

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

Francis Jones*, Lucy Porritt, Sara Harris

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.

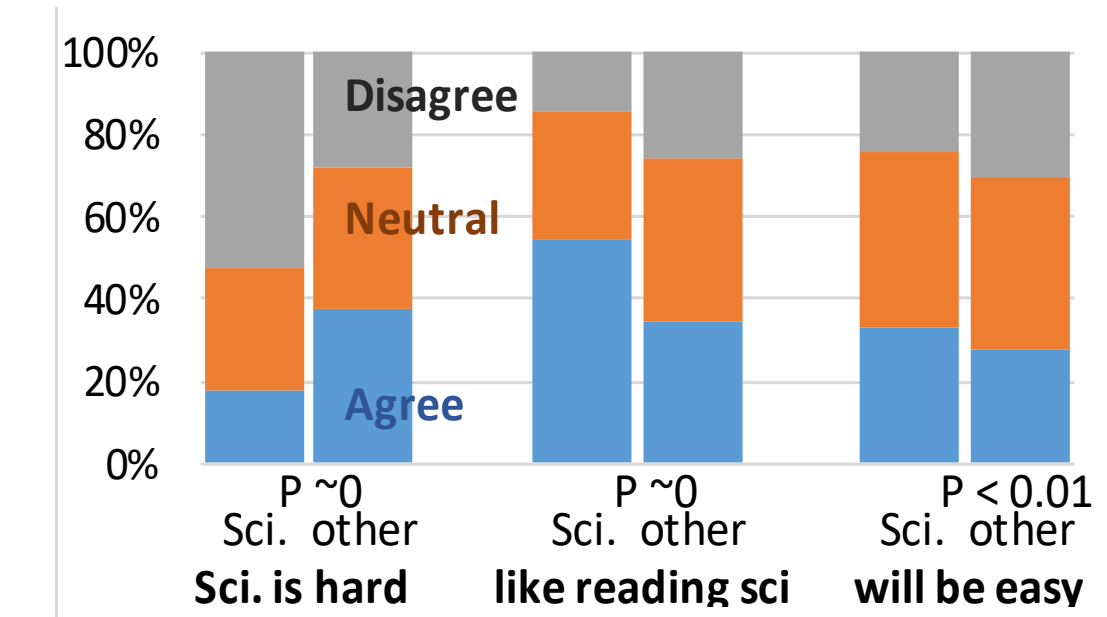
Progress: ½ way report ...

- 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”.
- Science-reasoning assessment tasks piloted.
- 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 and challenges

- **Large TLEF**, 2016-18: eos114 Natural Hazards.
- **Sections/students**: 5 f2f, 3 DE; >2000 students/yr.
- **Diversity**:
Gender: f / m = 54% / 46% **ESL**: <4 yrs English= 8%
Prior geoscience: 1 course = 38%, 2 or more = 21%

Attitudes by degree type (N=530, 850)

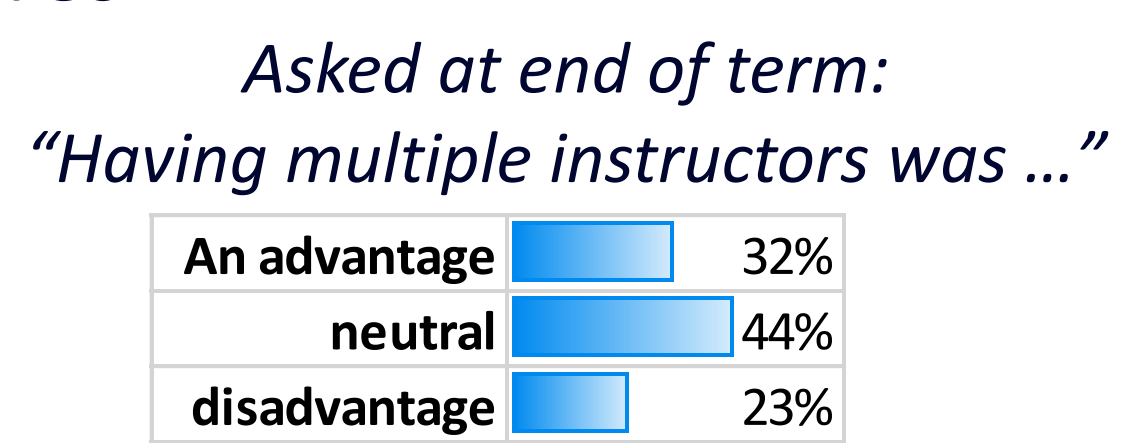


Enrollment: yr & degree

year	BA	BSC	BASC	BCOM	BKIN	E/U	Other
1st	14%	4%	1%	3%	1%	3%	25%
2nd	17%	9%	2%	3%	1%	0.1%	2%
3rd	8%	5%	2%	1%	1%	0.6%	1%
4th	4%	3%	2%	2%	0.2%	1%	11%
5th	0.2%	0.1%				0.1%	0%
other	1%	1%	0.3%	0.2%	0.2%	0.1%	1%
	43%	22%	6%	8%	3%	1%	7%

