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THE UNIVERSITY OF BRITISH COLUMBIA

Improving and Assessing Research, Design and Reporting Skills of STEM Students

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EOS-SEI

Interactive presentation goals …

1. Identify a range of needs and contexts for teaching & learning research, design and reporting skills.
2. Present our approach to improving students' abilities to …
   - Tackle open-ended design projects;
   - Synthesize results into efficient written reports.

→ What was done ("methods")

→ Results of what was done.

3. Discuss applicability, costs and benefits in settings suggested by everyone here …

Our context …

Improving & assessing research / design / reporting skills

Setting:

- 4th year course for geotechnical engineering students.
- First exposure to "design practices".

The challenge(s):

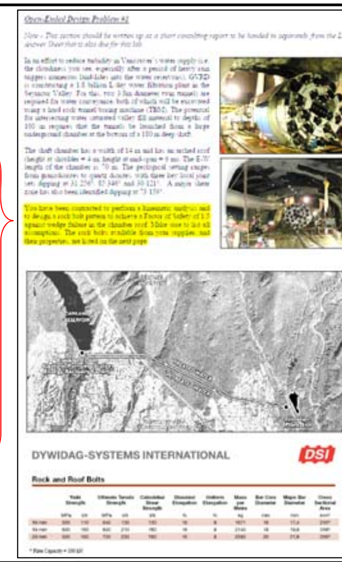
- *"The first design project is always a disaster."*
- *"They have no clue how to begin an open-ended design task."*
- *"many reports are hopeless – they miss obvious components."*
- *"Some TAs are great! Others … not so experienced …"*
- *"Students can not handle geological uncertainty with maturity"*

"*Engineering design is hard to learn and harder still to teach*" Clive etal, 2005.

Example:

One-sheet with an open-ended design project

"You have been contracted to perform a kinematic analysis and to design a rock bolt pattern to achieve a Factor of Safety of 1.5 against wedge failure in the chamber roof. Make sure to list all assumptions. The rock bolts available from your supplier, and their properties, are provided."



What are YOUR contexts for developing research, design and/or communicating skills.

Settings …

- Science? Departments?
- Arts? Departments?
- Applied science or engineering?
- Others?

Articulating Challenge(s)?

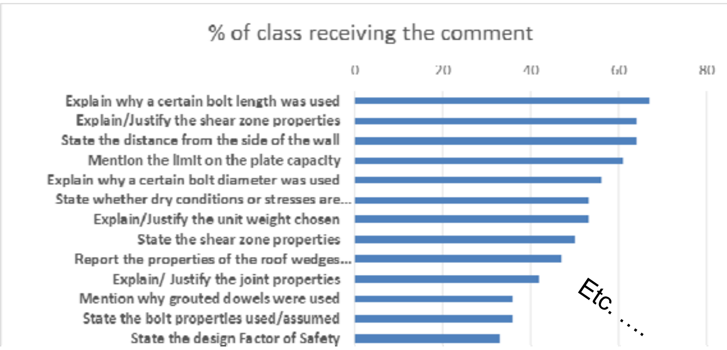
- "…

My plan here …

- Run through steps in our development sequence
- Summarize some indicators of "success"
- Revisit YOUR settings
  – discuss pros, cons, costs, challenges, opportunities …
- Email details (slides) plus a reference list to those on the participation list.

Challenge that sparked this project

Feedback compiled by TA: **similar for all four design projects** ☹



IN OTHER WORDS … ***"Wisdom can't be told …".***

"Theoretical" underpinnings:

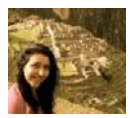
- Highly "expert" tasks: Experts have…
  – Deep foundation of (fluency in) factual and procedural knowledge;
  – Well organized conceptual framework for that knowledge;
  – Discipline-specific metacognitive abilities.
- Novices progress towards expertise by "**deliberate** practice".
- "**Deliberate**" means targeted at improving *specific* abilities.
- Expert instructors can make opportunities for students to practice deliberately, and generate feedback at critical points.

