Fostering & assessing scientific reasoning in a large 1st yr course: ½ way report

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Project goals

- Move beyond clicker-enhanced lectures + recall-oriented testing.
- Engage students with scientific data and readings.
- Enhance 6-module, 6-instructor teaching model.
- Target >800 students per term, addressing logistical & assessment challenges.
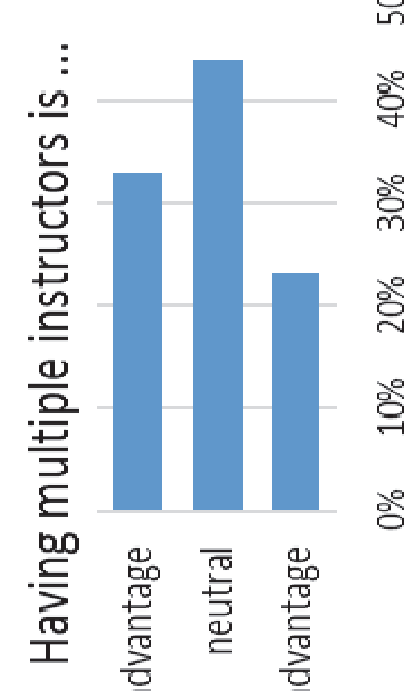
Progress towards goals

