Template for developing activities to help learn a challenging concept

This summarizes results from the BC Earth Science Articulation Workshop, May 2011. After about an hour of interactive presentation and discussions, participants chose to gather in two groups of four or five in order to brain storm active ways of addressing challenging concepts. The following template was used:

1. **Pick a challenge**: _____
2. **Identify action-oriented learning goal(s)** using verbs that speak to the need for making student thinking visible, i.e. for assessing the thinking and providing useful and timely feedback. This will invariably require iteration.
3. **Outline an activity** using precedent-based ideas if possible; ideally what's been shown to be efficient and effective by your experience, by colleagues or from the literature.
4. **Specify means of measurement** (assessment)
5. **Feedback is a crucial** component. How will that be done? How will the feedback help students AND instructors modify their learning and grow during and beyond the activity? This might include grading, but not necessarily.

EXAMPLE 1: Thanks to M.L. Bevier. This is used regularly in a first year introductory solid Earth course.

- The challenge: Students do not seem able to apply knowledge of volcanic hazards to a particular local setting.
- Learning goal(s)
  - **Overarching course goal** (one of several): Apply geoscience knowledge to environmental, socio-economic, & political concerns.
  - **Goal for this exercise**: Students should be able to identify which type of volcanic hazard will cause the most serious damage at any given location near a volcano, and explain why.
- Active learning (precedent-based: ideally what's been shown to be efficient and effective.)
  - Basic content via readings, notes, & some lecture.
  - Question and images projected …
  - Discuss with peers (sometimes) ...
  - Complete on 3x5 cards (1-min. paper): *My friends should know that ____ is the most likely volcanic hazard from Mt Baker that might affect UBC because ____.*
- Measurement (assessment)
  - Participation marks + cards sampled to see student thinking.
- Feedback (might include grades, but not necessarily)
  - In the NEXT class: show histogram … or just state results.
  - Discuss maps of source, rivers, lahar volumes & transport, etc.
  - COULD: follow up with a similar question using a different setting or hazard.
- Undoubtedly you will have other ideas for implementing, measuring and giving feedback.

