Promoting & Measuring Scientific Reasoning Expertise of 2nd Year Students

EOS-SEI Science Education Initiative

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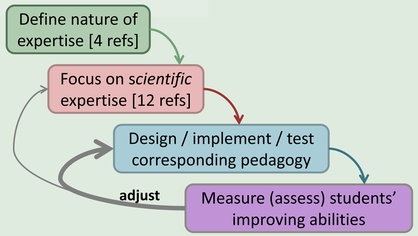
a place of mind THE UNIVERSITY OF BRITISH COLUMBIA

Project outline



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 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.

Assessment practices:
- individual / team quizzes
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- 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 …
  - 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

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

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.

Experts Have . . .

- 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
- Pedagogic domain knowledge **[2]**

Expert Scientists . . .

- Have significant domain knowledge **[2][6][12]**
- Use analogic 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 and relate models & data (including math and others) **[4][8]**
- Can articulate explanations & syntheses **[12]**
- Use evidence & rhetoric in argumentation **[12]**
- Use graphical representations both for making sense and arguing. **[2][12][9]**

EOSC212: Topics in Earth & Planetary Sciences

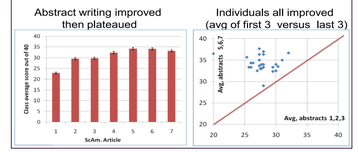
Features of this course:

- 2-3 readings per module
  - Solid Earth physics
  - Planetary science
  - Atmospherics/oceanography
- Individual and team quizzes
- Model based reasoning Pre-Post
- 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

Data demonstrating learning

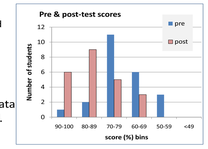
Writing abstracts for science articles

- Workshop in week 2 → rubric for abstracts.
- Write abstracts for 1-2 SciAm or Nature articles per wk.



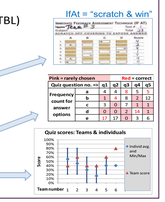
Reasoning with models and data

- Pre-test: based on article #1
  - 6 questions about models & data.
- Post-test:
  - Students reminded to re-read article.
  - Same questions.
  - Done in last week of class.
- Ability to discuss data & models matured.



Quizzes on readings: Individual & Teams

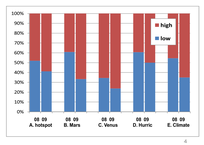
- Team-Based-Learning style (TBL)
  - Individuals … then … in teams.
- Team quizzing promotes:
  - Instant feedback (IfAt cards)
  - Peer discussion & instruction
- Monitor quiz metrics:
  - Find and fix poor questions
  - Identify misconceptions
  - Compare teams & individuals



Question *level*

"Low" level => background, basics, unqualified 'what if', etc.
"High" level => relationships, assumptions, extensional thinking, etc.

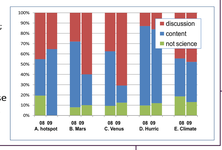
- Fewer low's in 2009
  - Better students?
  - Better pedagogy?
- Depends on article.



Question *type* : Discussion vs Content

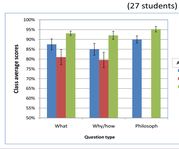
Does ***type*** of question posed depend on article or year?
- More discussion questions in 2009.
- ~10% of questions are *"non-science"*.
- Hurric vs Climate : Depends more on ***article***;
- Mars vs Venus: Depends more on ***year***;

Therefore … in 2010 …
- Require students pose both question types.



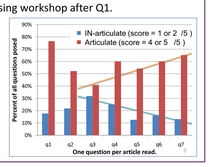
Guided question posing - 2010

- Assignment: pose 3 types of questions (27 students)
- Preliminary results:
  - 'Grading' via rubric.
  - Questions posed for:
    - 2 articles in Sept.
    - 1 article in Nov.
  - Questions get better.
  - Class consistency improves (std error).

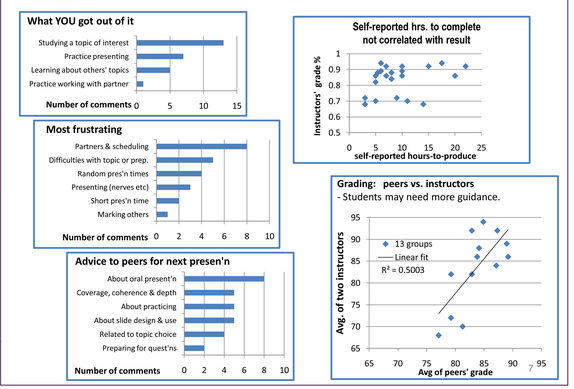


Is the question succinct and well articulated?

- "Pose one good question … " (with abstract-writing assignment)
  - Scored using 1 = NOT articulate … 5 = VERY articulate
- Questioning posing workshop after Q1.
- Q1: generally articulate , but simple.
- Q3-Q7: decline followed by improvement



Feedback about presentations ; self-selected topics & peer assessed



Readers … Did we forget any aspects of "*scientific expertise*"?

Use *post-its* to contribute below .

References on attached handout, & via
http://www.eos.ubc.ca/research/cwsei/scientificskills.html

Acknowledgements:
- This project is generously supported by the ***UBC Carl Wieman Science Education Initiative (CWSEI)***
- Thanks to: Carl Wieman, director, CWSEI; Sara Harris, EOS education initiative supervisor; Instructors & guest contributors; Graduate student TAs helping with the course; all students in the course.

Fostering & Measuring General Scientific Reasoning Expertise of 2nd Year Students

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Project Outline

Define nature of expertise [4 refs] ➔
Focus on s*cientific* expertise [12 refs] ➔
Design / implement / test corresponding pedagogy ➔
Measure (assess) students' improving abilities ➔ *Iterate.*

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References listed on reverse.
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