- Students do auto-graded assignments using 6 different types of scientific writings & data.
- Tasks span cognitive levels, ranging from recall through application to evaluation and judgement.
- Background skills are assessed and mitigated.
- Feedback, time-on-task, scores: all are positive.
- A science-reasoning test was piloted. Analysis in progress. Results inform learning-task design.
- Observations of classes (COPUS) and assessment strategies are informing recommendations.
- Pre-post of attitudes towards geoscience (SPESS [1]) completed twice.
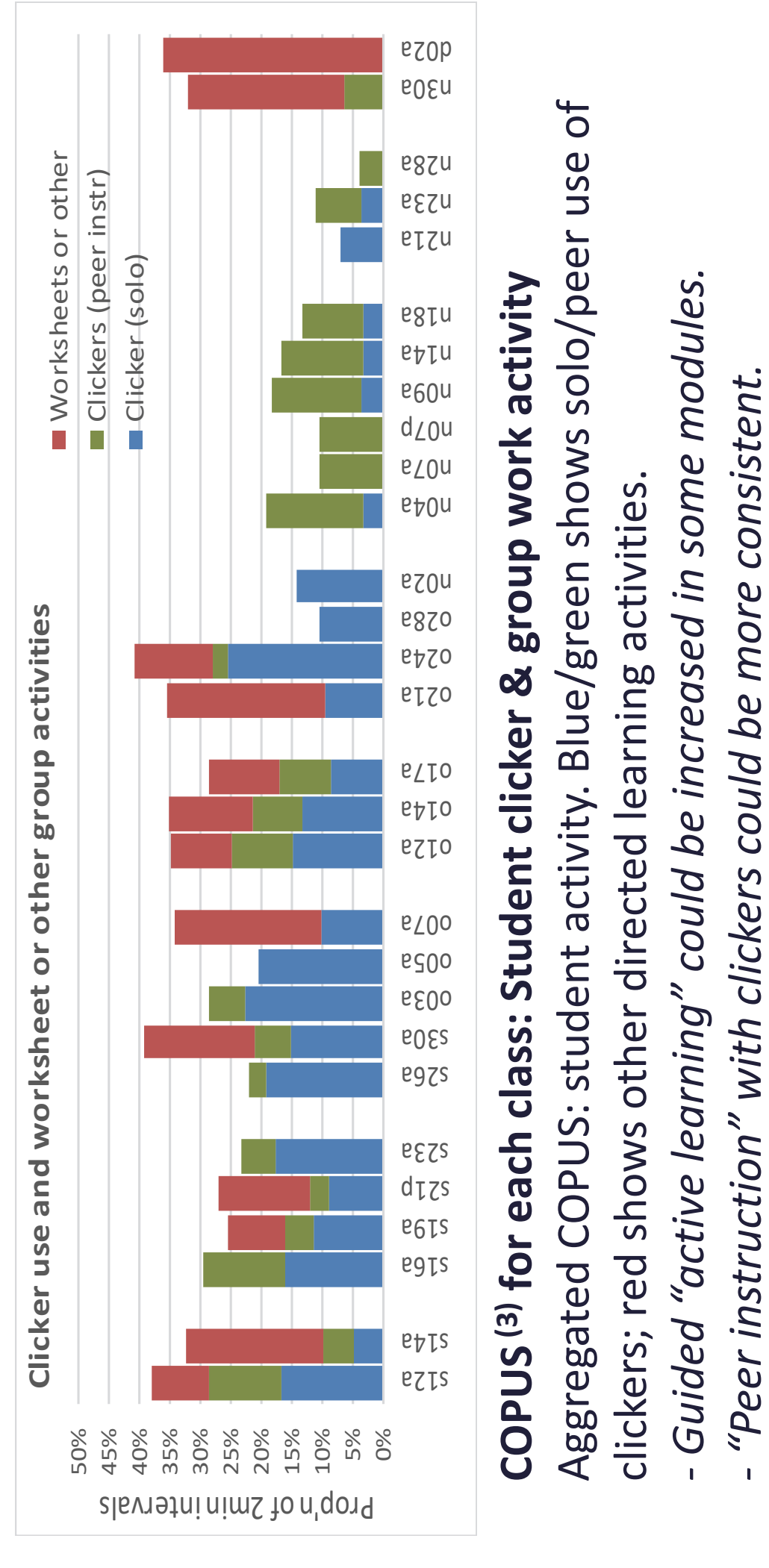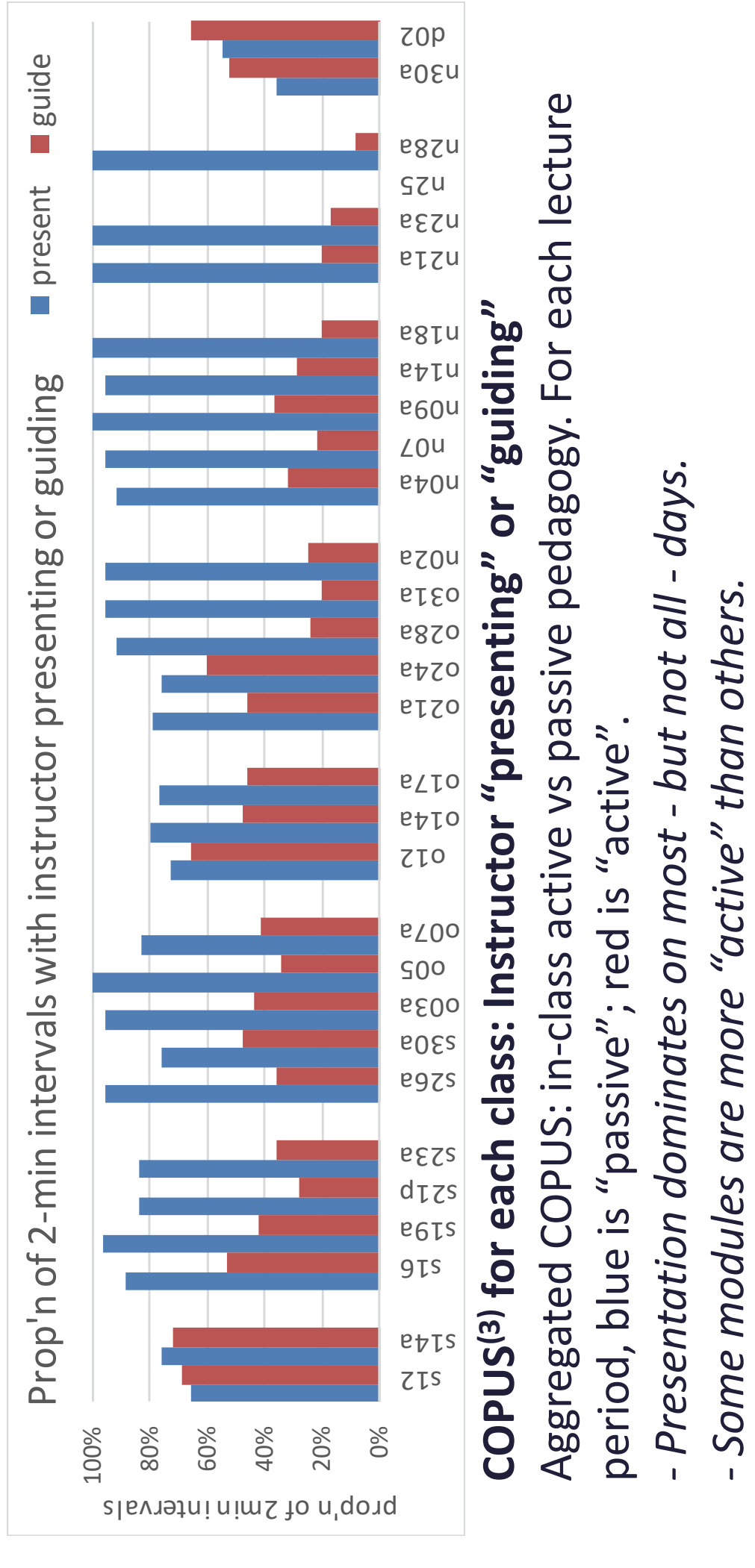- Costs of course-delivery remain unchanged.