Instructing

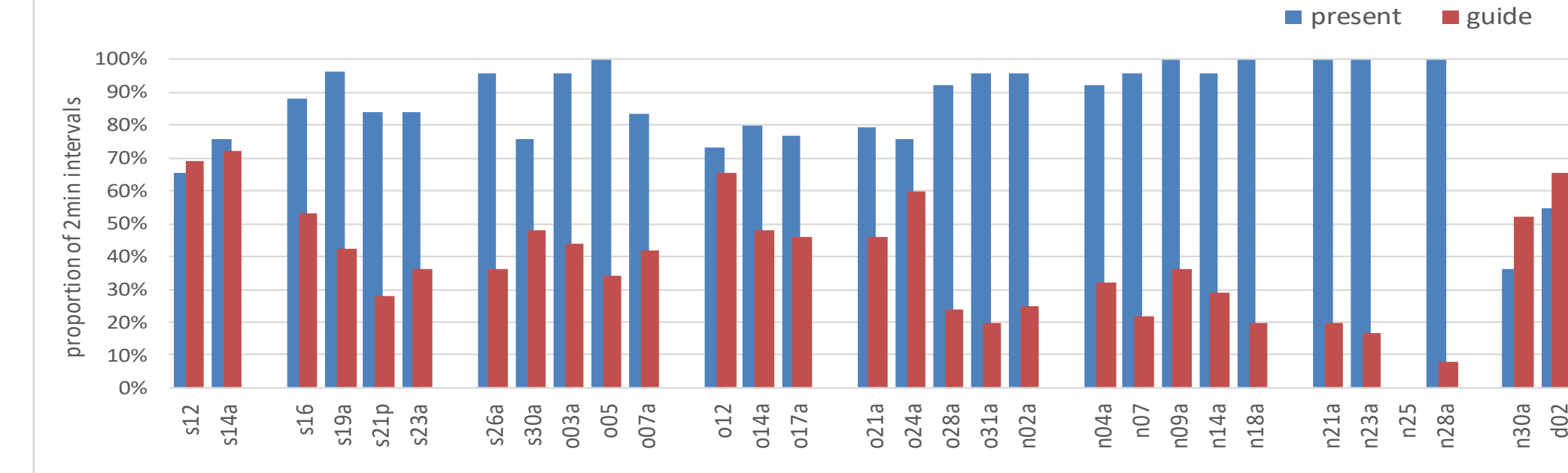
- **F2F**: clicker-based lectures
 - 7 modules,
 - 3-6 instructors.
 - 1 administrator
- **DE**: same 7 modules
 - 1 instructor
 - some discussion board activity
- **Content**: No textbook
Online and lecture notes only.



Classroom observations

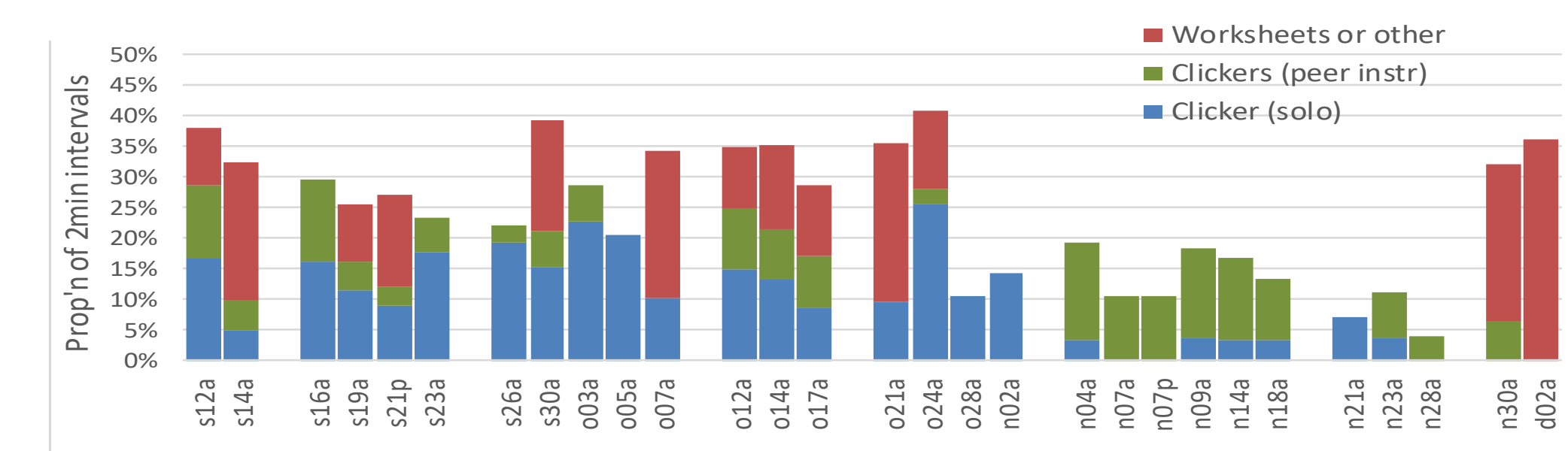
Results are informing active learning enhancements.

COPUS⁽³⁾ in each class: Instructor as “presenter” or “guide”



Aggregate COPUS data: For each lesson, **blue** is “passive”; **red** is “active”.
- Presentation dominates on most - but not all - days.
- Some modules are more “active” than others.

