Innovations and Assessment in the College Science Classroom

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To improve our classrooms, we:

- changed our classes from a lab-lecture format to a studio classroom
- meet in longer blocks of time
- spend most class time on cooperative/collaborative learning
- have our students get involved in original scientific investigations
- cover a smaller number of topics in greater depth
- de-emphasize knowledge-based learning
- emphasize development of comprehension, application, analysis, synthesis, evaluation and other skills
- help our students develop good habits of the mind and fundamental skills useful for lifelong learning

Some instructors have collected data showing that a studio/collaborative classroom promotes better learning, (including problem solving skills and understanding of key principles), improved student attitudes and better performance on exams. While documenting student attitudes and grades is not difficult, it is extremely difficult to make objective comparisons of learning outcomes between classes taught as a studio class, and those taught in a more traditional manner. If only the format of the class is different, comparison of exam and project grades, and use of traditional assessments would be adequate to evaluate improvements in student learning. Unfortunately, a completely redesigned class with new goals cannot be evaluated as it was done in the past.

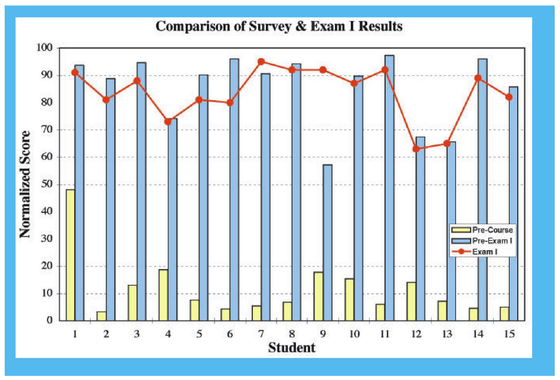
The big question is:

How can we tell if we have been successful*?*

To try to answer this question, we used a number of different approaches to assessment.

A Battery of Assessment Methods

instrument/method	purpose
•Pre-exam, before-exam, and after-exam ***Knowledge Surveys***	•to assess student mastery of course material
•**Bloom's Surveys** (students describe what they learn in terms of Bloom's taxonomy)	•to evaluate the kind of learning that occurred
•***SGIDs***: weekly formative assessments (once a week, students discussed the class with the teaching consultant in the instructor's absence)	•to give students a sense of ownership of the class to determine what was working •to adjust and fine-tune as needed
•pre- and post-course learning ***Attitudes Surveys***	•to evaluate changes in student attitudes toward learning
•teaching journal kept by instructor (entries 1-4 times a week while preparing for the class and also while it took place)	•to encourage introspection, to permit me to go back and assess what issues I dealt with and when
•post-class student interviews (several small groups)	•to expand on some ideas and concerns
•student performance on projects, quizzes, and exams	•to measure learning and progress toward class goals



Histogram plot of pre-course and pre-exam knowledge survey and first mid-term exam results for students (n = 15) in the Macalester College Dynamic Earth and Global Change course.

Knowledge Surveys
Main Survey Instructions

This is a knowledge survey, not a test. The purposes of this survey are to (1) provide a study guide that discloses the organization, content and levels of thinking expected in this course and (2) help you monitor your own growth as you proceed through the term. In this knowledge survey, don't actually try to answer any of the questions provided. Instead rate (on a three-point scale) your confidence to answer the questions with your present knowledge. Read each question and then click the radio button {(a), (b), or (c)}corresponding to the response that best describes your confidence level in accord with the following instructions:

Mark (a) "Could answer now" as your response if you feel confident that you can answer the question sufficiently well for graded test purposes.

Mark (b) "Could quickly find answer" as your response if you can now answer at least 50% of it or if you know precisely where you could quickly get the information needed and could return here within 20 minutes to provide a complete answer for graded test purposes.

Mark (c) "Could not answer" as your response if you are not confident that you could adequately answer the question for graded test purposes at this time.

Do your best to provide a totally honest assessment of your present knowledge. When you mark (a) or (b), this states that you have significant background to address an item.

Your instructor may have you demonstrate your level of mastery by actually answering any of the questions on this survey; this demonstration might take place as part of a test or at some other occasion.

The survey will be given twice during the semester. Refer to this survey to monitor your increasing mastery of the material through the semester.

Some Sample Questions

40. What are the chemical formulae for: talc, calcite, gypsum, apatite.

41. All minerals that form crystals in the cubic system appear isotropic when viewed under crossed polarizers. How do we determine they are isotropic? Why are "cubic" minerals isotropic?

42. In general, high density minerals have high refractive indices compared to low density minerals. Why?

43. We can classify minerals as istotropic, uniaxial or biaxial. How does this relate to the crystal systems of the minerals (cubic, tetragonal, orthorhombic, hexagonal, monoclinic, triclinic). Explain the relationship.