Context and challenges

- **Large** TLEF, 2016-18: eosc114 Natural Hazards.
- **Sections/students:** 5 f2f , 3 DE; >2000 students.
- **Diversity:**
  - Year & gender . . . . →
  - Gender: f / m = 54% / 46%
  - ESL: <4 yrs English: 8%
  - Done 1 or >1 geoscience courses: 38% or 21%

year	BA	BSC	BASC	BCOM	BKIN	E/U	Other
1st	14%	4%	1%	3%	1%	0.1%	25%
2nd	17%	9%	2%	3%	1%	0.6%	34%
3rd	8%	5%	2%	1%	1%	1%	19%
4th	4%	3%	2%	2%	0.2%	1%	11%
5th	0.2%	0.1%			0.2%	0.1%	1%
other	1%		0.3%	0.2%	0.1%	1%	7%
	43%	22%	6%	8%	3%	3%	

- **F2F:** 7 modules, 3-6 instructors.
  - Re. multiple instructors:[2] →

Having multiple instructors is …
advantage
neutral
disadvantage

- **DE:** same modules, 1 instruct.
- **No text:** online and lecture notes only.
- **Past assessments:** 3-5 midterms, 1 final, all tests are 2-stage mult. choice. Same final in F2F & DE.

Classroom observations

COPUS [3] for each class: Instructor "presenting" or "guiding"
Aggregated COPUS: in-class active vs passive pedagogy. For each lecture period, blue is "passive"; red is "active".
- Presentation dominates on most - but not all - days.
- Some modules are more "active" than others.

COPUS [3] for each class: Student clicker & group work activity
Aggregated COPUS: student activity. Blue/green shows solo/peer use of clickers; red shows other directed learning activities.
- Guided "active learning" could be increased in some modules.
- "Peer instruction" with clickers could be more consistent.
- Recommendations to the instructing team will be discussed for Sept 2017.