Aim for consistency with best practices:
EG: Table 1 in Litzinger etal, 2011, a metastudy on education and development of engineering expertise.

- Affective
  - Raise interest, challenge, motivate, relate to needs/interests
- Cognitive
  - Prior knowledge, deep engagement, integrate skills / knowledge,
  - Scaffolding, timely feedback,
  - Formative assessment and summative evaluation
- Metacognitive
  - Self regulation, awareness of progress and needs, reflective
  - Feedback about learning progress and skills
  - Engage "collective reasoning" (teams / groups); i.e. peer feedback

Thoughts / questions on underpinnings?

Resources and "costs"



- 1 experienced and confident graduate TA
  - Working in industry & pursuing an M.Sc.
  - TA'd in this course once before
  - Paid 1 full TA-ship during summer to help develop strategies and tools
  - Piloted the activities and assessment rubrics
  - Shared this role a third time with a new TA.
  - ~100 hrs during a 4-mth summer
  - Normal TA duties during the teaching term.

- 1 Teaching and learning support
  - "Science Teaching and Learning Fellow" (me ☺)
  - ~ 40hrs over 4-mth summer
  - ~ 20hrs over 4-mth teaching term

- 1 lead instructor (Prof. E. Eberhardt)
  - Occasional meetings for updates and to "approve" actions.
  - Our changes must fit with this course that HE teaches.

Sequence of steps …

1. Analysis of expertise; establishes a framework for work
2. Corresponding tools = process-oriented rubrics
3. Instructional scaffolding of authentic tasks
4. Mentoring of graduate teaching assistants (TAs)

Step 1: Analyze expertise (develop framework)

1) Framework for approaching open-ended design problems:

- Initial challenges discussed by interviewing TA:
  - Anecdotes about grading challenges.
  - Narrative of the Design Problem (DP1)
- Convert the narrative into an outline
  - The "generic process guidelines" outline.
  - BUT, the narrative is "just telling" … and …

    "*Wisdom can't be told*", Gragg 1940 & Bransford *etal*. 1986.
    (more on this later)
- Modify the generic process for each specific problem.

Analyze expertise …

2) Framework for synthesizing and communicating results

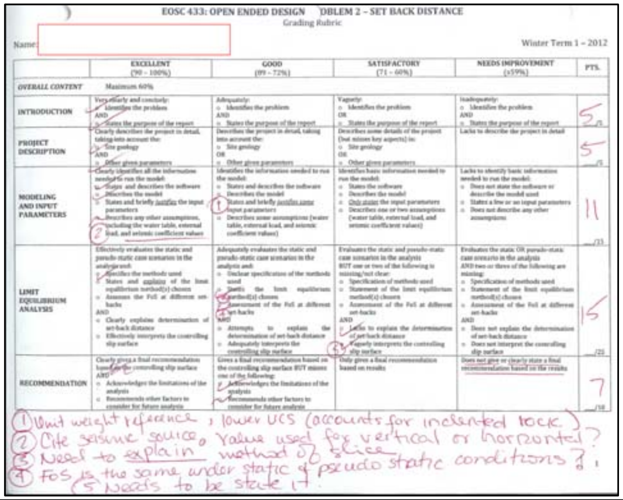
- TA collected comments provided on graded work
  - Seen earlier …
- Based on the "process-outline" for specific problems, define criteria for each process component.
- This became the rubric.
- Are rubrics an effective alternative for steering and assessing high-level skills – like engineering design?
  Eg. Woodhall 2008.

Compare "expertise" for your contexts with a neighbor How would you deconstruct expert tasks?