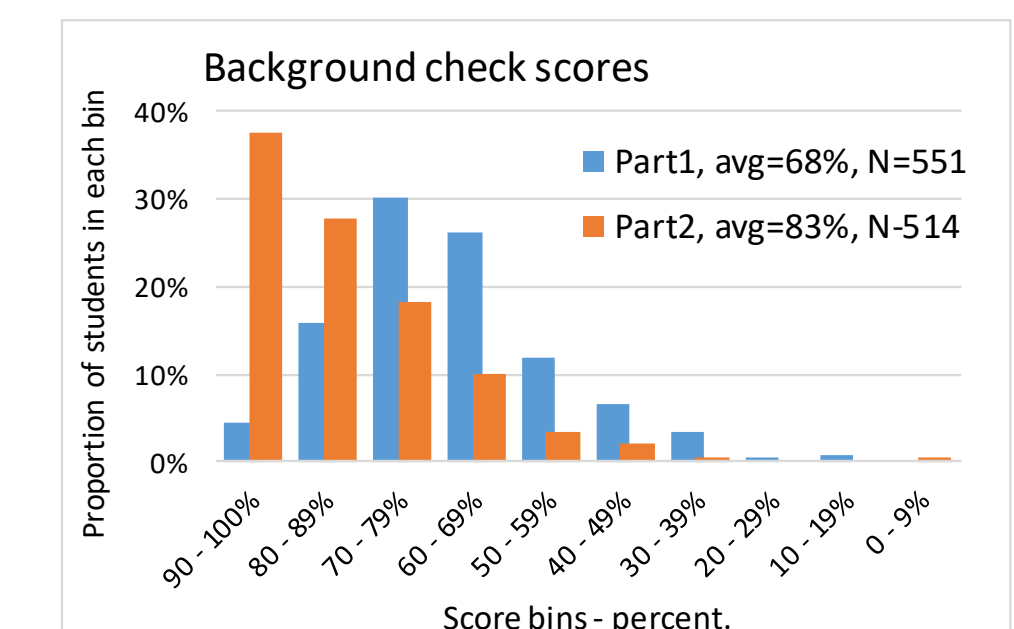
COPUS⁽³⁾ in each class: Students clicker & groupwork activities



Aggregate COPUS data: For each lesson **blue**=solo 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.

Assessment initiatives

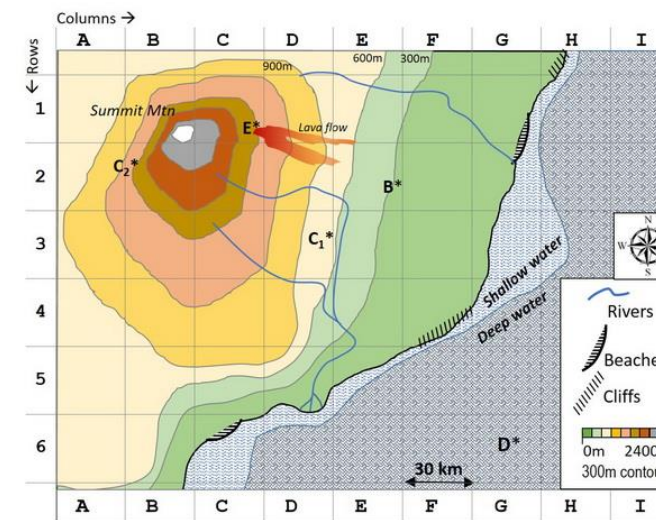
- New background check exercise (week 1).
 - 20 qns: density, geoscience, maps, numeracy ...
 - Do once → close → feedback with resources → redo.
 - **Result**: self-check helped; a few concepts still not known.



Were resources helpful? Prop'n respondents (N=487)

extremely; could not have done without.	7%
very; needed for 3 or more questions.	36%
a little; needed for only 1 or 2 questions.	36%
Did not use any resources.	10%
unhelpful; Led me astray or wasted > 15mins	6%

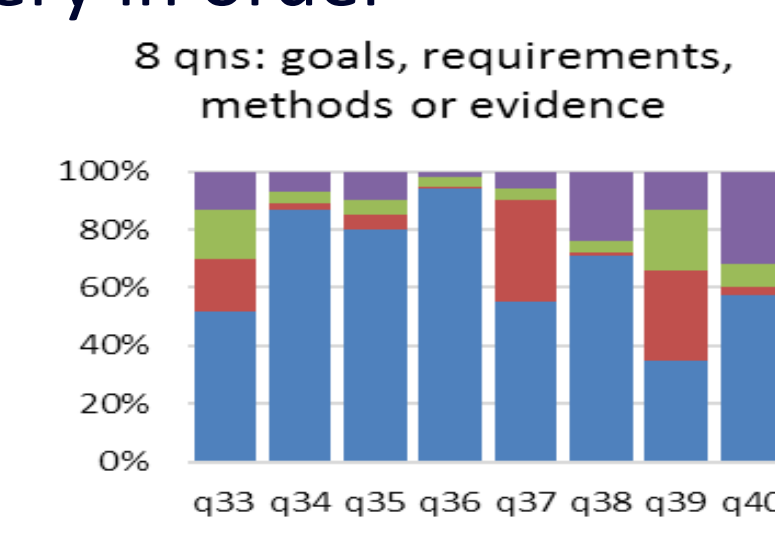
- New questions based on reasoning tasks. Eg:
 - “Is the phrase ... a claim, reason, evidence, neither?”
 - “Place 6 observations in the order that lead to discovery”.
 - “Identify most likely map location where ...xyz... occurs”