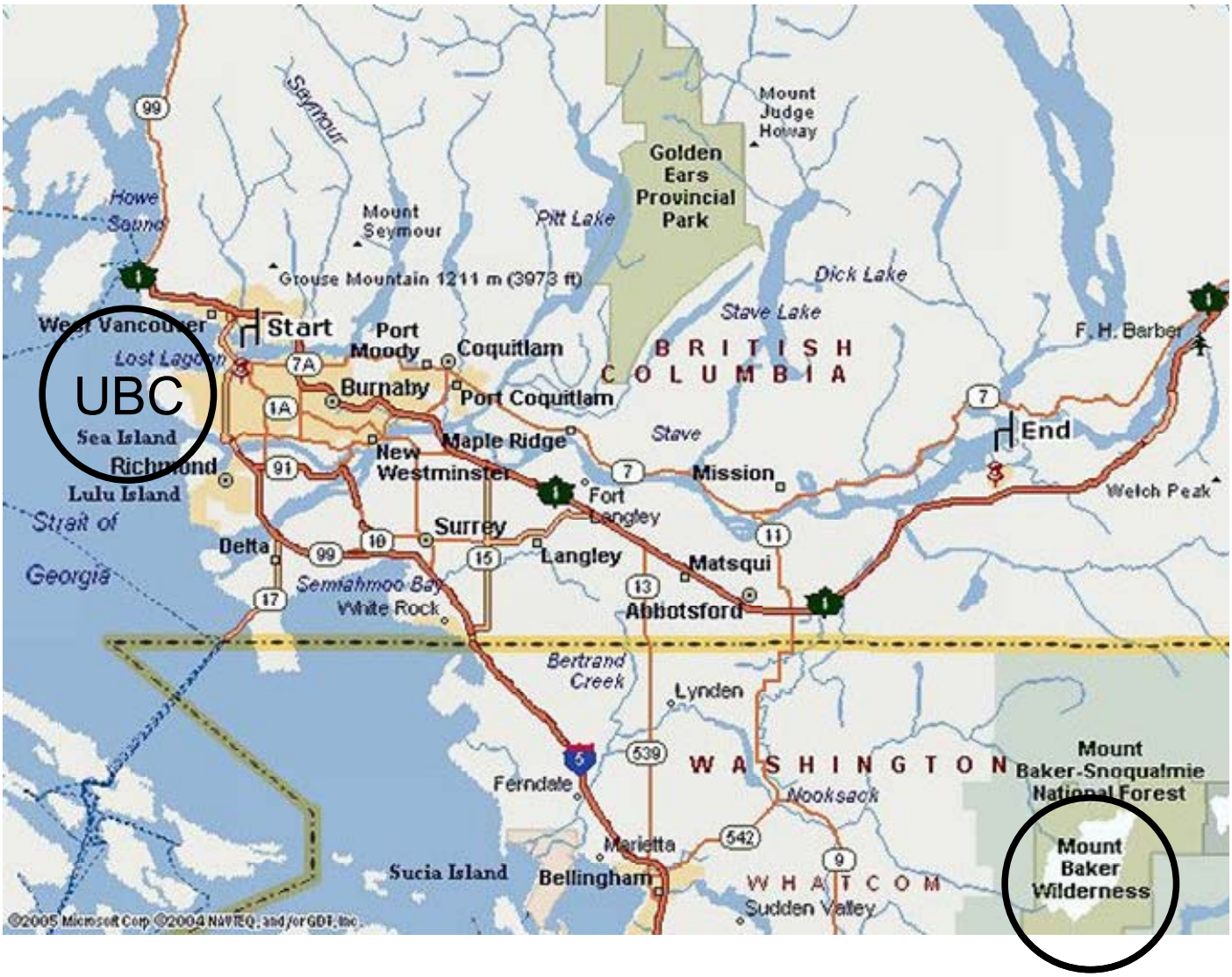
3X5 Card Exercise

Last name, First name
Student #12345678
Today's date

Write the question here.

Write your answer here.

↑ Mt Garibaldi



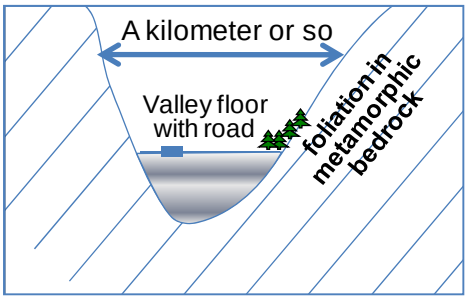
My friends should know that _____ is the most likely volcanic hazard that might affect us at UBC. This is because _____.

EXAMPLE 2: GROUP 1. Not tested – an idea only.