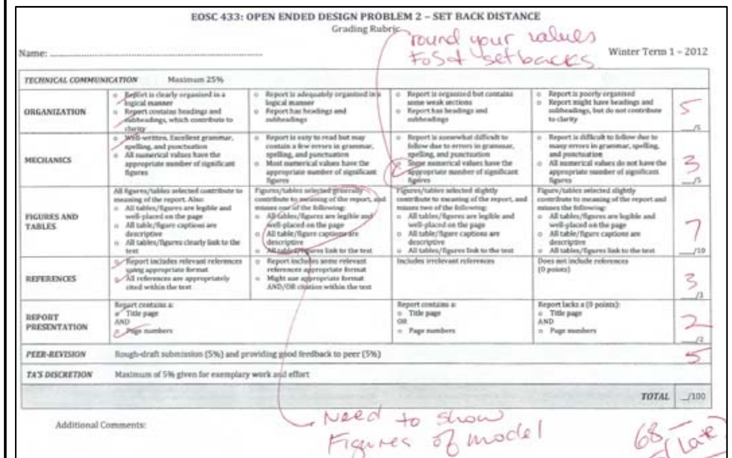
Step 2: Develop <u>tools</u> and <u>strategies</u> to foster design & reporting expertise

- A feedback and grading rubric
  - Similar to Hafner and Hafner, 2003 (for "oral presentation"; biology)
- Have students deliberately consider what might be involved.
  - A facilitated workshop run by the TA.
- Incorporate experts' procedures into the assignment.
- Assess work USING this procedure so feedback is targeted.
- Gradually withdraw this "scaffolding" in subsequent assigs.
- Do something very similar for the "expert" reporting process.
  - A second facilitated workshop.
  - Add a facilitated peer-review step.

Feedback and grading rubric. (pg 1 of 2)


EOSC 433: OPEN ENDED DESIGN PROBLEM 2 – SET BACK DISTANCE
Grading Rubric
Winter Term 1 – 2012

Feedback and grading rubric. (pg 2 of 2)


EOSC 433: OPEN ENDED DESIGN PROBLEM 2 – SET BACK DISTANCE
Grading Rubric
Winter Term 1 – 2012

Pros-cons of "complex" rubrics …

- Criteria ... but not prescriptions.
- Also – staged removal reduces dependence once.

Thoughts or local contexts?

- Rubrics for guidance / feedback / assessment of "high level" expert skills or knowledge?

Step 3: Instructional scaffolding of authentic tasks

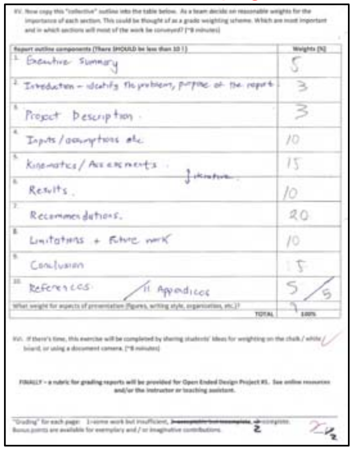
Wisdom can't be told …
Therefore cause students to confront challenging concepts.

Exercise 1 learning goals: Students will …

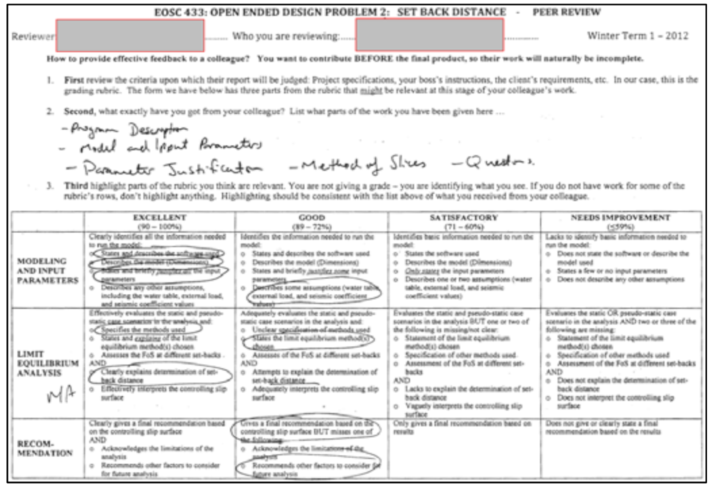
- Articulate / discuss steps necessary for carrying out a design project.
- Outline components and key aspects of a design project report.
- Discuss expectations for report sections and corresponding weightings in terms of importance.
  "Expectations" means answering "how will I know if my work is appropriate?"
- Build, then take home an outline for assignment 1 and report.

