Fostering & assessing scientific reasoning in a large 1st yr course

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Project goals
- Move beyond clicker-enhanced lectures with purely recall-oriented assessment.
- Engage students with scientific data and readings.
- Enhance 6-module, 6-instructor teaching model.
- Target >900 F2F and DE students per term, addressing logistical & assessment challenges.

Progress: ½ way report...
- Students do auto-graded assignments.
- They use 6 types of scientific writings & data.
- Tasks at all cognitive levels (recall, apply, evaluate...)
- Background skills are assessed and mitigated.
- Feedback, time-on-task, scores: all are “good”.
- All classes in one term observed (COPUS).
- Work & assessment analysis (Item analysis, etc.).
- Pre-post geoscience attitudes (SPSS[1]).
- Costs of course-delivery to remain unchanged.

Context & challenges
- Large TLEF, 2016-18: eosc114 Natural Hazards.
- Sections/students: 5 F2F, 3 DE; >2000 students/yr.
- Diversity:
  - Gender: 1/ m = 54% / 46%
  - ESL <4 yrs English 8%
  - Prior geoscience: 1 course = 38%, 2 or more = 21%
- Attitudes by degree type (N=530, 850)

Instructing
- F2F: clicker-based lectures
  - 7 modules.
  - 3-6 instructors.
  - 1 administrator.
- DE: same 7 modules
  - 1 instructor
  - some discussion board activity
- Content: No textbook
  - Online and lecture notes only.

Classroom observations
Results are informing active learning enhancements.

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<tr>
<th>COPUS²[2] in each class: Instructor as “presenter” or “guide”</th>
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| Aggregated COPUS data: For each lesson, blue is “presentative”, red is “active”.
- Presentation dominates on most – but not all – days.
- Some modules are more “active” than others.

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<tr>
<th>COPUS²[2] in each class: Students clicker &amp; groupwork activities</th>
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| Aggregated COPUS data: For each lesson blue=clicker questions, green=peer clickers and red = other directed learning activities.
- Guided “active learning” could be increased in some modules.
- “Peer instruction” with clickers could be more consistent.


classroom observations

| New background check exercise (week 1).
- 20 qns: density, geoscience, maps, numeracy
- Do once ➔ close ➔ feedback with resources ➔ redo.
- Result: self-check helped, few concepts still not known.

New questions based on reasoning tasks. Eg:
- “Is the phrase... a claim, reason, evidence, either?”
- "Place 6 observations in the order that lead to discovery".
- "Identify most likely map location where... occurs.”

| F2F: 3 tests + final (all 2-stage).
| DE final: Identical to F2F.
| DE midterms (5)
  - Solo part:
    - 20 qn “sets” of 5-20 questions each.
    - organized by learning goals.
  - Group part:
    - 20 new questions, real-time disc’ns.
- Results of item analysis:
  - “Sets” could be more isomorphic.
  - Re-distribute questions based on “difficulty” & topic.
  - Tested in 1 module: Std Dev’n of “difficulty” fell 50%
  - Also consider making sets smaller.

New activities for 900+ students
- Bi-weekly homework:
  - Worksheets + resources ... work entered online.
- Six exercises – six reading & data types
  - 1. New York article (earthquakes in the PWH)
  - 2. Nature Geoscience commentary (mega-volcanoes)
  - 3. Technical peer reviewed article (landslides near Vancouver)
  - 4. Image-based problem set (hurricanes)
  - 5. Contracted reports for decision-makers (Tsunami, SW. BC.)
  - 6. Web info. & NASA / other databases (extinctions / impacts)
- Tasks designed for...
  - Low, intermediate, high cognitive levels (5, 5, etc)
- Variety of auto-graded qn. Types:
  - Ordered matching, numeric, fill-blank, jumbled sentence, MC, etc.
- Frameworks for learning goals & learning tasks
  - Processes, forecasts, consequences, risk, mitigation, inspiration.
  - Know, perform, argue, compare, create, judge/eval. & opine.
- Task examples (3 of many):
  - Place evidence leading to discovery in order
  - Does “...xyz...” refer to...
  - Goals of the research;
  - Requirements for meeting goals;
  - Methods: obtain or analyze data;
  - The evidence or data itself.
- Obtain high-water times from article, measure distance on Google maps, estimate tsunami velocity.
- Feedback FROM students obtained for each hmwk.
- Feedback TO students prepared without answers but with recommended thinking strategies.
- TAs can generate feedback & sample open comments.
- Item- & results-analysis informs feedback to students and the next iteration of exercises.
- Time spent & scores are consistent for six different types of tasks. Results will inform a “version 2”.

Highlights so far...
- Meaningful, efficient homework for 800+ is practical but takes care to prepare.
- Students express awe, fascination etc. if asked.

Eg: “What did YOU find interesting, amazing or noteworthy about the image of Hurricane Felix from space?”
- “Amazing... immense... impressive... clarity... so intense... so huge... so expansive... contains so much energy & force, yet seems so calm”
- Great responses to “one thing that surprised you”
  - “It takes more time than I thought to develop accurate forecasts”
  - “How a better model can yield different results & change the way you can mitigate for the risk in an area.”
- “There are so many close approaches to the Earth by NEOS”
- Higher cognitive level qns are possible, but tricky.
- Assessing “science reasoning” needs context(4, 5, etc).

Some feedback results:
Change hwqk / midterm balance?

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<tr>
<th>Which exercise was most... (N=406)</th>
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| De/Teaching 40 (5): 103 vs 36 vs 27. |
| Teaching 60 (4): 132 vs 71 vs 63. |

Some project components
- Frameworks for learning: recast Learning Goals
- Re-engage instructors: frameworks, hjwk, active classes
- Bloom’s Dichotomous Key:
  - compare task and quiz question cognitive levels before and after the project.
- Virtual field experience: Sea – to – Sky
  - Based on our real field trip[6, 7]
- Student projects:
  - Place-based, inquiry driven, peer-assessed.
  - Self-selected hazard and aspect of focus.
  - Precedent in eosc118, eosc326, geob316[8]
- Partner with The Pacific Museum of the Earth to engage students in meaningful content creation.
- DE: 1) assessments;
  2) homework, 3) projects later.

References and Acknowledgements
10. jollys@ucsb.edu

This project could not proceed without generous time and contributions from DEG114 instructors: Michael Baudier, Brent Bixby, Mike Madlewnski, Robert Clark, David Hsu, John McArthur, Alice O’Kane. Funding is provided by the Teaching and Learning Enhancement Fund, UBC, 2010-2018.

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Possible figures

hw2: What surprised you? 11% sample
- the geoscience
- consequences
- mitigation/preparedness
- risk = p * c
- predic’ n (time/place)
- the assignment
- other

 hw1: A claim t A reason
<table>
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<tr>
<th>Evidence</th>
<th>None of these</th>
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<tr>
<td>q12</td>
<td>12% 13% 71% 3%</td>
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<tr>
<td>q13</td>
<td>90% 5% 2% 1%</td>
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<tr>
<td>q14</td>
<td>5% 9% 8% 77%</td>
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<tr>
<td>q15</td>
<td>18% 52% 23% 6%</td>
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 hw5 a b c d e
- Most intense
- Intense
- Moderate
- Light
- None

 q10 6% 43% 26% 17% 7%
 q11 70% 15% 7% 5% 3%
 q12 4% 10% 14% 62% 10%

 hw7
Which exercise was most ... (N=406)
Interesting Challenging

 Very 23% 52%
 Somewhat 10% 38%
 Saw, but NOT worthwhile 10% 38%
 Did not use any 5% 38%
 Did not know there was any 5% 38%