# Inquiry Teaching, Learning and the Nature of Science

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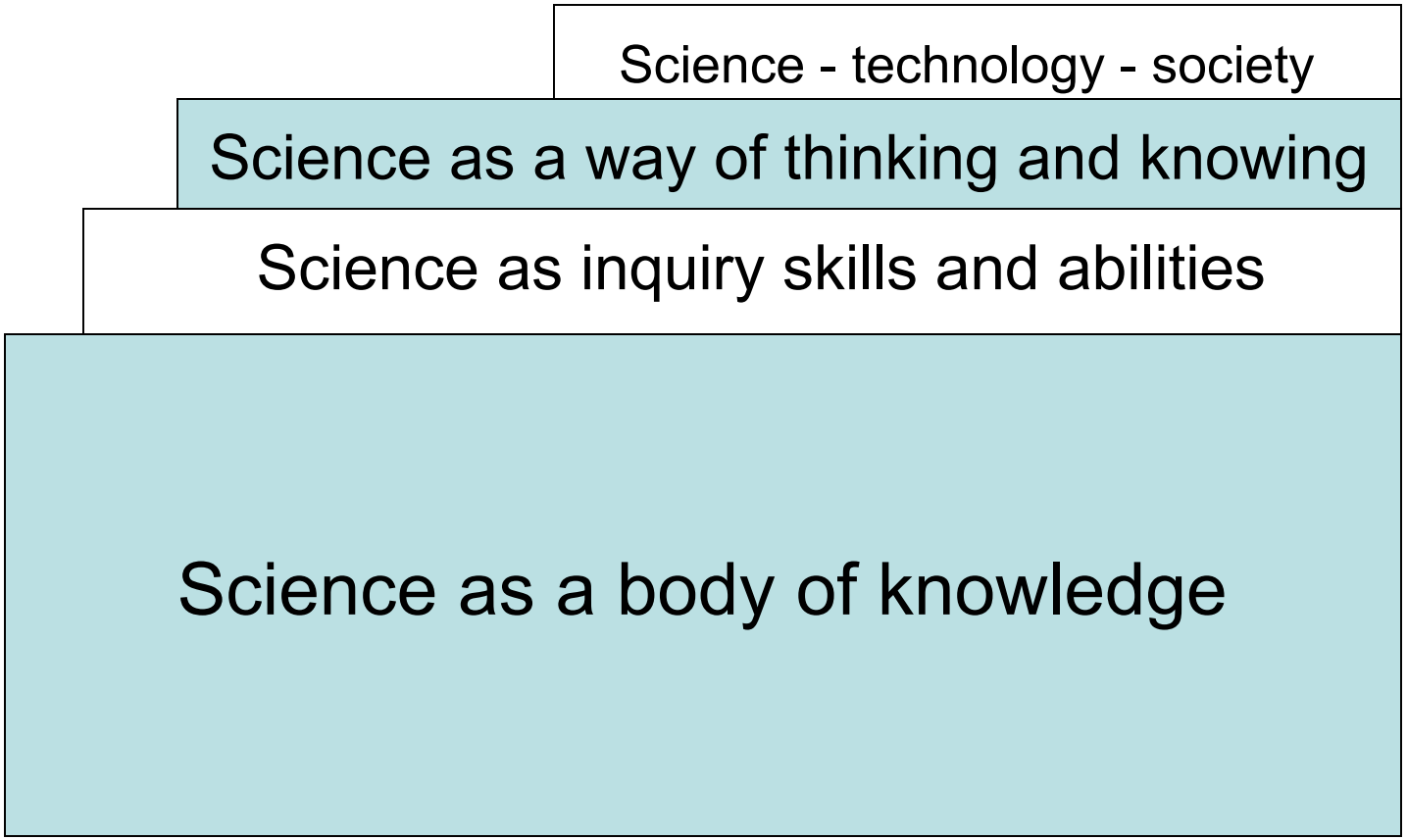
# What do you mean by inquiry?

There are multiple understandings of inquiry and its use has become so common that it is necessary to clarify what is inquiry. It does have different meanings in different context.