- The challenge: Students commonly have difficulty recognizing the distinction between lithosphere, crust and mantle.
- Learning goal(s)
  - Explain the difference between lithosphere and crust.
- Active learning (precedent-based: ideally what's been shown to be efficient and effective.)
  - Used after basic content (readings or lecture) about how density, temperature, physical state (and maybe P- &/or S velocity) vary as a function of depth between surface and core.
  - Probably worksheet based: probably best in pairs or groups. Two options: 1) given graphs of property versus depth presented side by side, or 2) given adjacent "pie" figures showing variations of properties versus depth …
  - 1) What is the best way to use the data provided to classify zones inside the Earth? 2) Sketch lines through graphs (or "pie slices") to indicate boundaries between your zones. 3) list zones and identify characteristics you used to classify each zone as different from its neighbors.
- Measurement (assessment)
  - Worksheets should need no other "marking" other than seeing boundaries marked and the list of characteristics. This could be "participation" style marking, or a more or less complicated rubric could be developed.
  - Rubric (if desired) could be based on the number of zones, locations of zones, and the lists of characteristics used to distinguish between zones. Rubric complexity will depend upon your willingness not look at all the work delivered in worksheets, which depends on class size, marking support (teaching assistants), the importance of the concept etc.
- Feedback (might include grades, but not necessarily) Ideas include:
  - Have several groups sketch their decisions on the chalk (white) board.
  - Display work of several groups using a document projector.
  - Use a clicker (or 'hands-up') question to ask "How many zones did you define? 2,3,4, 5 or 6". (You might want to modify this after trying it once because students might choose more than 6 zones.)
  - Call on groups to identify zones using a laser pointer that is passed around the class.
  - After reviewing all (or a few) worksheets, show range of results in the subsequent class and discuss pros/cons of most common options.
  - Incorporate "real" data (eg seismic tomography over continental & ocean crust) in follow up discussions in the subsequent class.
- Undoubtedly you will have other ideas for implementing, measuring and giving feedback in your particular setting.

EXAMPLE 3: GROUP 2. Not tested – ideas only.

- The challenge: students have trouble distinguishing between cleavage vs fracture, and mineral cleavage/fracture vs rock fracture. We found this had to be broken down into component parts. NOTE: this commonly happens when you start "deconstructing" a particular misconception or challenging concept.
- Learning goals
  - #1 In minerals, distinguish between cleavage; crystal faces; and fracture.
  - #2 Distinguish between cleavage or fracture in minerals versus planar fracture (sometimes called rock cleavage) in rocks.
- Activity for learning goal (LG) #1
  - 1) Groups: given hand samples of feldspar, identify and describe surfaces that are planar due to breakage along planes, and surfaces that broke irregularly (i.e are not planar).
  - In class, groups' "reporter" gives results. In lab or class, a sketch-and-label worksheet could be used.
  - 2) groups are given a mica book. Task is to identify and explain the distinction between crystal planes and cleavage plane.
  - Same reporting options as part (1)
- Active learning for LG #2
  - Introduction (after a reading, or lecture delivery of concepts): Describe a diagram like the one here. It could be useful to have hand samples of foliated metamorphic rock samples (in class or from a previous lab).
  - Could be groups/whole class, clicker question, worksheet … Given this V-valley, where would you put the "Rock Fall" warning sign "Previde da crappa", which in the Romansch language (Switzerland) means "Watch for falling rock"?



- Measurement – an assessment in a follow up setting, not of the actual activity itself:
  - Re. LG #1: More examples using images or samples (class / quiz / lab). Eg calcite rhomb, dogtooth spar, singly terminated quartz crystals with one fractured end; others. Could be part of oral lab exam.
  - Or – if worksheets used, check of work (participation only) or use rubric designed based on worksheet.
- Feedback (might include grades, but not necessarily)
  - In "real time", discussion that follows up this exercise could be instructor driven, but better students discussing and responding to questions (clickers, more worksheet questions, handsup, "cold calling" by group name or individuals …) such as How would the engineers make the necessary observations to make this decision? What should they look for? Etc.
  - Or show sampled work in subsequent class.
- Follow-up:
  - Consider relating this to aligned cleavages of mica grains within the foliated, metamorphic rocks.
  - Instructor – discuss applications of cleavage and strength versus direction (landslides, tunneling etc).
  - Extension towards jointing and relationship to tectonics, rock types etc.

Some resources that may help when introducing active components into geosciences classes

Goals & assessment

- Simon, B., and J. Taylor. 2009. "What is the Value of Course-Specific Learning Goals?" Journal of College Science Teaching 39 (2): 6. http://www.cwsei.ubc.ca/SEI_research/files/Life%20Sci/Simon_Taylor_ValueOfCourseSpecificLG.pdf
- http://www.cwsei.ubc.ca/resources/learn_goals.htm
- G. Gibbs and C. Simpson, "Conditions Under Which Assessment Supports Student Learning," Learning and Teaching in Higher Education, V. 1, pp. 3-31, (2004). 2-pg summary; complete article.
- "Course Goals/Syllabus Database" with 88 courses and examples of goals: This is one of many excellent resources in the NAGT/DLESE On the Cutting Edge project. http://serc.carleton.edu/NAGTWorkshops/tools/syllabus.html

Ideas: analogies, activities, demonstrations, etc.