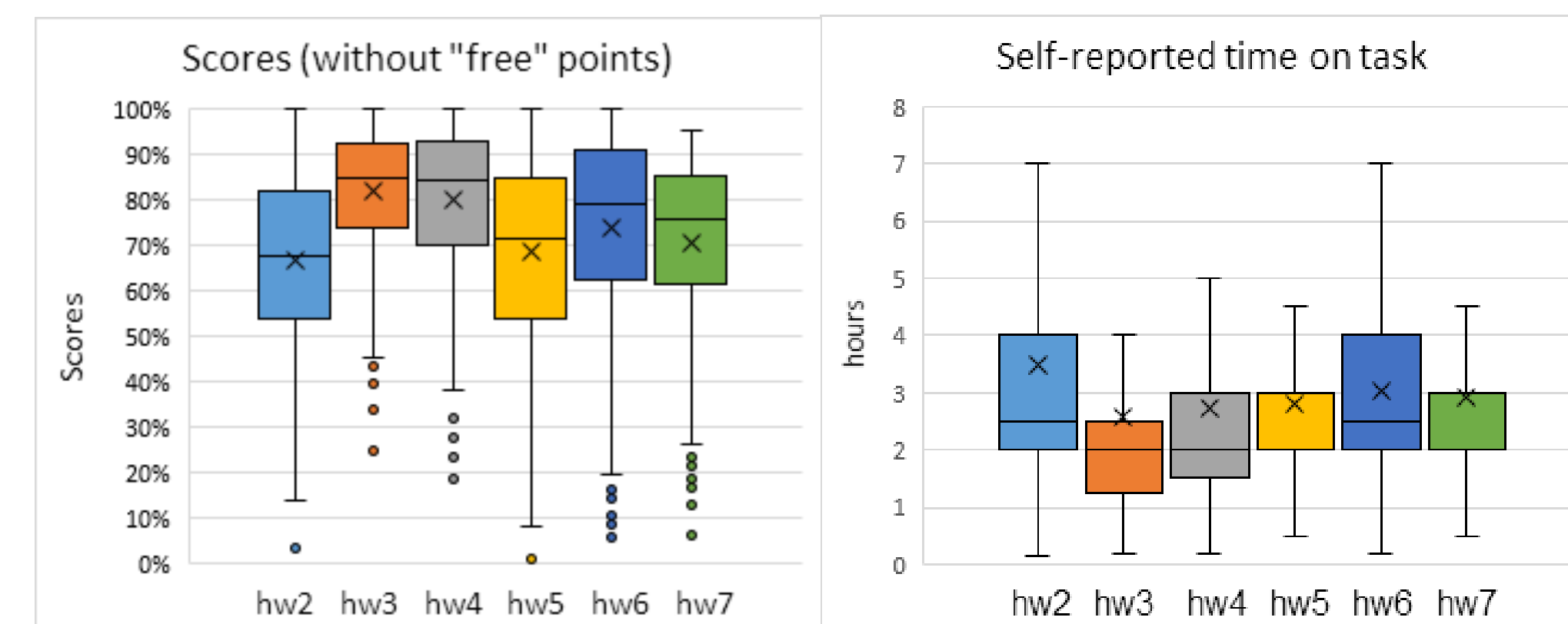
- F2F: 3 tests + final (all 2-stage).
- DE final: Identical to F2F.
- DE midterms (5):
 - **Solo part**:
 - 20 qn “sets” of 5-20 questions each.
 - organized by learning goals
 - **Group part**: 20 new questions, real-time disc’n.
 - **Results of item analysis**:
 - “Sets” could be more isomorphic
 - 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 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 (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 hwk.
 - Feedback: “To what extent ... improve knowledge & awareness”
 - **Asked in hw4: “How worth while was feedback in hw 2 & 3?”**
- 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 ...

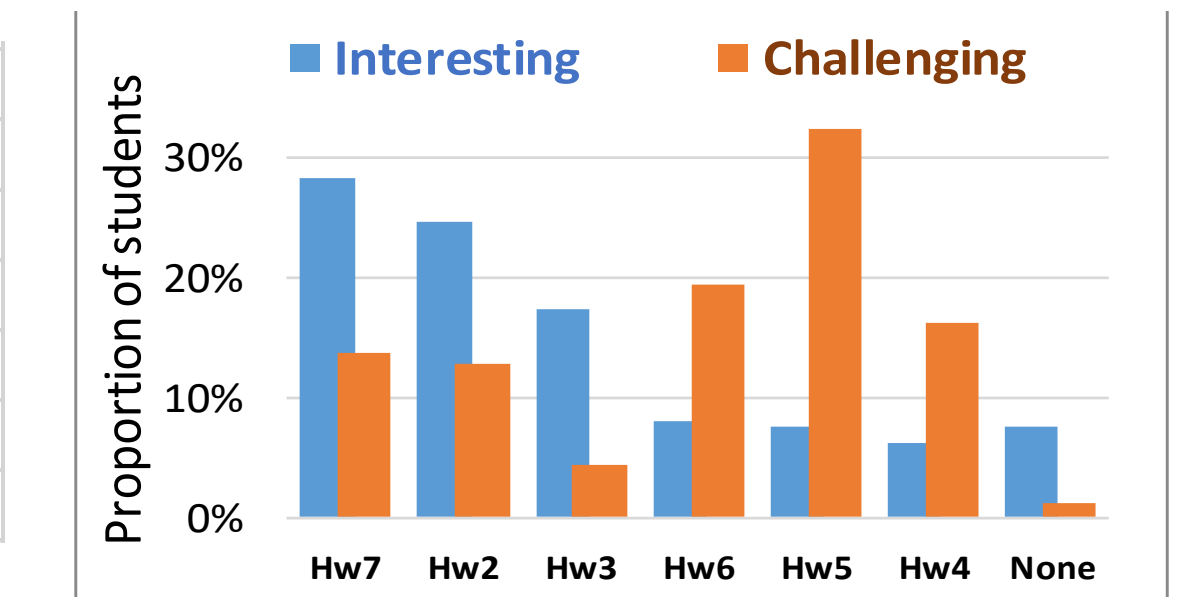
- Meaningful, efficient homework for 800+ is practical but takes care to prepare.
- Students express awe, fascination etc. if asked.
 - Eg: “What did YOU find amazing, interesting or noteworthy about this image of Hurricane Felix from space?”
 - “Amazed... immense... impressive... clarity... so intense... 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)

Some feedback results:

Change hwmk / midterm balance?

