Promoting & Measuring Scientific Reasoning Expertise of 2nd Year Students

F. M. Jones*, M. Jellinek, M. G. Bostock, Dep’t of Earth and Ocean Sciences (EOS), University of British Columbia (UBC), Vancouver, BC, Canada.

(*f.m.jones@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, 25th year course designed to:
  - Foster generic scientific skills while exploring 3-4 Earth and planetary science topics.
  - Pedagogy and assessment based on expertise and 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.

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

- Abstract writing skills improved then plateaued.
- Thinking with (about) models/data improves.
- Questions posed... o Depend on article type.
  - Become more articulate.
  - Become more insightful, less about content.
- Surveys showed students appreciate... o Topics
  - Team work
  - Practicing communication & peer assessment
  - Discussion orientation

**Continuing challenges:**

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

**The feedback & progress of the project**

- **Question type:** Discussion vs Content
  - **Expert students:** More about oral presentations.
  - **Beginning students:** More about content.

**Conclusions:**

- **Lessons learned:**
  - Improving thinking science expertise involves explicit guidance in aspects involving judgments and metacognition.
  - For EOSC212 these are:
    - Synthesis of new knowledge (abstract writing);
    - Appropriation of various & relevant types;
    - Appropriation of ‘models’ & ‘data’ in discussion;
    - Communication (written, oral, and poster);
    - Assessment of peers’ work & thinking.

**References on attached handout, via**

[http://www.eos.ubc.ca/teaching/val/scientifick.html](http://www.eos.ubc.ca/teaching/val/scientifick.html)

**Acknowledgments:**

- This project is generously supported by the UBC ESSH-Science Education Initiative (ENW2006)
- Thanks to: Carl Bannister, Bambos, (ENW), Harry Schwarz, 2005 education initiative expert.
- Individuals & project contributors.

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**Data demonstrating learning**

- **Writing abstracts for science articles**
  - Workshop techniques (students & self-assessment)
  - Abstract writing improves (mean F = 10.04, p<0.001)

- **Reasoning with models and data**
  - Pre-test: Based on an article 1:
    - Questions about models & data.

- **Quizzes on readings: Individual & Teams**
  - Team quizzing promotes:
    - Instant feedback (IfAt cards)
    - Compare teams & individuals

**Guided question posing – 2010**

**Question type:** Discussion vs Content

**Graduate Pre-Post**

- **Questioning posing workshop after Q1.**
  - Short pres'n time:
    - Questions get better.

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**Expert Scientists ...**

- Have significant domain knowledge [2][6][12]
- Use analogical thinking [5]
- Use distributed reasoning (team player) [5]
- Identify & follow up anomalies [5]
- Frequently questions work & assumptions and generates hypotheses [4][7][10][11]
- Can design & execute experiments [14]
- Are measurement and/or observation oriented [3][14]
- Evaluate relevance & quality of data [12][14]
- Fluently use & relate models & data
  - Including math & others [4][8]
- Can articulate explanations & syntheses [12]
- Use evidence & rhetoric in argumentation [12]
- Use graphical representations both for making sense and arguing. [12][19][9]

**Pedagogic domain knowledge [2]**

- Concept (content) knowledge [2][6][14]
- Strategic knowledge [2][6][14]
- Procedural knowledge [1]
- Frameworking (uses schemas) [2][6]
  - Flexible retrieval
  - Noticing patterns
  - Integrate new info. into schema
  - Adaptable (transfer)
- Metacognitive habits [2][6]
  - Learning is “deliberate”
  - Actions are planned & monitored
  - Making judgments is multifaceted
- Affective characteristics: [1]
  - Beliefs: relevance / irrelevance
  - Motivated to apply expertise
  - Expectations of what’s achievable

**Experts Have ...**

- Concept (content) knowledge [2][6][14]
- Strategic knowledge [2][6][14]
- Procedural knowledge [1]
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**Topics in Earth & Planetary Sciences**

- 2-3 readings per module
- Solid Earth physics
- Planetary science
- Atmospheres/oceanography
- Individual and team quizzes
- Abstracts / questioning workshops
- Abstracts written for each article
- Questions posed for each article
- Team exercises with data & models
- Discussion oriented lectures lead by
  - Dual instructors
  - Single instructors
  - Guests
- Student - chosen projects
  - Oral presentation
  - Poster presentation
  - Peer assessments

**Questions posed about articles...**

- Number of questions posed:
  - Q0: 0% ~ Q7: 100%
- Questioning posing workshop after Q1.
  - Questions get better.

**Feedback about presentations:**

- Self-selected topics & peer assessed

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**In the question session and self-assessment...**

- Year on topic question... (introduced only segment)
  - Independent - 40% (2009 students)
  - Students selected topics & peer assessed
  - Students to work independently.
  - All students in the course.

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**Readers ...**

- Did we forget any aspects of “scientific expertise”?
- Use post-its to contribute below.

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**IfAt cards**

- **Average of students' grade**
  - Articles & data
  - Indicators - do and don’t.
  - Three groups: 10, 70, 90%.
  - Ability to discern data & model results.

**Abstract writing skills improved then plateaued.**

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**Reading with models and data**

- Pre-test: Based on an article 1:
  - Questions about models & data.

**Team quizzing promotes:**

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- Compare teams & individuals

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**Quiz scores: Teams & individuals**

- Team score
  - Average of peers' grade
  - Score (%) bins
  - 100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
  - Team number

**Students reminded of class.**

- Students reminded of class.