Worksheet establishing needs & criteria for tackling & reporting on open ended design projects

Two of four pages ...



A 2nd worksheet: Peer Review with rubric pg1 of 2



EOSC 433: OPEN ENDED DESIGN PROBLEM 2: SET BACK DISTANCE - PEER REVIEW

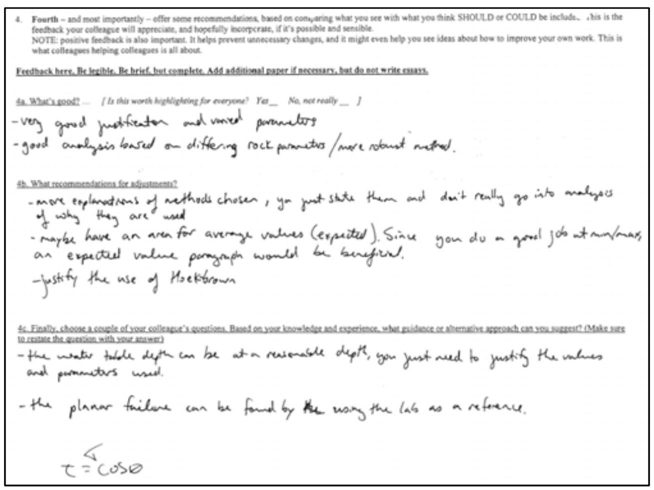
Reviewer [redacted] Who you are reviewing: [redacted] Winter Term 1 - 2012

How to provide effective feedback to a colleague? You want to contribute BEFORE the final product, so their work will naturally be incomplete.

1. First review the criteria upon which their report will be judged: Project specifications, your boss's instructions, the client's requirements, etc. In our case, this is the grading rubric. The form we have below has three parts from the rubric that might be relevant at this stage of your colleague's work.
2. Second, what exactly have you got from your colleague? List what parts of the work you have been given here ...
   - Program Description
   - Model and Input Parameters
   - Parameter Justification – Method of Slices – Question.
3. Third highlight parts of the rubric you think are relevant. You are not giving a grade – you are identifying what you see. If you do not have work for some of the rubric's rows, don't highlight anything. Highlighting should be consistent with the list above of what you received from your colleague.

	EXCELLENT (90 – 100%)	GOOD (89 – 72%)	SATISFACTORY (71 – 60%)	NEEDS IMPROVEMENT (≤59%)
MODELING AND INPUT PARAMETERS				
LIMIT EQUILIBRIUM ANALYSIS				
RECOM-MENDATION				

Peer review worksheet pg 2 of 2



4. Fourth – and most importantly – offer some recommendations, based on comparing what you see with what you think SHOULD or COULD be include. This is the feedback your colleague will appreciate, and hopefully incorporate, if it's possible and sensible. NOTE: positive feedback is also important. It helps prevent unnecessary changes, and it might even help you see ideas about how to improve your own work. This is what colleagues helping colleagues is all about.

Feedback here. Be legible. Be brief, but complete. Add additional paper if necessary, but do not write essays.

4a. What's good? [Is this worth highlighting for everyone? Yes__ No, not really__]

- very good justification and varied parameters
- good analysis based on differing rock parameters/more robust method.

4b. What recommendations for adjustments?

- more explanations of methods chosen, you just state them and don't really go into analysis of why they are used
- maybe have an area for average values (expected). Since you do a good job at min/max, an expected value paragraph would be beneficial.
- justify the use of Hoek-Brown

4c. Finally, choose a couple of your colleague's questions. Based on your knowledge and experience, what guidance or alternative approach can you suggest? (Make sure to restate the question with your answer)

- the water table depth can be at a reasonable depth, you just need to justify the values and parameters used.
- the planar failure can be found by the using the lab as a reference.