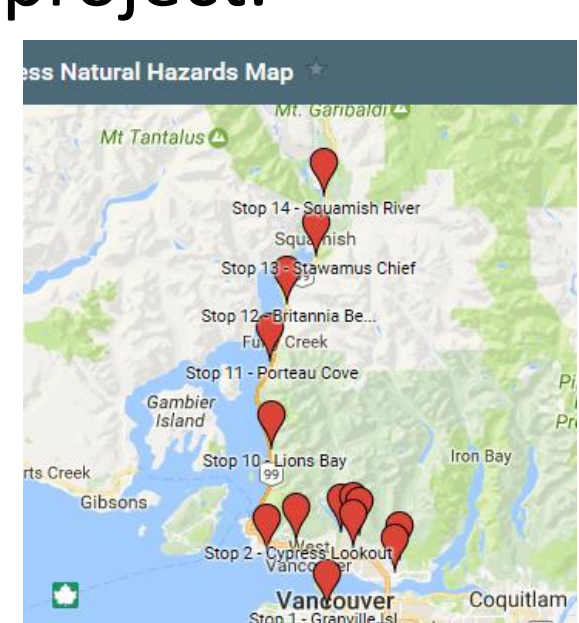
homework amount	weight	midterms amount	weight	
same	more	same	less	36%
same	same	same	same	26%
less	same	same	same	21%
more	more	less	less	13%
same	less	same	more	5%

Which exercise was most ... (N=406)



Upcoming project components

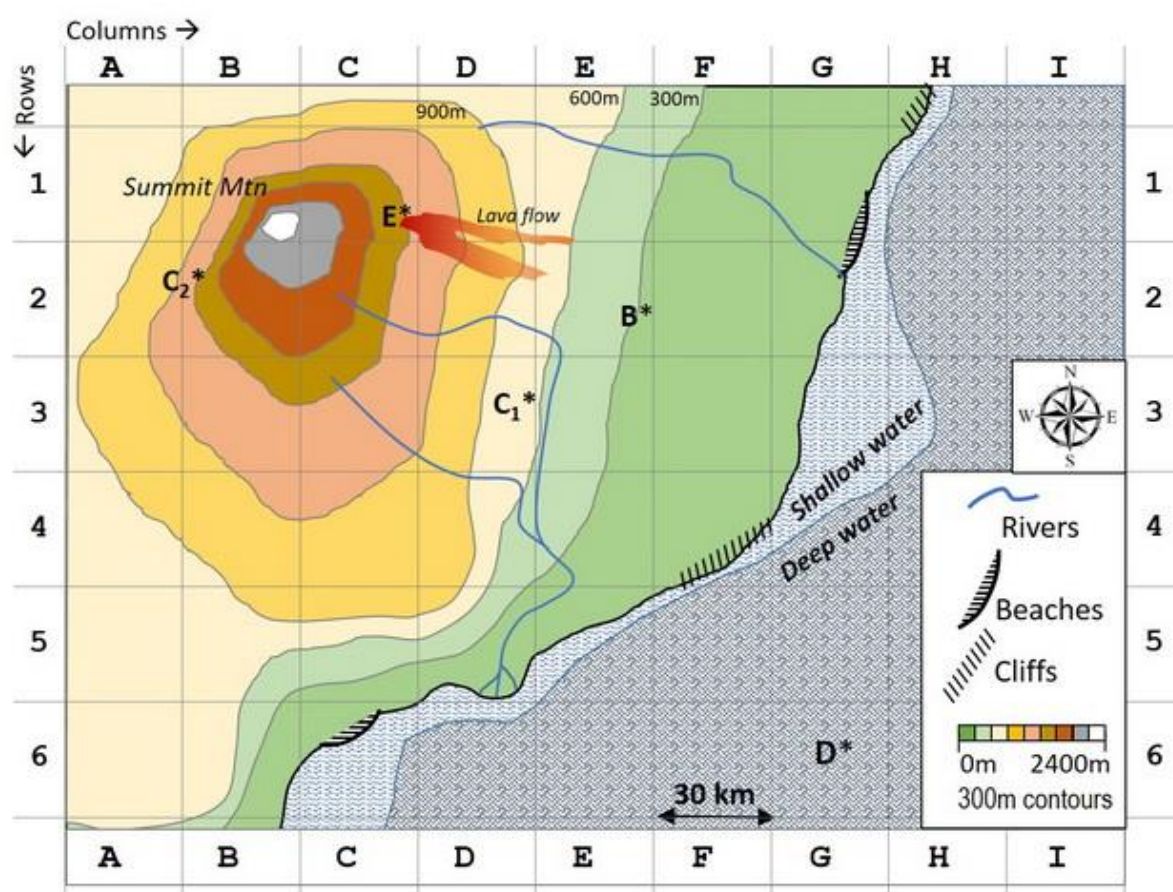
- **Frameworks** for learning: recast Learning Goals
- **Re-engage instructors**: frameworks, hwmk, active classes
- **Bloom’s Dichotomous Key**; compare task and quiz question cognitive levels before and after the project.
- **Virtual field experience: Sea – to – Sky**; Based on our real field trip^(6, 8)
- **Student projects**:
 - Place-based, inquiry driven, peer-assessed.
 - Self-selected hazard and aspect of focus.
 - Precedent in eos118, eos326, 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.



