# IUT 2009 Workshop:

# Closing the Loop: Connecting learning goals to assessment.

## Workshop Learning Goals

After this workshop you should be able to …

- Use guidelines provided to justify & construct learning goals.
- Apply a three-part framework to build assessments that explicitly target goals.
- Discuss implementation of assessment and feedback.
- Constructively critique your (and peers') goals & assessments.

## Acknowledgements

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- Carl Wieman and Sarah Gilbert of the Carl Wieman Science Education Initiative (CWSEI, at http://www.cwsei.ubc.ca/) who developed the original 2-day version of this workshop.
- Science Teaching & Learning Fellows associated with the CWSEI.
- Past workshop participants.
- IUT and the Conference organizers.

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Remaining pages contain some information we will refer to.

## 1. Check-list for creating Topic-Level learning goals:

1. Does each goal use a verb that clearly identifies what students will be able to DO?
2. Is terminology familiar/common? If not, is terminology a goal?
3. Is each goal unique and independent?
4. Are relevant contexts clear?
5. Is the goal's implied Bloom's Taxonomy level aligned with your expectations for students' learning?
    a. Eg: if you expect reasoning for "why", does the goal convey that?
    b. Could you expect a higher level goal?
6. Is expected student performance evident?
7. Is it clear how achievement would be tested?
8. Are all the goals for this course visible? In other words, there should be no "hidden" goals.

**Not every goal can achieve the following, but it is better if …**

9. It is clearly relevant and useful to students. E.g. is the goal connected to their everyday life, or does it represent a useful application of ideas?

## 2. Assessments That Support Student Learning

(This is a two-page summary of *Key points and factors from the review paper "Conditions Under Which Assessment Supports Student Learning,"* by G. Gibbs and C. Simpson[1,] From the Carl Wieman Science Education Initiative at http://www.cwsei.ubc.ca/resources/instructor_guidance.htm).

**Key points** (extensive references to data supporting all these points are listed in the original article.)

*From the students' point of view:*

- What is tested in a course dominates what students think is important and what they do.
- Effective feedback is *the* most powerful single element for achieving learning. Feedback that is not attached to marks can be highly effective.
- Students who focus on picking up cues as to what will be on exams and study accordingly do much better than those who do not. Students often realize this form of studying is not the same as studying to master (i.e. understand and apply) the course material.
- Students prefer courses with a significant marked assignment component, feeling that such courses provide them with more practice and feedback, and the assessment is fairer.

*Marked assignments versus exams:*

- Much assessment fails to engage students with appropriate types of learning.
- Exam scores correlate very weakly with post graduate performance. Scores on marked assignments are better predictors than exams of long term learning retention.
- When assignments are a significant fraction of the course mark, the failure rates are 1/3 what they are when course mark is based solely on exam scores. Students also study and learn in more naïve ways when mark is based solely on exams. Although not in Ref. 1, there are techniques to minimize cheating on such marked assignments.[2]

**Factors that make assessments contribute to learning** (and are frequently neglected)

1. Assigned and assessed tasks that:
   - are focused on the most important aspects of the course (tied to learning goals),
   - require extended time to complete,
   - are given frequently,
   - engage students in appropriate forms of study/effort.

2. Students need to have a clear concept of the assigned task and of learning in the discipline. The criteria for setting the mark on the assignment needs to be explicit and understood by the student.

3. The single most important element of assessment supporting learning is the frequency and type of the feedback provided with the assessment. Feedback that supports learning:
   - is frequent and sufficiently timely to the task so that it still matters to the student
   - focuses on student performance and learning, rather than student characteristics
   - is specific and detailed, addresses small chunks of material, and provides guidance for future efforts
   - matches the purpose of the assignment and encourages the student to improve
   - is supported by mechanisms that require the student to attend to and act upon the feedback

**Implementing good assessment and feedback without spending excessive time marking**

It is particularly challenging to have frequent assignments and timely feedback in large-enrollment classes. Below are a few examples of ways to do this.

Online, computer graded homework. There are numerous systems for this. (Instructor needs to generate or find source of good multiple-choice questions, many systems provide these.)[3]