44. Why might you expect network (= framework) silicates to have low birefringence?

45. What causes birefringence? Why do some minerals have greater birefringence than others? Some minerals display no birefringence. What do we call such minerals; and what do they have in common? Explain why they have no birefringence.

46. Explain what we mean when we talk about constructive or destructive "interference" of light rays (or of X-rays)?

47. Some minerals have optic axes. What are optic axes? How many can a mineral have? What sorts of minerals have none?

48. What causes minerals to exhibit interference colors? In other words, what is the "physics" behind their formation?

49. What are interference colors? Under what circumstances do we see them?

50. Some minerals appear isotropic when viewed with an optical microscope. Others are anisotropic. What do the terms isotropic and anisotropic mean?

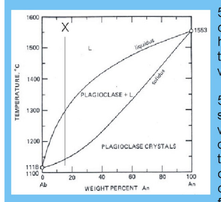
51. Quartz, feldspars, zeolites and other network silicates appear somewhat similar when viewed with a petrographic microscope. One property they share is that they all have low birefringence. How do we see birefringence?

52. Name a mineral that often exhibits polysynthetic twinning in thin section?

53. When we say a mineral has "high relief" in thin section - what do we mean?

55. A few years ago the UND Plant Services came to put in some new computer wiring but spotted what they thought was asbestos and refused to do the work. I looked at it quickly using a petrographic microscope and assured them that it was fiber glass. (They didn't believe me and spent lots of money sending a sample out for analysis, but I was correct.) What property distinguishes asbestos from glass fibers (fiberglass) when they are viewed using a petrologic microscope?

54. Here is a phase diagram that describes the crystallization of plagioclase feldspar. Describe



54. Here is a phase diagram that describes the crystallization of plagioclase feldspar. Describe what happens as a magma of composition X cools. At what temperatures will it begin to crystallize? At what temperature will it be completely solid? What happens in between?

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Best method for evaluating content mastery

Higher-order learning?

Outstanding midterm formative feedback

What Sort of Learning is Taking Place?

Bloom et al. (1956) classify learning into six categories, summarized below. Students were asked to estimate how much time they thought the class will/did devote to each of the six general categories, using this scale:

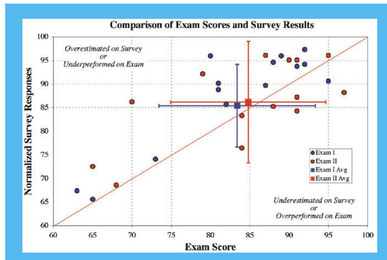
1=almost none 2= minor focus 3= some of the time 4=major focus 5=almost all of class

Before the students completed this survey, we took about 15 minutes to discuss learning and Bloom's Taxonomy. The survey was conducted during the first class meeting and then again at the end of the semester. Before and after responses are separated by an arrow.

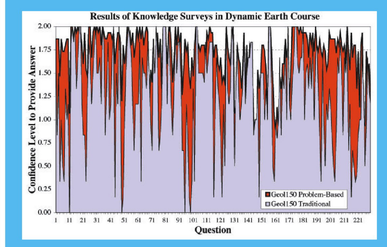
Competence	Skills Demonstrated
Knowledge 4.2 => 2.9	•observation and recall of information •knowledge of dates, events, places •knowledge of major ideas •mastery of subject matter
Comprehension 2.8 => 3.9	•understanding information •grasp meaning •translate knowledge into new context •interpret facts, compare, contrast •order, group, infer causes •predict consequences
Application 2.2 => 4.2	•use information •use methods, concepts, theories in new situations •solve problems using required skills or knowledge
Analysis 1.9 => 2.2	•seeing patterns •organization of parts •recognition of hidden meanings •identification of components
Synthesis 1.9 => 2.4	•use old ideas to create new ones •generalize from given facts •relate knowledge from several areas •predict, draw conclusions
Evaluation 1.6 => 3.4	•compare and discriminate between ideas •assess value of theories, presentations •make choices based on reasoned argument •verify value of evidence •recognize subjectivity

Boom's Survey and Attitudes Assessment for Mineralogy (Geo 318) at the University of North Dakota in Spring 2004 (n=22)

Learning attitudes & skills



Plot of exam scores (midterm exams I and II) versus normalized survey results for students in the Dynamic Earth and Global Change course (circles). Also shown are class averages for each survey and exam (square symbols).