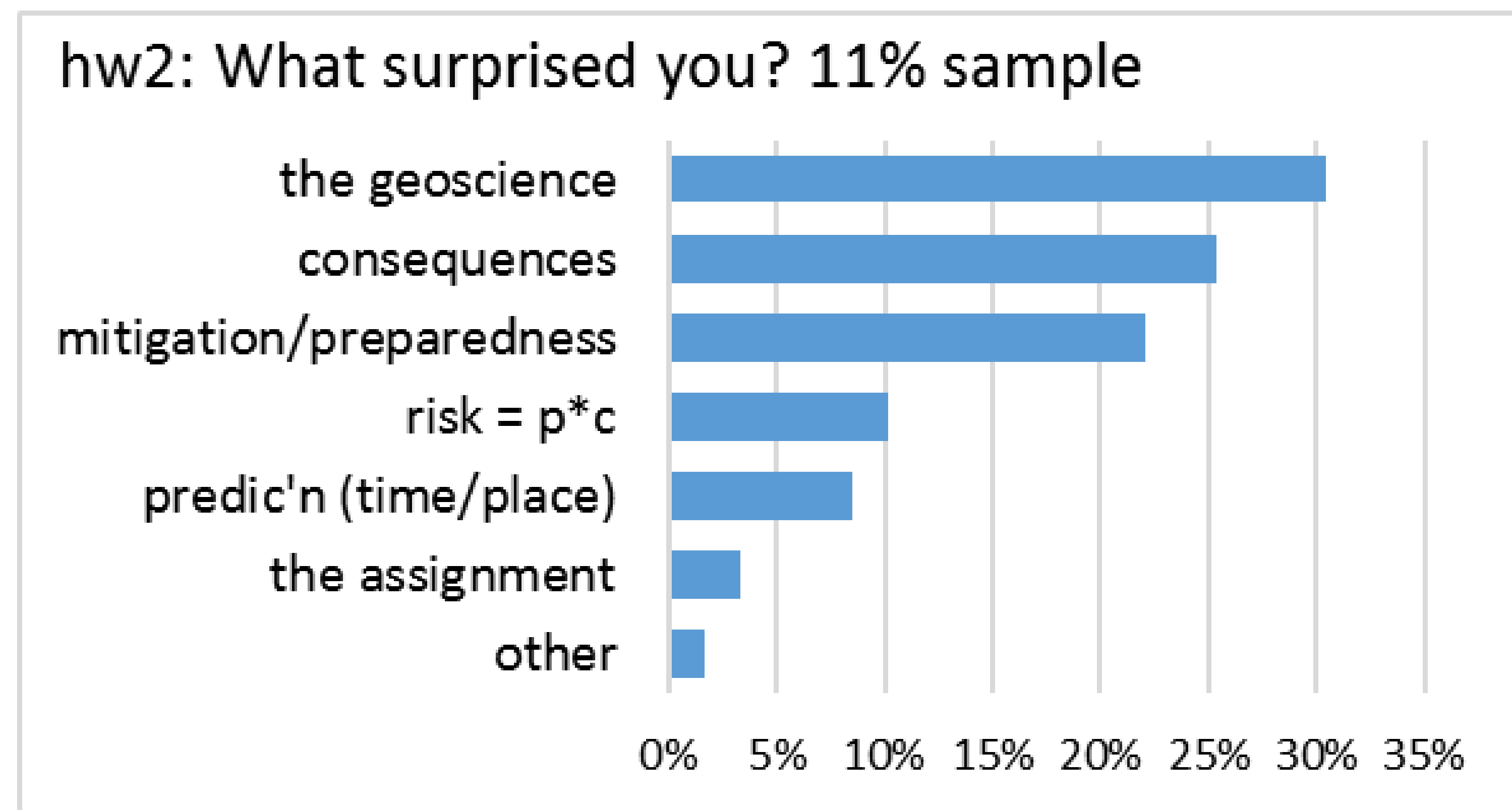
References and Acknowledgements

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2. Jones, F., and S. Harris. 2012. “Benefits and Drawbacks of Using Multiple Instructors to Teach Single Courses.” College Teaching 60 (4): 132–39.
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6. Gilley, B., et al. 2015. “Impact of Inclusive Field Trips.” Nature Geoscience 8 (8): 579–80.
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8. <http://open.geog.ubc.ca/resources/fieldpress/> and <http://fieldpress.ca/fields/>; particularly <http://fieldpress.ca/fields/natural-hazards-of-vancouver-north-shore-and-the-sea-to-sky-highway/>
9. http://serc.carleton.edu/serc/site_guides/hazards.html and others at serc.carleton.edu