- ****On the Cutting Edge**; search for geosciences Activities (1445), Assessments (49), Course Information (379), Datasets and Tools (86), Audio/Visual (109), Computer Applications (20), Pedagogic Resources (47), Scientific Resources (3) … http://serc.carleton.edu/NAGTWorkshops/search.html
- **On the Cutting Edge**; The NAGT On the Cutting Edge project helps geoscience teaching faculty stay up-to-date via a series of workshops and websites, providing professional development opportunities, resources, and collegial interaction opportunities for who are interested in improving their teaching. http://serc.carleton.edu/NAGTWorkshops/index.html
- **The Digital Library for Earth System Education** (DLESE) at http://www.dlese.org/library/index.jsp is an extensive collection of resources operated by the National Center for Atmospheric Research (NCAR) with National Science Foundation funding. It takes a bit of getting used to, but it is well worth a hour or so of exploring if you have a specific area of interest.
- "PheTs" – http://phet.colorado.edu/ - explore all this, especially the "for teachers" link. Start by click on the "Simulations" menu item.
- Francek, M. A., and Winstanley, J. D. W., 2004, Using food to demonstrate earth science concepts: a review: Journal of Geoscience Education, v. 52, p. 154-160.
- Jee, B. D, D. H Uttal, D. Gentner, C. Manduca, T. F Shipley, B. Tikoff, C. J Ormand, and B. Sageman. 2010. "Commentary: Analogical Thinking in Geoscience Education." Journal of Geoscience Education 58 (1): 2–13.
- Roth, Wolff-Michael, Campbell J. McRobbie, Keith B. Lucas, and Sylvie Boutonn. 1997. "Why may students fail to learn from demonstrations? A social practice perspective on learning in physics." Journal of Research in Science Teaching 34 (5) (May): 509-533.
- Clickers! See http://www.cwsei.ubc.ca/resources/clickers.htm & http://www.cwsei.ubc.ca/resources/SEI_video.html
- 50 Classroom Assessment Techniques: http://pages.uoregon.edu/tep/resources/newteach/fifty_cats.pdf or find the book "*Classroom assessment techniques: a handbook for college teachers"* by T.A. Angelo, K. Patricia Cross.

General starting points for background resources

- CWSEI resource page with sub-headings: Instructor Guidance, Student Guidance, Clickers, Video, Learning Goals, Workshops, Papers, Other Resources. See http://www.cwsei.ubc.ca/resources/index.html.
- EOS-SEI resource page with 28 tips and background about learning and teaching. Most are 2 pages. http://www.eos.ubc.ca/research/cwsei/resources.html
- "Learn BEFORE Lecture" - Moravec, M., A. Williams, N. Aguilar-Roca, and D. K O'Dowd. 2010. "Learn before Lecture: A Strategy That Improves Learning Outcomes in a Large Introductory Biology Class." Life Sciences Education 9 (4) 473
- Eric Mazur and peer instruction:
  - Catherine H. Crouch and Eric Mazur, *Peer Instruction: Ten years of experience and results*, American Journal of Physics -September 2001- Volume 69, Issue 9, pp. 970
  - Mazur Physics education at http://mazur-www.harvard.edu/education/educationmenu.php
- Carl Wieman talk: Science Education Based on the Data. Video - April 2009 (Courtesy of Harvard University, http://www.cfa.harvard.edu/sed/events.html or http://www.cwsei.ubc.ca/resources/other.htm#Talks .