PComparison of post-course knowledge survey results from two different sections of the Dynamic Earth and Global Change course. One section (n = 15) utilized problem-based and collaborative learning approaches, and the other section (n = 10) utilized a traditional lecture-based approach. Each section of the course had its own instructor, but both sections used the same textbook and had the same instructor and exercises in laboratory sessions. The results suggest that student learning gains in the problem-based and collaborative learning course were similar to, or slightly greater than, those in the traditional lecture section.

Small Group Instructional Diagnosis

A Method for Getting Student Feedback on a Class in Progress

Who can profit from an SGID?

Anyone teaching a class may learn a great deal about their teaching, students and classroom through the SGID process. This includes faculty, part-time instructors, and GTAs.

Who conducts the process?

All SGIDs are conducted by volunteer SGID consultants– faculty members who receive special training in how to conduct instructor and student interviews according to the established SGID process.

How does the process work?

1. A few days before the scheduled time, the instructor and consultant meet to discuss the course and determine what questions the instructor would like to see addressed in the interviews.

2. On the day of the scheduled class visit, the consultant meets with the class, in the absence of the instructor, for about 30 minutes. The consultant directs students to form small groups, select a leader, and come to consensus on answers to three questions. Although the questions may vary in form, they always focus on strengths in the class, areas for change, and ways of making suggested changes. (If an instructor wants to focus feedback on specific aspects of the class, he/she may choose additional questions designed to obtain information on those aspects.)

3. Soon after the class, instructor and consultant meet again to review the process. The consultant provides a written summary of student comments for the instructor, and together they review and interpret these comments.

4. When the instructor next meets the class, he/she takes a few minutes to respond to the student comments and discuss questions and issues that arose in the SGID.

How is an SGID report used?

Because the SGID is a confidential report designed to give formative feedback to the instructor, no one besides the instructor sees it. No copy of the report is kept in any file. (While consultants file a final report to indicate that an SGID was completed, the instructor's name does not appear with this record-keeping data.)

The SGID is definitely not to be used as an instrument to evaluate teaching. Although an instructor may choose to refer to or quote from an SGID report in a teaching portfolio, to explain how he or she responds to student feedback, the report itself should not be included. The reason for this is to help insure that the SGID process remains confidential and that the results of the process are used only by the instructor, for the purpose of improving teaching and learning in the class.

What are the benefits of an SGID?

Student and instructor response to the SGID process has been outstanding. Students appreciate the midterm timing, which provides opportunity for changes to affect them. Instructors value the personal interaction and supportive interpretation by a consultant/colleague, as well as the concrete student input in a form which facilitates its use by the instructor.

Attitudes Assessment

Question #	Statement	Likert Response before	Likert Response after
1	I like to read textbooks.	4.5	4.5
2	**I learn a great deal by reading textbooks.**	**3.5**	**4.3**
3	I feel more comfortable about what I am learning when I have a textbook to read.	3.1	3.3
4	Often, I learn a lot from answering questions at the end of chapters.	4.1	4.3
5	**I prefer to read a textbook before a topic is discussed in class.**	**3.9**	**4.9**
6	**I enjoy working in a group to solve problems and do assignments.**	**2.3**	**1.8**
7	**I understand material better and learn more when I work with someone else to solve problems and do assignments.**	**2.4**	**1.7**
8	A serious problem with group projects is that some people do most of the work while others get a "free ride."	3.4	3.1
9	I feel comfortable asking questions during class.	2.8	2.9
10	I learn more when I hear another students viewpoint.	2.7	2.4
11	**I am comfortable discussing things with other students in the class.**	**2.4**	**1.8**
12	My participation contributes to what I learn in a class.	2.9	2.6
13	The methods others use to work problems may be different than mine.	2.2	2.3
14	**I learn more by listening to a lecture than I do by doing projects or working problems.**	**4.1**	**5.4**
15	In general laboratory activities involving rocks and microscopes, etc., are better learning activities than paper or pencil in-class activities.	3.1	3.0
16	**Term papers and other individual projects often contribute significantly to my learning.**	**3.6**	**4.1**
17	Although having students give presentations in class may help develop speaking skills, it is NOT an efficient use of class time.	3.1	3.1
18	Giving class presentations is a good way for the speaker to learn things.	2.2	2.3
19	Having students give class presentations is a good way for the listeners to learn things.	5.5	5.3
20	**Having separate lab and lecture meeting times helps improve learning.**	**2.9**	**3.6**
21	I learn more in classes if they meet more than two times a week compared to classes that meet less often but for longer times.	3.8	4.0
22	**It is important that I am present every time a class meets.**	**3.4**	**2.7**
23	I learn best if a course lasts a whole semester instead of being focused in a shorter time period.	3.6	3.4
24	**The teacher's job is to present the material. Its my job to**	**4.6**	**5.1**