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Possible figures

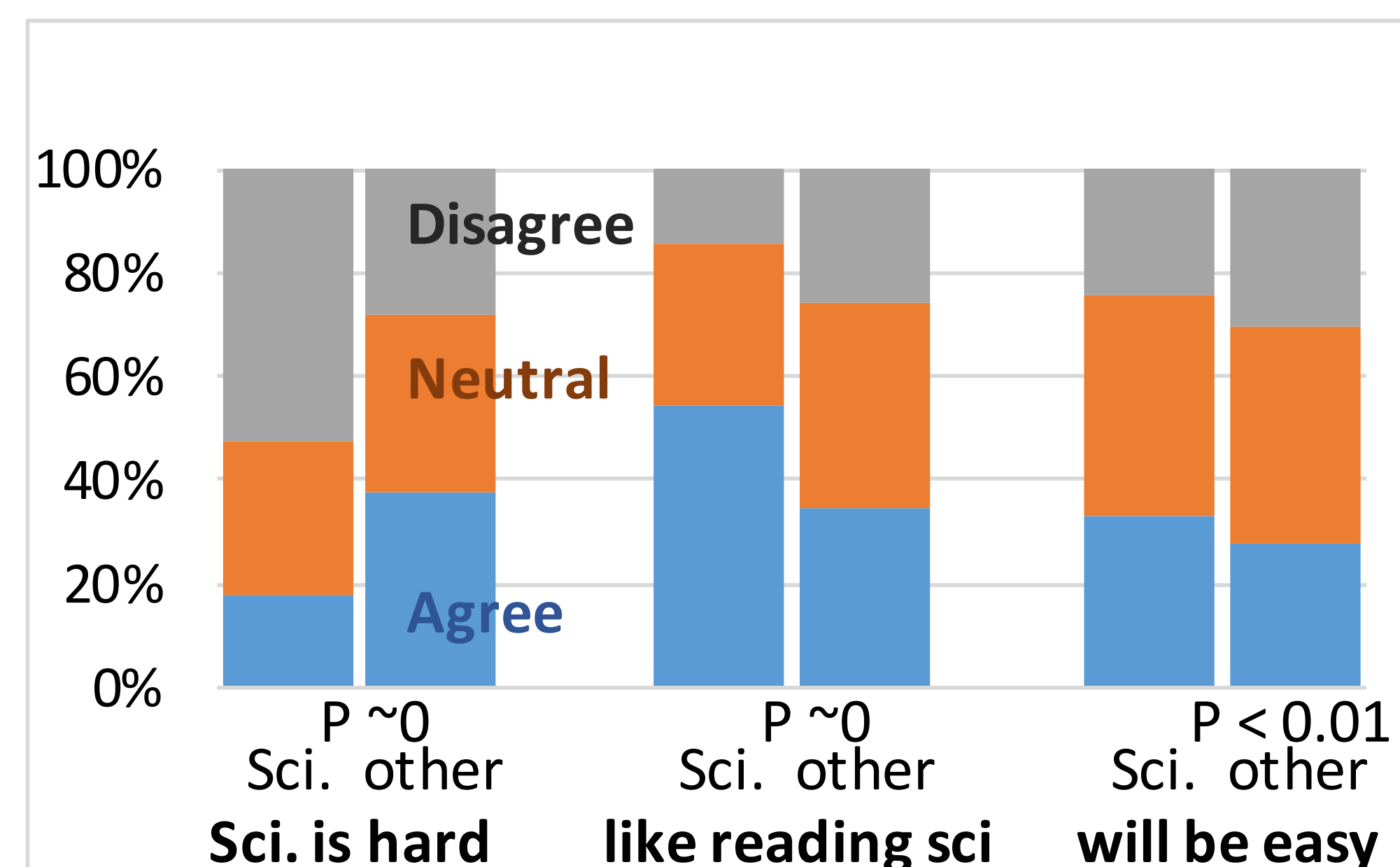


hw1:	A claim t/A reason	Evidence	None c
q12	12%	13%	71%
q13	90%	5%	2%
q14	5%	9%	8%
q15	18%	52%	23%

hw5	a	b	c	d	e
	Most inter mod light, none				
q10	6%	43%	26%	17%	7%
q11	70%	15%	7%	5%	3%
q12	4%	10%	14%	62%	10%

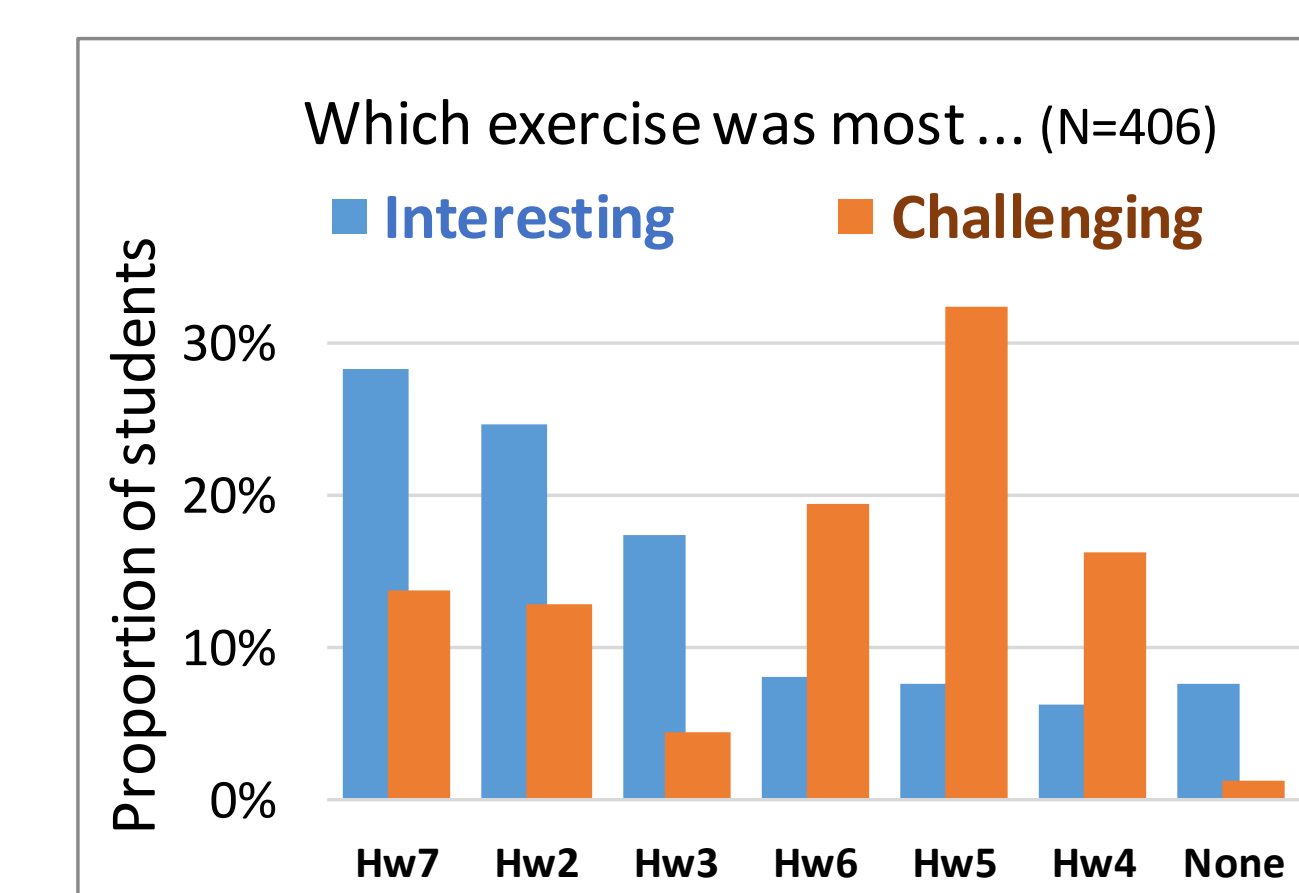
Change balance of hwmk & midterms?