τ = cosθ

Do you or a neighbor deliberately address students' preconceptions about expertise?

"Step 4" …
Mentoring the graduate teaching assistant (TA): 1) Developing the activities …

- TA was the "expert" (engineer AND teacher/grader)
- STLF overlaid a pedagogic framework onto discipline expertise.
  - Expertise and frameworking
  - Task analysis
  - Active scaffolding to develop design and report writing expertise.
  - And scaffolding to develop expertise at giving and using peer review.
- STLF guided construction of resources to
  - A) support student learning without simply "telling".
  - B) develop 2 guided active-learning exercises for the TA to run. (not easy for beginners!)
  - C) ensure that resources will help future TAs run exercises then grade efficiently and consistently.

"Step 4" …
Mentoring the graduate teaching assistant (TA): 2) Developing TA *pedagogic* expertise …

- STLF ensured resources have a TA's version with guidelines for running the exercise
- Worked with the instructor to ensure
  - TA with experience AND enthusiasm was involved
  - Same TA piloted the exercises
  - AGAIN this TA mentored a new TA in a subsequent term.

How do you mentor and/or engage TAs in development and delivery?

Project "products":

Resources
- Generic process guidelines
- Specific design problem guidelines
- Rubrics for 4 design problems (as used during grading)
- An active exercise to explore the design process and reporting
- An active exercise to practice peer review.

Strategies
- Workshop and facilitating strategies
- Grading with rubrics
- Pair up new TA with experienced TA.

Non-engineering science course examples we have supported using similar strategies.

- Expert task analysis and scaffolding:
  - "Reading", "Questioning", presenting – one 2nd year course
  - Framework and corresponding exercises – 2nd, 3rd yr courses in mineralogy and ore deposits
  - Researching a topic and presenting – 3rd year science elective.
  - Field school: Explicit deconstruction of thinking that goes on during field mapping. **This was transformative** for field school instructors!
- Rubrics:
  - Honors thesis,
  - Posters including peer assessment – 2nd, 3rd and 4th yr courses, including a "virtual poster session" in a 4th year fisheries course.
- TA development and mentoring:
  - Four other projects were funded this way
  - We advocate for partnering new TAs with experienced TAs.

Results, or impacts of efforts.

Project evaluation challenges: Little data from before the initiative.

- Copies of student work not kept from past years.
- Grading <u>comments</u> were kept from 2011w.
- Grades? Commonly not a useful measure of innovation or impact.

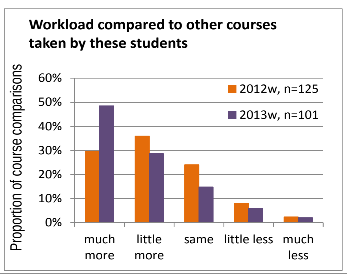
Artifacts from this project:

- Workshop activity worksheets, with documented strategies for Tas.
- Rubrics with TA feedback
- Peer review worksheets
- End of year survey in the first pilot year.
- Student Learning Experiences Survey (SLES) in all EOAS courses for 2013
- Workloads relative to other courses
- Enthusiasm relative to other courses
- Direct feedback from TA.

Students' workloads, 2012 & 2013

- *"Identify one other course you are taking this term _____."*
- *"Compared to that course, was your workload in our's …*
  - much more / a little more / similar / a little less / much less ?
- Repeat for up to four other courses …

Similar perceptions of workloads in 2012 and 2013



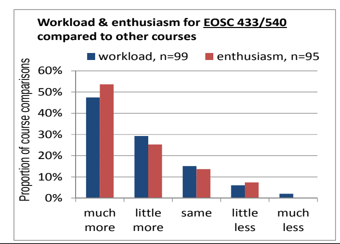
Workloads and Enthusiasm, 2013 only:

- Workloads – exactly as per 2012.
- Also …
  "Compared to that course, was your enthusiasm for our's
  - much more / a little more / similar / a little less / much less ?
- Repeat for up to four other courses …

