How Can the History and Philosophy of Science Contribute to Contemporary U.S. Science Teaching

Friday, 07 December 2012

Sponsored by the National Science Foundation's Division of Research on Learning in Formal and Informal Settings under REESE grant 1205273. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Organized by the School of Education and the Center for Philosophy and History of Science at Boston University.

Philosophy of Science and Science Education Reform

Greg Kelly
Penn State University

Boston University Interdisciplinary conference on
Teaching Science through History and Philosophy of Science

Similar to chapter to appear in HPS&ST Handbook (Michael Matthews (ed.)), entitled, “Inquiry teaching and learning: Philosophical Considerations.”

Science education reform & philosophy of science

- NextGen as example of reform

- Following other reforms in science education:
  - nature study
  - discovery learning
  - science-technology-society
  - constructivism
  - inquiry
  - NextGen
  - ?

- Address the question: How can philosophy of science contribute to effective reform in science education?

Outline of central points

- HPS and epistemic practices
- Educational challenges of teaching NextGen science standards
- Challenges and opportunities of using philosophy of science to inform science teaching and learning
- Discussions for philosophy of science and science education

Science education & science studies: HPS+

Disciplinary orientation
Focus from history and philosophy: normative, theory change, models, recognizes social aspects of knowledge construction

Social practices perspective
Empirical study of scientific practices: recognizes the sociocultural nature of knowledge and practices, contextual, contingent, centered in everyday action

Learner orientation
Epistemology at individual level: personal views of knowledge and ways of knowing, tied to learning

Premises about discourse and social practice

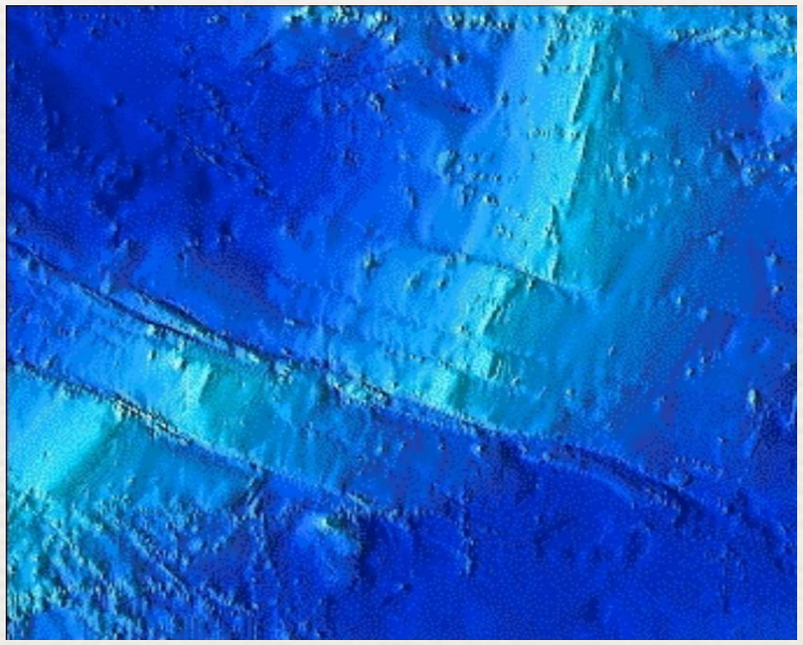
As members of a group affiliate over time, they

- create through social interaction particular ways of talking, thinking, acting, and interacting,
- establish cultural practices, which become resources for members and evolve as members internalize the common practices but also transform them through externalization,
- define membership in a community through adherence to cultural practices (e.g., standardized genres, social languages, accepted patterns of interaction)

Example of epistemic practices

Constructing and assessing evidence through written argument & peer-review:

Plate tectonics in undergraduate oceanography



Environmental toxicology in teacher education

<u>Both examples</u>:

Reasoning with disciplinary knowledge, constructing arguments with evidence, peer-review, and revision.

Applying NRC framework/NextGen to examples

plate tectonics

toxicology

common practices

asking questions

developing & using models

analyzing & interpreting data

constructing explanations

obtaining, evaluating, & communicating

engaging in argument

common crosscutting concepts

patterns

scale & quantity

systems & system models

cause & effect

varying disciplinary core ideas

plate movement

faults

topography

earthquake depth & location

bioassay

toxicity

dose/response

TC50

Engaging in epistemic practices

Constructing an argument entails, not just reasoning or using evidence in the abstract, or *knowing that* evidence is important for scientific inquiry, but <u>also</u> *knowing how* by ...

... drawing from and applying relevant scientific and rhetoric knowledge, framing this knowledge in a social language, adhering to relevant genre norms, for a given audience, in a particular instance of use, and so forth.

➡ Integration of propositional knowledge and procedural knowledge: The learning of disciplinary practices, crosscutting concepts, and core ideas come together.

Learning science through inquiry

Inquiry entails seeking knowledge of natural, designed, or social world.

Often this involves:

- engaging in dialectical processes
- treating uncertainty

Often this includes:

- drawing from extant knowledge
- using common practices

Inquiry teaching can be viewed as an approach for communicating the knowledge and practices of science to learners.

Educational challenges

for teaching ideas, crosscutting concepts and practices from an inquiry approach:

- Concepts are tools for learning, not just result of learning (problem of induction)
- Conceptual, social, epistemic goals (beyond final form knowledge) - need alignment of curriculum, & pedagogy & assessment
- Inquiry across the curriculum: scope vertically & horizontally (supported or undermined across the curriculum)

Reasons for inquiry approaches

- Consistent with “meaning as use” view of discourse
- Learning practices & knowledge through engagement
- Potential to develop understandings about science through engagement in scientific practices and discourse about practices
- Develops capacity for further learning

Challenges for philosophy of science

for applications in science education:

- Technical, specialize knowledge (e.g., instrumentalism vs. realism)
- Philosophy of science includes diverse views and they change
- Philosophy has been normative (e.g., provides reasons for theory change in science)
- Risks reduction to platitudes (e.g., falsification, scientific method)

Reasons for use of philosophy of science

- Fosters development of understandings about aspects of scientific inquiry - knowledge about science
- Contributes to debates in science education (e.g., nature of science, argument & explanation)
- Identifies values of scientific communities
- Emphasizes importance of critical discourse - shifts the epistemic subject from the individual learner to the relevant epistemic community, matching trends in sociocultural psychology
- Develops skepticism regarding ways of characterizing science in curriculum materials and instructional practices

How can philosophy of science contribute to effective reform in science education?

- Question for science learning:

  How can philosophy and history of science contribute to learning opportunities that incorporate critical discourse?

How can philosophy of science contribute to effective reform in science education?

- Question for development of science curriculum:

  How can philosophy and history of science contribute to curricula that support citizens’ abilities to decipher, analyze, and participate in socioscientific issues?

How can philosophy of science contribute to effective reform in science education?

- Question for science teacher education:

  How can philosophy and history of science develop in teachers a critical stance toward science, views of science, and science and engineering standards and curricula?

Discussion questions for POS & HOS

Learning:

How can POS & HOS contribute to learning opportunities that incorporate critical discourse?

Curricula:

How can POS & HOS contribute to curricula that supports citizens abilities to decipher, analyze, and participate in socioscientific issues?

Teacher education:

How can POS & HOS develop in teachers a critical stance toward science, views of science, and science and engineering standards and curricula?