Assessment practices

Face to face (f2f):

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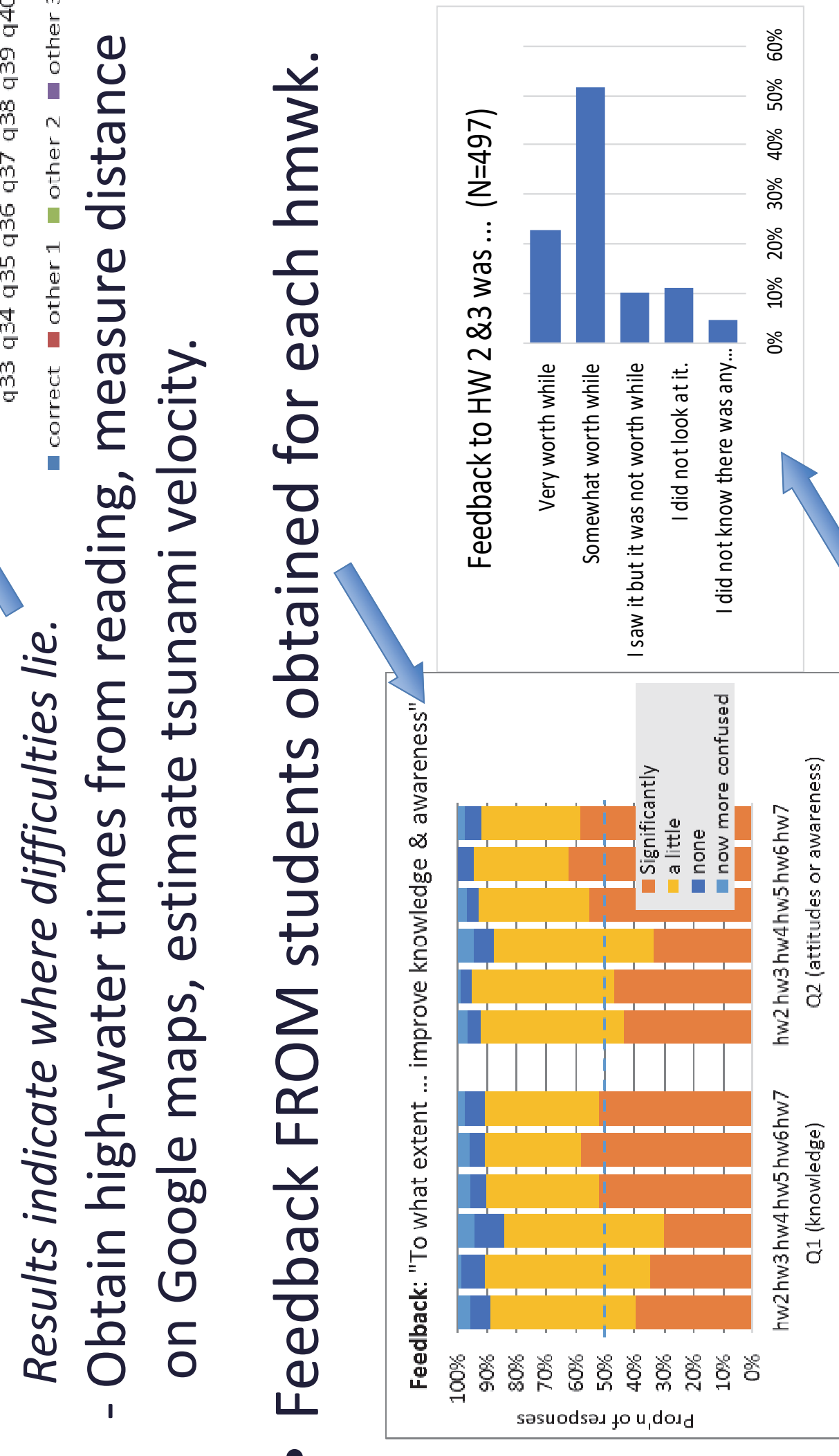 - Result: self-check works; a few concepts still not known

- Six new homework activities; see next col.

