How Student questions and answers can bring quality learning to your high school science class

Gordon Berry, University of Notre Dame
Mary Hynes-Berry, Erikson Institute, Chicago

How to enhance student learning in a science modeling class (and everywhere else?)

HASTI-2015 – Thursday, 12 February
The Essential ABCs of Learning

Always Be Conversing

Always Be Connecting

Always Build Competence (Competence)
**First:** Some introductory ideas: 
*SIP, question taxonomy, modeling*

**Second:** a modeling activity  
- to illustrate the question

**Third:** extending the conversation

**Fourth:** Does it work?  
Analyzing our results, Evaluating learning  
Trying again......

**Conclusions:** Can you help our research?

Tonight – a party for all......
Are all your science classes Satisfying, Intentional and Problem-Solving (SIP) for all your students?

The **SIP principle** [*Satisfying, Intentional Problem-Solving*] describes an effective classroom which uses these characteristics to reach the goal of quality intellectual student work.

**Satisfying:** quality intellectual work which is engaging, intrinsically rewarding, and develops competence and confidence for the student.

**Intentional:** students constructing models and strategies leading to the students’ realization that they are building competence.

**Problem-solving:** students developing their own progress milestones, accomplishing them and explaining their own achievements.
Do students take ownership of their learning when THEY are asking and answering their questions?

Bloom’s taxonomy as an inverted pyramid (most important at the TOP)

- 6 Creating
- 5 Evaluating
- 4 Analyzing
- 3 Applying
- 2 Understanding
- 1 Remembering

A simplified taxonomy of questions (Mary Hynes-Berry)

3 Evaluating/Synthesizing Inquiry    Abstract/Symbolic
2 Analyzing/Applying Inquiry          Pictorial
1 Knowledge & Comprehension Inquiry  Concrete
What do we mean by “Modeling”*?

MULTIPLE!  Symbolic Representations

- Verbal
- Picture
- Mental Model
- Diagrammatic
- Graphical

*Modeling in HS physics & chemistry as developed at Arizona State University
An important part of the modeling procedure is to give students a chance to show each other (and the teacher) to help explain – in their own words - what they have been learning...

One “modeling” way: transfer their group ideas to large whiteboards Which can then be presented (in various ways) to the other students

We add to this Modeling presentation system:

“Student” Questions........ and their answers

As you all can expect, or know from experience, it is often DIFFICULT to persuade some (or most of the) students to make comments....VERY OFTEN, such discussions tend to be led or even monopolized by the teacher.

Let’s try to CHANGE that.... (slowly, slowly)
A GROUP activity to illustrate modeling...with questions

A double-question for you
How do clouds form? and how is rain produced?

Form a group of 3-4 people – you will need a “whiteboard”, plus some writing implements.

1. Discuss these questions amongst your group:
   Do they trigger any thoughts about topics in high school science learning?
   ........ In physics or in chemistry or in biology or in earth/space science..........

2. Prepare your whiteboard for a presentation to everybody, following the precepts laid out in the previous slide –
   Include several representations – e.g. verbal, algebraic, picture, diagram, graph....

   Also include 2 questions raised by your group........
Presentations

Condensation onto salt particles, inside a saturated chamber (enlarged pic - that’s a pin)

How about some theories....? (a teacher question?)
How about some more experiments....?

The California Desert Is Now Home to the World's Largest Solar-Power Plant  Helen Regan, TIME
10 February  2015

The world’s largest solar-power plant officially opened in the Riverside County desert, in California, on Monday. The 550-megawatt Desert Sunlight Solar Farm will produce enough energy to power 160,000 California homes, reports USA Today.
Reflecting on today’s exercise

Who is doing the thinking and learning?
Who is making connections?
Did you use all 8 science practice standards? (next slide)

Do you remember your own question(s)?
Do you remember your own answer(s)?

Did you worry about “Peer pressure”?

Can you think of any extensions to this exercise that you might use in your classroom? Let’s try........
The NGSS Framework of Scientific and Engineering Practices

“The Practice Standards”

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

How many of these are STUDENT Developed and driven IN YOUR CLASSROOM?
The **AIR Principle:**

*for teachers in all classrooms and all grades...*

**Attend & Intentionally Respond**

**Attend**: Keenly observe and reflect on the observable indicators of disposition, engagement, and of level of understanding or of misconceptions and

**Intentionally**: plan what is likely to be a productive next step, based on observations and knowledge of the student as well as of developmental considerations

**Respond** in ways that will support the student in continuing to feel or be restored to feeling safe, valued and competent.
**A second visit to questions....**

| PING PONG | Facilitator/teacher asks a question; labels response right or wrong and then moves onto another question and another student |
| FEEDBACK LOOPs (Batting practice) | Teacher/facilitator/(student) and responder engage in more than a single exchange as point is clarified or expanded. May involve more than 1 participant |
| RICH CONVERSATIONS (Volleyball) | While the facilitator takes responsibility for guiding the conversation, all members of the learning community take active roles in commenting, questioning, offering clarifications and extending the thought. |
## Question Rungs on the Ladder of Inquiry