homework		midterms		
amount	weight	amount	weight	
same	more	same	less	36%
same	same	same	same	26%
less	same	same	same	21%
more	more	less	less	13%
same	less	same	more	5%



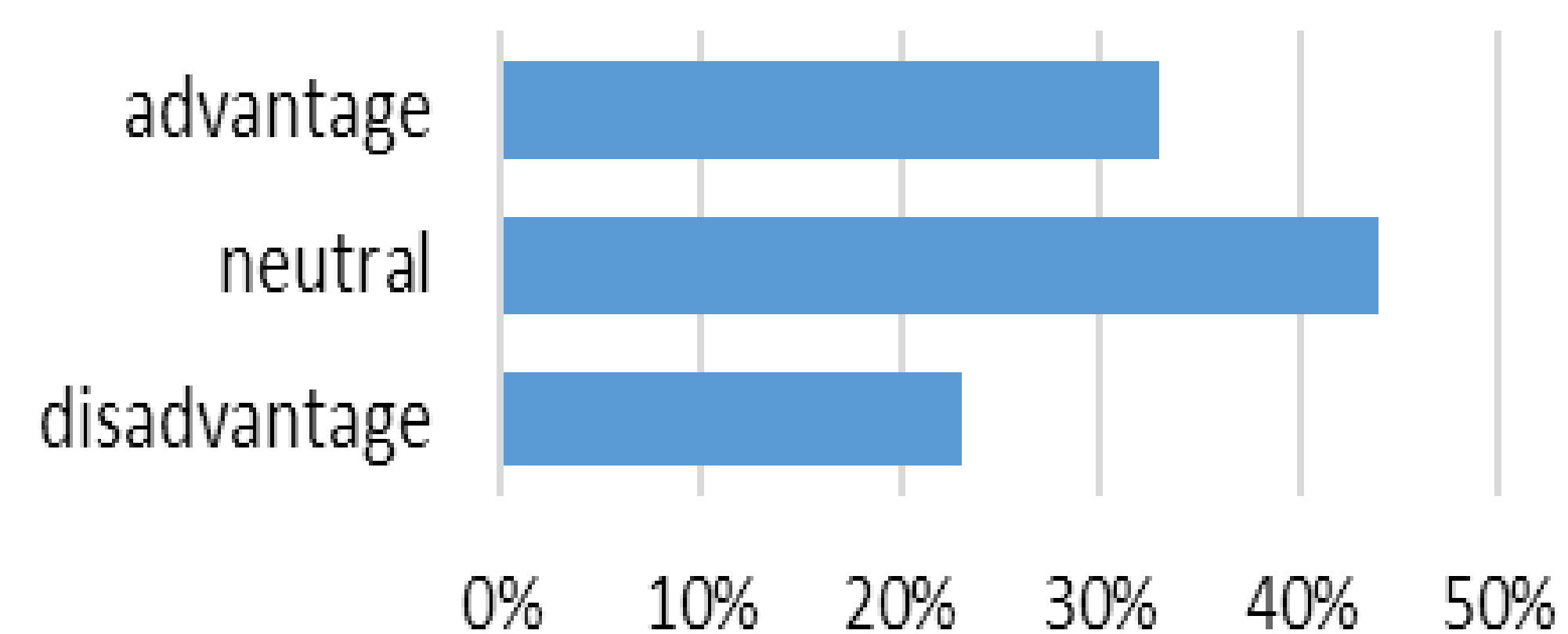
What surprised you about this article?

Related to geoscience	31%
Hazard consequences	25%
Mitigation/preparedness	22%
Related to risk = p*c	10%
Prediction (time/place)	8%
Abot the assignment	3%
Other	2%



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Having multiple instructors is ...



Very	23%
Somewhat	52%
Saw, but NOT worthwhile	10%
Did not use any	11%
Did not know there was any	5%