- Inquiry as curriculum.
- Inquiry as learning
- Inquiry as teaching

# Dimensions of science



# Inquiry as curriculum

Scientific inquiry is the way in which scientists study the natural world. For students, this includes both abilities and understandings of inquiry.

- *Inquiry abilities and skills* include asking questions, planning and conducting an investigation, using tools, make relationships between evidence and explanations, using mathematics, and communicating.
- *Understanding about science inquiry* include why scientists conduct investigations, use of technology to gather and manipulate data, rules of evidence, need for logically consistent arguments, and be open to modification in light of new evidence.

# Inquiry as learning

Learning should be an active process reflecting how scientists learning about the natural world. Assumes experience, evidence, and discourse, consistent with constructivist learning. Consists of four elements;

- Learning is active with individuals constructing meaning for themselves.
- Individual constructs dependent upon prior knowledge which may be modified.
- Understanding dependent upon context, more abundant and varied these context, the richer the understanding.
- Meanings are socially constructed.

# Inquiry as teaching

The understanding of student learning shapes classroom instruction. Inquiry instruction may use a variety of teaching strategies. Essential features of inquiry teaching include;

- Students engaged by *scientific questions*.
- Students give priority to *evidence*.
- Students formulate *explanations* from evidence.
- Students *evaluate* explanations in light of alternative explanations.
- Students *communicate and justify* their explanations.

# Inquiry as teaching

## Getting from here to there

| | | | | |
|---|---|---|---|---|
| Learner engages in scientifically oriented questions | Learner engages in questions provided by teacher or materials | Learner sharpens or clarifies questions provided by teachers or materials | Learner selects among questions, poses new question | Learner poses a question |
| Learner gives priority to **evidence** | Learner given data and told how to analyze | Learner given data and asked to analyze | Learner directed to collect certain data | Learner determines what evidence and collects it |
| Learner formulate **explanations** from evidence | Learner provided with evidence | Learner given possible ways to use evidence to formulate explanations | Learner guided on process of formulating explanations from evidence | Learner formulates explanations after summarizing evidence |
| Learner connects explanations to scientific knowledge | | Learner given possible connections | Learner directed toward areas and sources of scientific knowledge | Learner independently examines other resources & forms links to explanations |
| Learner communicates and justifies explanations | Learner given steps and procedures for communication | Learner provided broad guidelines to use sharpen communication | Learner coached in development of communication | Learner forms reasonable & logical arguments |
| | Less << | Amount of student self-direction | | >> More |
| | More << | Amount of direction from teacher or materials | | >> Less |

Inquiry as teaching

# Levels of Inquiry

Where are we and how do we move towards open inquiry?

| | | | |
|---|---|---|---|
| **Confirmation  Cookbook**<br>Students confirm a principle through an activity when the results are known in advance | X | X | X |
| **Structured Inquiry**<br>Students investigate a teacher-presented question through a prescribed procedure | X | X | |
| **Guided Inquiry**<br>Students investigate a teacher-presented question using student design/selected procedures | X | | |
| **Open Inquiry**<br>Students investigate questions that are student formulated through student design/selected procedures | | | |

Banchi, H. & Bell R. (October 2008). The many levels of inquiry. *Science and Children*. *(46)* 2, 26-29.

Inquiry as teaching

# Analysis and Modification

Lesson example:

Saving energy in the household by knowing the energy consumption of household appliances (PROMOTE MSc Ph5)

| | | |
|---|---|---|
| 1. Engage learners in scientifically oriented questions? | Y | N |
| Do questions guide labs? | | |
| Do students generate, refine, and focus questions for investigation? | | |
| Are questions relevant to students? | | |
| 2. Ask learners to give priority to evidence? | Y | N |
| Do students use their senses and instruments to collect evidence? | | |
| Are recipe like procedures present as the only way to address the objective? | | |
| Do students have opportunities to decide what data to collect or how to collect it? | | |