<table>
<thead>
<tr>
<th>Closed Questions</th>
<th>Comprehension Level questions: “Right” or “Wrong” Answers</th>
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</thead>
<tbody>
<tr>
<td><strong>Level 3: Evaluating and synthesizing open questions</strong></td>
<td>Call for “higher order thinking”&lt;br&gt;Allow respondents to make highly personal, individual connections and synthesize understandings in a unique and creative way.</td>
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<tr>
<td><strong>Level 2: Analyzing open questions</strong></td>
<td>involve inferences as well as comparisons or other kinds of structural analysis;&lt;br&gt;More than one response is possible, but all must include explanations or support that are likely to go back to the text or to further unpacking a previous statement,</td>
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<tr>
<td><strong>Level 1: Unlocked closed comprehension questions</strong></td>
<td>Ask for description, definition, examples from the text&lt;br&gt;Useful for developing and clarifying comprehension of the text as well as of a respondent’s meaning.</td>
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<tr>
<td><strong>Locked closed questions</strong></td>
<td>Call for a <strong>yes or no</strong> or can be answered with a <strong>single word or phrase</strong>. Often Ping Pong interactions. Emphasis on rote recall.</td>
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The dynamic C-P-S Principle

Concrete Understanding & Representation

Pictorial Understanding & Representation

Symbolic Understanding & Representation

Deep STEM Understanding
Learning from each other by DOING

- Authentic & Engaging
- Appropriate Respects Learner’s Developmental Stage
- Automaticity As a result of meaningful repetition—not rote
- Deep STEM Understanding

Automaticity As a result of meaningful repetition—not rote
Our Follow-up group activity.....

How are snow clouds different (or the same) from rain clouds?

In a few minutes, make up a whiteboard which includes

A - At least 3 representations – extra credit given for 4 or 5 !! (verbal, picture, diagram, algebraic, graphical...)

B – 3 questions – one from each level....

3  Evaluating/Synthesizing Inquiry Abstract/Symbolic
2  Analyzing/Applying Inquiry  Pictorial
1  Knowledge & Comprehension Inquiry Concrete
A personal request.....

I am looking for some research-based evidence for the ideas presented today:
For enhancing the modeling teaching process through the use of student questions

Would you be interested in helping?

The procedure will include a questionnaire to identify the changes between including and excluding student questions and answers
Especially in whiteboard presentations
But also in other classroom formats

Please contact me now or later or by email at hgberry@nd.edu or at 574-514-4009 (cell)

Thank you for any help
Reflecting on today’s session

Who is doing the thinking and learning?
Who is making connections?
Did you use all 8 science practice standards?

The ABCs of learning (Mary Hynes-Berry)
Always Be Connecting
Always Be Communicating
Always Build Confidence

Contacts: Gordon Berry: hgberry@nd.edu
NISMEC: http://www3.nd.edu/~nismec/nismec11.htm
<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Presenters</th>
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<tbody>
<tr>
<td>Thursday</td>
<td>How Student Questions and Answers Can Bring Quality Learning to School</td>
<td>Gordon Berry, Mary Hynes-Berry</td>
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<tr>
<td>8:30 am</td>
<td>High School Science Class</td>
<td></td>
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<tr>
<td>Thursday</td>
<td>Modeling Chemical Bonds and Reactions with Legos</td>
<td>Craig Williams</td>
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<tr>
<td>10:45 am</td>
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<tr>
<td>Thursday</td>
<td>The Indiana Modeling Program for High School Science Teachers - Are</td>
<td>Gordon Berry, Robert Pustek, Lynda</td>
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<tr>
<td>10:45 am</td>
<td>You In It? Join Now!</td>
<td>Rose</td>
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<tr>
<td>Thursday</td>
<td>The Scientist Notebook: A Rhythmic Framework to Guide Teachers and</td>
<td>Joseph Bellina</td>
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<tr>
<td>12:30 pm</td>
<td>Students in Any Classroom Investigation</td>
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<td>Thursday</td>
<td>So You Want to Try Modeling -- A Pedagogy Not a Curriculum</td>
<td>Lynda Rose</td>
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<td>Thursday</td>
<td>Focus Question and Making Meaning Conference, the Bookends for A</td>
<td>Joseph Bellina</td>
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<td>1:30 pm</td>
<td>Classroom Investigation</td>
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<td>Thursday</td>
<td>How to Engage Students in a Whiteboarding Session</td>
<td>Lynda Rose</td>
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<td>Thursday</td>
<td>Using Goal-Less Problems in the Chemistry and Physics Curriculum</td>
<td>Amanda Horan, Hugh Ross, Gary</td>
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<td>2:30 pm</td>
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<td>Pritts, Karen Kennedy</td>
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<td>Thursday</td>
<td>Making Sense of Graphs, a Natural Math Extension from Science</td>
<td>Joe Bellina</td>
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<td>Friday</td>
<td>Hoosier Modeling Connection: Q &amp; A with New and Experienced Modelers</td>
<td>Erica Posthuma-Adams, Amanda Horan,</td>
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<td>12:30 pm</td>
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<td>Lori White</td>
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<td>Friday</td>
<td>AP Science Courses Redesigned: Impacts and Lessons Shared</td>
<td>Karen Morris, Maureen McGrail</td>
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<td>Friday</td>
<td>Using Bar Charts to Introduce the Momentum Conservation Model</td>
<td>Hugh Ross, Ben Buehler, Ben Grimes</td>
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<td>Friday</td>
<td>Physical Challenges: Using Lab Practicums in the High School</td>
<td>Ben Buehler</td>
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<td>9:30 am</td>
<td>Physics Classroom</td>
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<td>Focus: Authentic Learning</td>
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<td>Friday</td>
<td>Modeling Chemical Equilibrium: A Conceptual, Particle-Based Approach</td>
<td>Jeremy Horner</td>
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<td>2:30 pm</td>
<td>for High School Chemistry</td>
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1 - The **Indiana** ICP and Biology Modeling Curricula are available on the NISMEC website (Password required – ask me)

2 – Further details on the 2015 Modeling workshops are also available on the NISMEC website and will be updated on a regular basis this spring

3 – For more information
Visit the NISMEC booth at HASTI-2015 and our website:
http://www3.nd.edu/~nismec/nismec11.htm