Distance education (DE):

- 2-stage final identical to f2f.
- Five module tests.
  - Solo part: 20 qn "sets" targeting learning goals. Sets include ~5-20 questions each.
  - Online real-time groups: 20 new questions.
- 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 make sets smaller?
  - Options to be considered during summer 2017

New activities for 800+ students

- Bi-weekly homework:
  - Worksheets + resources … results entered online.
- Six exercises – six reading & data types
  1. New Yorker article (earthquakes in the PNW)
  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 (4, 5, etc)
  - Variety of auto-graded qn. Types; Ordering, 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:
  - 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.
    Results indicate where difficulties lie.
  - Obtain high-water times from reading, 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; but refinements can be made.
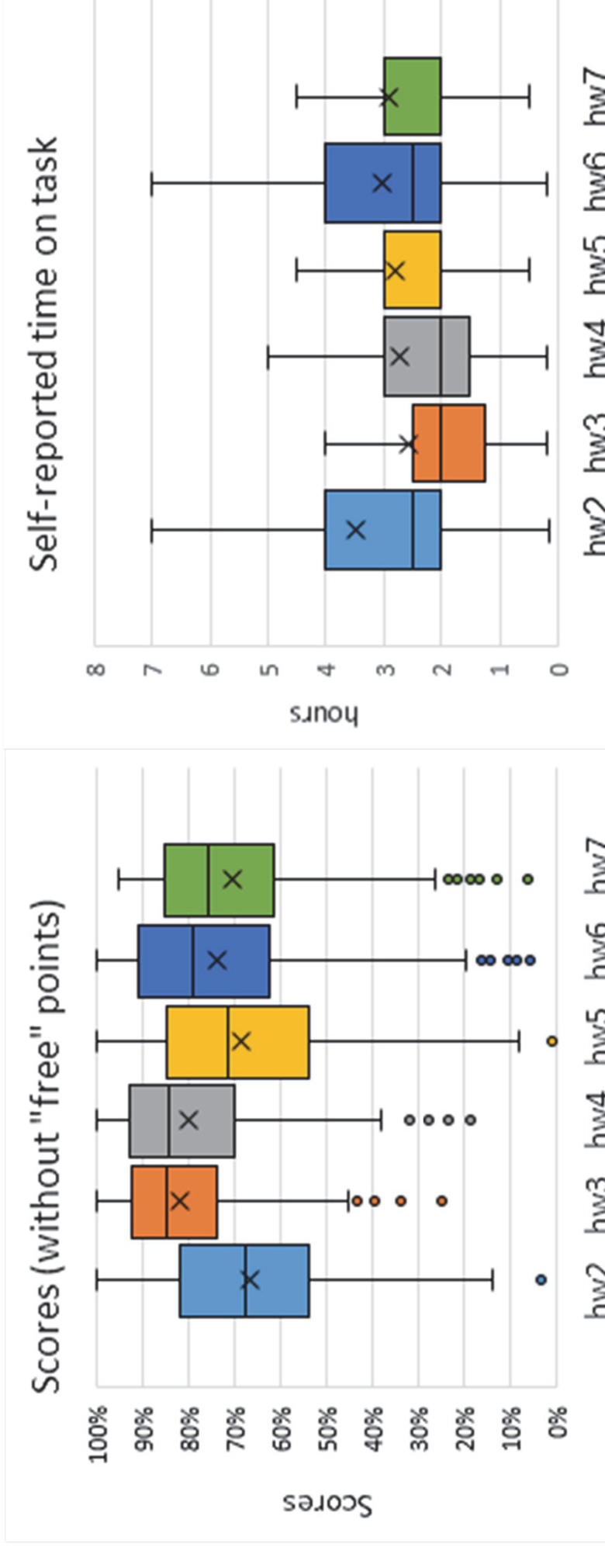

Highlights so far …

- Meaningful, efficient homework for 800+ is practical
- Students express awe, fascination etc. if asked.