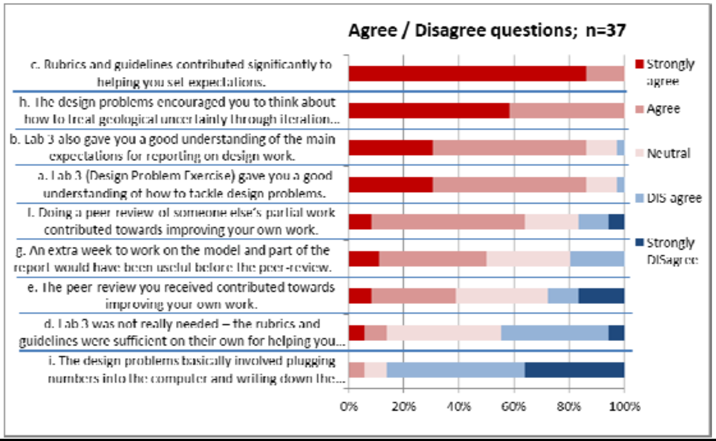
More work than other courses

AND

More enthusiasm for this course.

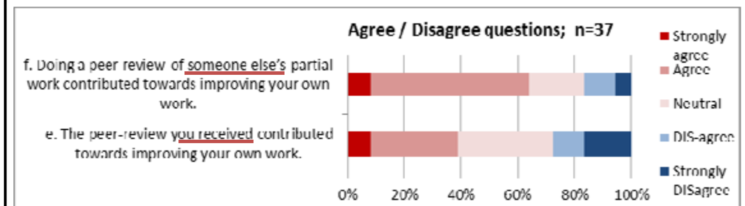


Perception questions 2012; - Sorted by "agree"



Peer review, 2012

- Generally well received but not as strongly "endorsed" as other aspects.
- Therefore … should we …
  - Improve relevance and motivation ?
  - Mitigate against "unhelpful" peer reviews ?



2013: Learning Experiences Survey highlights:

"How important was each of the following for helping you succeed in this course" … 40 items: information | classroom | homework.

- Examples: "Extremely or Very helpful" were …
  - Rubrics
  - Projects (solo and group)
  - Feedback (intermediate and final)
  - Studying in groups
- Also,
  - Learning goals, work done and content were all "clearly related"
  - This course was "important to me or my degree"
- These data can be shown if interested.

Does anyone here try to measure impacts of initiatives via perceptions of students or other ways?

TA – feedback

- Grading is more efficient and consistent (and "easier")
- Engaging with students feels more like "being a scientist" or "doing science" (or engineering).
- I learned a lot about how people learn !
- Recipient of the 2013 EOAS Teaching Assistant Award: *"To formally recognize the outstanding contribution of Teaching Assistants in the delivery of EOS undergraduate courses."*

Further questions and ideas

- "Transfer" of new skills has not been explicitly tested. Ideas:
  - Has capstone work of these students improved?
  - Explore further removal of scaffolding for the final design project.
  - Align exam work with scaffolded skills by using instructions that are either explicit, suggestive, or un-aided.
- Comprehensive comparison of before / after initiatives was not done. We applied previously "proven" Research Based Instructional Strategies (RBIS). i.e. our effort was not so much education "research" as development using best practices.

How applicable are ideas in your settings? How **sustainable** are such strategies?

- Deconstruction of expertise.
- Scaffolding – guidelines, rubrics, workshop strategies.
- Engaging TAs in the process.

Thank you – and thanks to organizers ☺

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13. AACU's collection called VALUE (Valid Assessment of Learning in Undergraduate Education) Rubrics: http://www.aacu.org/value/rubrics/index_p.cfm
14. Creating and Using Rubrics - Enhancing Education - Carnegie Mellon University: http://www.cmu.edu/teaching/assessment/assesslearning/rubrics.html
15. http://eos.ubc.ca/research/cwsei/ and http://cwsei.ubc.ca/
16. Search Amazon or Google for "rubrics" – there are many many resources and examples out there!