Inquiry as teaching

# Analysis and Modification

| | | |
|---|---|---|
| 3. Encourage learners to formulate explanations from evidence? | Y | N |
| Are students encouraged to provide preliminary explanations? | | |
| Do students generate explanations from evidence? | | |
| 4. Compel learners to evaluate their explanations in light of alternative explanations? | Y | N |
| Do students compare explanations based on how well they account for the evidence? | | |
| Are students asked to revise their explanations in light of evidence? | | |
| 5. Expect learners to communicate and justify their proposed explanations? | Y | N |
| Do students have opportunities to discuss their ideas in small groups? | | |
| Do students have opportunities to present their ideas through writing, drawing or thinking? | | |
| Do students have opportunities to present their ideas to other audiences? | | |

## Inquiry as teaching
# Analysis and Modification

Questions

- Change the purpose statement of activity into a question.
- Involve students in activities where they generate questions to be investigated.
- Make the questions relevant to the students.

Evidence

- Throw away the recipe (or parts of it) and give students, groups, or the class opportunities to define variables, develop procedures, set up data tables, and make predictions.

Explanations

- Move the teacher's explanation and textbook reading from before the lab to after the lab.
- Provide students with opportunities to work and talk together.
- Engage students in the analysis of data by looking for patterns, using evidence and logic to support explanations, and honing their skills at constructing evidence-based explanations.

Communication

- Provide opportunities to present explanations to other audiences through discussion, writing, and drawing.
- Ask students to evaluate the logic of their explanations in terms of evidence.

Volkmann, M.J., Abell, S.K. (September 2003). Rethinking laboratories: Tools for converting cookbook labs into inquiry. *The Science Teacher*. *(70)* 7, 38-41

- In small groups, examine the lesson plan.
- What are some simple modifications you can make so it the lesson is
  - Structured
  - Guided
  - Open

Inquiry as curriculum

# Examples of key science abilities

Taught like other skills by modeling, practice, and review

- Identify testable questions and hypothesis
- Design and conduct investigations (procedures, use of equipment, safety, control of variables, recording data)
- Use technology and math to improve investigation and communication
- Formulate explanations and models using evidence and logic
- Use scientific criteria to determine a preferred explanation
- Communicate and defend a scientific argument

National Research Council (2000). *Inquiry and the national science education standards*. Washington DC: National Academy Press.

Inquiry as curriculum

# Examples of key science understandings

Often known as the Nature of Science (NOS), refers to the values and assumptions inherent to scientific knowledge and the development of scientific knowledge.

- Science demands and relies on empirical evidence of the natural material world - can't answer all questions, there are limits
- There is no single step-by-step scientific method for all science - common features like data collection and reasoning.
- Science knowledge is tentative but durable - cycle of prediction and deduction -science knowledge subject to change
- Laws and theories are related but distinct types of knowledge
- Science is creative and involves imagination
- Science has a subjective element -need for check and balances
- There are historical, cultural and social influences on science

Inquiry as curriculum

# How to teach the nature of science

- Inquiry labs important but not enough
- Direct teaching of the nature of science and use of teaching methods that model the nature of science
- Not all NOS elements can or should be taught with every lesson - focus on a few most appropriate
- Must explicitly integrate NOS elements into labs using reflective discussions and careful questioning
- Review at the end of an activity the NOS elements - can be more teacher centered at the end
- Use of journals for reflection and notebooks for lab reports/data.
- Plan teacher questions and discussion - look for opportunities to compare, discuss, like scientists

Lederman, Norman. 1998. "The State of Science Education: Subject Matter without Context." Electronic Journal of Science Education, V 3, N 2. http://unr.edu/homepage/jcannon/ejse/lederman.html

- Revisit the “Saving energy” lesson.
- How can we modify to incorporate one Nature of Science element?
- Which element would be the best? (tentativeness, subjectivity, empirical evidence . . . )

# Summary of inquiry curriculum and teaching

How does inquiry curriculum and teaching address these learning goals?

- Learning is active with individuals constructing meaning for themselves.
- Individual constructs dependent upon prior knowledge which may be modified.
- Understanding dependent upon context, more abundant and varied these context, the richer the understanding.
- Meanings are socially constructed.