  Eg: "What did YOU find amazing, interesting or noteworthy about this image of Hurricane Felix from space?"
  "Amazed… 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 q'ns are possible, but tricky.
- Assessing "science reasoning" needs context [4, 5, etc]

Upcoming project components

- **Frameworks** for learning: recast Learning Goals
- **Re-engage instructors**: frameworks, hmwk, active classes
- **DE**: Homework and assessments, projects later".
- **BDK:** Bloom's Dichotomous Key; compare task and quiz question cognitive levels before and after the project.
- **Virtual field experience;** based on 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 [7].
  ○ Partner with the **Pacific Museum of the Earth** to engage students in content creation.
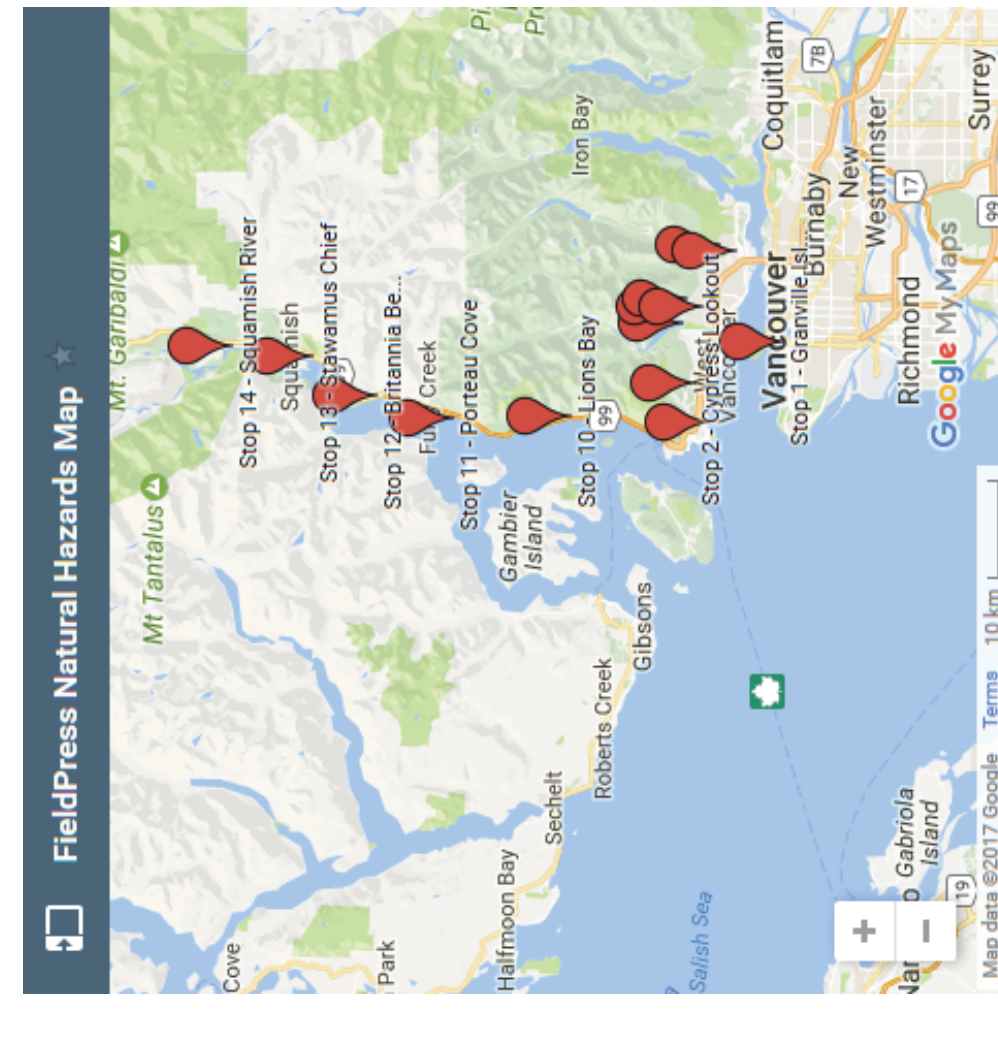
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8. http://serc.carleton.edu/serc/site_guides/hazards.html and others at serc.Carleton.edu

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