Promoting & Measuring Scientific Reasoning Expertise of 2nd Year Students

F. M. Jones, M. Jellinek, M. G. Bostock, Dept of Earth and Ocean Sciences (EOS), University of British Columbia (UBC), Vancouver, BC, Canada.

(*fjones@eos.ubc.ca)

---

**Project outline**

- Define nature of expertise [4 refs]
- Design / implement / test corresponding pedagogy
- Measure (assess) students’ improving abilities

---

**The Course: EOSC212**

- **Topics in Earth and planetary sciences**
  - 13-week, 2nd year course designed to:
    - Foster generic scientific skills while exploring 3-4 Earth and planetary science topics.
    - Pedagogy and assessment based on experience in literature on expertise & science expertise.

---

**Classroom practices:**

- Team-based learning strategies: replace exams with quizzes and projects, mix team-teaching with solo-teaching, discursive rather than didactic instruction, use of diverse, Department-specific topics.

---

**Assessment practices:**

- Individual / team quizzes
- Weekly abstract writing
- Weekly assessed questioning
- Team-based data analysis exercises
- Pre-post testing of model-based reasoning
- Poster & presentations (students choose topics)
- Peer assessment of posters & presentations

---

**Data & results of using strategies (3 terms):**

- Abstract writing skills improved then plateaued.
- Thinking with (about) models/data improves.
- Questions posed …
- Team work: project or team work: communicating 
- Discussion of opinion

---

**Continuing challenges:**

- Assessment of question type and quality
- Use of question-posing as a measure of expertise

---

**Feedback about presentations:**

- Self-selected topics & peer assessed

---

**References on attached handout, & via**

http://www.eos.ubc.ca/research/views/scientific-skills.html

---

Acknowledgments:

- This project is generously supported by the UBC Carl Wieman Science Education Initiative (CWSEI)
- Thanks to: Carl Wieman, panlab, CWSEI, Brent, 2007 education innovation University (Instructors & students); students helping with the course; all students in the course.

---

**Questions level:**

- Low: basic (1) = knowledgeable; basic, unqualified ‘what if’, etc.
- High: basic (5) = knowledgeable, assumptions, experimental thinking, etc.

---

**Guided question posting – 2010**

---

**Conclusion:** (Lessons Learned)

Improving science thinking expertise involves explicit guidance in aspects involving judgments and metacognition. For EOSC212 these are:

- Synthesis of new knowledge (abstract writing);
- POsing questions of various (relevant) types;
- Appropriate use of ‘models’ & ‘data’ in discussion;
- Communication (written, oral, and poster);
- Assessment of peers’ work & thinking.

---

**Data demonstrating learning**

- Writing abstracts for science articles
- Reasoning with models and data
- Quizzes on readings: Individual & Teams
- Students feedback: survey/evaluation

---

**Writing abstracts for science articles**

- Workshop in week 2 – Making introductions:
  - Abstract writing improved
  - Self-assessment vs. peer assessment

---

**Reasoning with models and data**

- Pre-test: based on article 1, 6 questions: about models & data
- Post-test:
  - Students (5): 3-4 questions
  - Test scores: 1-2 questions
- Trends over group:
  - Ability to discern data & models interact

---

**Quizzes on readings: Individual & Teams**

- Team-based learning style (TBL)
  - Individual – done as teams
  - Internal & external TBL
  - Q: Read a passage & answer
  - Q: List the key words & phrases
  - Q: What do you think of the article?

---

**Students feedback: survey/evaluation**

- Q: What did you learn from the article?
  - Students may need more guidance.
- Q: What was your experience like?
  - More discussion questions in 2009.
- Q: Was your experience more difficult in 2009?
  - Depends more on article type

---

**Abstract writing improved then plateaued.**

- Abstract writing improved
- Self-assessment vs. peer assessment

---

**Questions level:**

- Low: basic (1) = knowledgeable; basic, unqualified ‘what if’, etc.
- High: basic (5) = knowledgeable, assumptions, experimental thinking, etc.

---

**Instructors’ grade %**

- Average of two instructors
- Better students?
- Better pedagogy?
- Low: 70%
- Medium: 80%
- High: 90%

---

**Students feedback:**

- Student - chosen projects
- Oral presentation
- Poster presentation
- Peer assessments

---

**Questions level:**

- Low: basic (1) = knowledgeable; basic, unqualified ‘what if’, etc.
- High: basic (5) = knowledgeable, assumptions, experimental thinking, etc.

---

**Guided question posting – 2010**

---

**Questions level:**

- Low: basic (1) = knowledgeable; basic, unqualified ‘what if’, etc.
- High: basic (5) = knowledgeable, assumptions, experimental thinking, etc.
Fostering & Measuring General Scientific Reasoning Expertise of 2\textsuperscript{nd} Year Students

*F. M. Jones*, M. Jellinek, M. G. Bostock, Earth and Ocean Sciences, University of British Columbia, Vancouver, BC, Canada  (*fjones@eos.ubc.ca*)

\textbf{Project Outline}

- Define nature of expertise [4 refs] \Rightarrow
- Focus on scientific expertise [12 refs] \Rightarrow
- Design / implement / test corresponding pedagogy \Rightarrow
- Measure (assess) students’ improving abilities \Rightarrow \textit{Iterate.}

\textbf{The Course: EOSC212}

\textit{Topics in Earth and planetary sciences}

13-week, 2\textsuperscript{nd} year course designed to:

- Foster generic scientific skills while exploring 3-4 Earth and planetary science topics.
- Pedagogy and assessment based on experience and literature on expertise & science expertise.

\textbf{Classroom practices}

- team-based learning strategies,
- replace exams with quizzes and projects,
- mix team-teaching with solo-teaching,
- discursive rather than didactic instruction,
- use of diverse, Department-specific topics.

\textbf{Assessment practices}

- individual / team quizzes
- weekly abstract writing
- weekly assessed questioning
- team-based data analysis exercises
- pre-post testing of model based reasoning
- Poster & presentations (students choose topics)
- Peer assessment of posters & presentations

\textbf{Data & results of using strategies (3 terms)}

- Abstract writing skills improved then plateaued.
- Thinking with (& about) models/data improves.
- Questions posed …

- depend on article type.
- become more articulate.
- become more insightful, less about content.
- Surveys showed students appreciate topics
- team work
- practicing communication & peer assessment
- the discussion orientation

\textbf{Continuing challenges}

- Assessment of question type and quality
- Use of question-posing as a measure of expertise

\textbf{Conclusion (Lessons Learned)}

Improving science thinking expertise involves explicit guidance in aspects involving judgments and metacognition.

For EOSC212 these are

- Synthesis of new knowledge (abstract writing);
- Posing questions of various (& relevant) types;
- Appropriate use of ‘models’ & ‘data’ in discussion;
- Communication (written, oral and poster);
- Assessment of peers’ work & thinking.

\textit{References listed on reverse.}
Reference List


13. Mark Windschitl, Rethinking Scientific Inquiry, NSTA Reports.


For a summary of this project see http://www.eos.ubc.ca/research/cwsei/scientificskills.html