Concrete Material	1		2
Visual Pictorial	6	1	1
Gestural Bodily			1

NCLT Primary Workshop Models

	Static	Dynamic: Deterministic	Dynamic: Stochastic
Concrete Material	5	1	6
Visual Pictorial			1
Gestural Bodily			1

Conclusions

Model Connections to Inquiry and Design

- Teachers did not view models as a way for students to collect data, make meaning of data, and generate understanding of a phenomenon. They viewed models primarily for "show-and-tell" purposes.

Redesign of NCLT Modeling Activities

- Presentation of research literature on models and modeling
- Accuracy of Model Issue
  - Encourage of teachers to first select a topic and do background research before choosing a model

  OR
  - Provide teachers with technical information (and no model) of a few pre-selected topics in nanoscale science
- More emphasis on the role of models for conducting design- or inquiry-based instruction
- Inclusion of instructional activities that facilitate teachers' understanding of how to use models to generate student understanding during design- or inquiry-based science investigations

References

Boulter, C., & Buckley, B. (2000). Constructing a typology of models for science education. In Gilbert & Boulter (2000) Developing models in science education. Dordrecht: Kluwer.

Coll, R. K., France, B., & Taylor, I. (2005). The role of models/and analogies in science education: Implications from research. *International Journal of Science Education, 27*(2), 183-198.

Gilbert, J., & Boulter, C. (2000). *Developing models in science education*. Dordrecht: Kluwer.

National Nanotechnology Initiative. (2006) National Nanotechnology Initiative. Retreived December 2006 at http://nano.gov.

Stevens, S., Sutherland, L., Schank, P., & Krajcik, J. (2007). *The big ideas of nanoscience*. Unpublished manuscript.

[1]http://www.nbtc.cornell.edu/mainstreetscience/nanosmores_and_photolithography.pdf
[2]http://upload.wikimedia.org/wikipedia/commons/f/f8/Eight_Allotropes_of_Carbon.png
[3]http://www.concepts.aero/news.html
[4]http://kimandjason.com/escapeplan/images/colored_water.jpg