- Problem-solving sessions associated with quizzes or homework. This could be informal (groups of students voluntarily get together to work on problems with or without TA or instructor present) or formal (tutorial, recitation, workshop with TA and/or instructor using Socratic approach).
- Peer Instruction:[4] during class pose questions, student discussions about which answer is correct, vote on answer, instructor does short lecture on which answer is correct & why. Works in large lecture halls (This moves the feedback part into the classroom and shares it between students and instructor. Some coverage of material is moved from lecture to assigned reading.)
- Regular in-class group exercises done in stages that include partial deliverables (sketches, lists, worksheet answers, etc) which are discussed in class. Simply working in groups provides "instant" peer feedback (as above), and the whole class benefits from feedback that results from the instructor-led discussions at intermediate stages of the exercise.
- Just-In-Time Teaching:[5] Web-based assignments due a short time before class, followed by discussion/lecture focusing on areas of student difficulty (often involves adjustment of teaching based on responses, for large classes, instructors usually go through a subset of the responses). Can also be implemented as quiz at start of class with electronically collected responses.
- Have some long-answer or essay-type questions on assignments, but only grade some of these (important to be clear to students that they will get some credit on a problem for turning something in, and a subset of those problems will be graded for marks – students won't know in advance which questions will be graded)
- Have multistage assignments with feedback in the middle that students need to use to complete assignment (way to get students to act on feedback)
- Peer assessment (important for instructor to provide good marking rubric). Imperfect feedback from a fellow student provided almost immediately can have much more impact than more perfect feedback from an expert many weeks later. Students learn a lot by *doing* peer assessments – particularly when done as a group activity.[6]
- Self assessment or reflection assignments (e.g. have students grade own work using a rubric created by instructor, or have students go over a problem from previous assignment that they got wrong and explain what they did, and why it was not the correct approach.)

**The bottom line?**

Teaching students to monitor their own performance should be the ultimate goal of feedback.[1] Continuous support for improving these skills will help students transfer learning to new situations and become effective lifelong learners.

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[1] G. Gibbs and C. Simpson, "Conditions Under Which Assessment Supports Student Learning," Learning and Teaching in Higher Education, V. 1, pp. 3-31, (2004), http://resources.glos.ac.uk/shareddata/dms/2B70988BBCD42A03949CB4F3CB78A516.pdf

[2] Effective techniques are designing assignments to be of obvious benefit to the learning of the student, have substantial overlap with the exams, and have some portions of the assignment that involve "explaining in your own words".

[3] S. Bonham, "Reliability, compliance, and security in web-based course assessments," Physical Review Special Topics - Physics Education Research V. 4, paper 010106 (2008).

[4] C. Crouch and E. Mazur, "Peer Instruction: Ten years of experience and results," American Journal of Physics, V. 69, pp. 970-977 (2001).

[5] See: http://jittdl.physics.iupui.edu/jitt/

[6] K. Topping - Review of Educational Research, V. 68, No. 3, 249-276 (1998), http://rer.sagepub.com/cgi/content/abstract/68/3/249

# 3. Formative Assessment Questions & Learning Domains

This page introduces the single most important aspect of using goals – how to think when developing assessments that are intended primarily to enhance learning, rather than merely evaluate it. Such assessments, called "formative assessments", are extremely effective instructional tools.

For guidance on developing assessment questions, we recommend reading the article entitled "*Designing Effective Questions for Classroom Response System Teaching*", by Ian D. Beatty, William J. Gerace, William J. Leonard, and Robert J. Dufresne, American Journal of Physics, V.74 (1), 2006 (see http://srri.umass.edu/files/beatty-2006deq.pdf). Many of their points are summarized here.

There are three different kinds of pedagogic goals which you may try to accomplish in any given assessment question.

1. Content: Does the question test an essential aspect of the material? Always keep the learning goal in mind.

Are you testing Conceptual Understanding or Retention of Facts?
Be aware of what you are testing. Questions that test retention of facts or vocabulary may not test conceptual understanding. A question may appear conceptual to you because you are familiar with the vocabulary involved. Are your students? Will they be hung up on a word they don't know, spending time trying to figure out what it means? Here is an example:

Q: A gas is compressed and its temperature rises. Could this be an adiabatic process?

This question may be testing students' memory of the word adiabatic. If students know what adiabatic means, the question may test their ability to apply concepts. If students get this question wrong, the teacher may not be able to determine why and will be uninformed about how to adjust teaching to address the problem.

2. Cognition: How do students use the content to arrive at the answer? What are the cognitive processes involved? Are they comparing and contrasting phenomena, ranking, classifying, or performing a mathematical manipulation?

Q: If x = 1.63, what is $x^2$ ?

This question requires more than one cognitive process. Students must be able to both understand how to square a number, and how to multiply numbers with decimals (1.63 * 1.63) without error. If the cognitive process of interest is squaring numbers, the multiplication process should be simplified.

3. Metacognition:
- What does it means to learn or "do" this subject (chemistry, geology, physiology, computer science, etc.)?
- Is this subject pursued through classifying and categorizing material, relating mathematical descriptions to physical phenomena, creating a logical flow for a computer program, ...?
- How important are mathematical details?
- Is this material mastered through remembering factual content, or does the subject need to be examined from different perspectives to be understood?

## 4. A few references and information we have found useful.

1. The Carl Wieman Science Education Initiative at UBC (CWSEI) http://www.cwsei.ubc.ca/resources/index.html
2. The Earth and Ocean Sciences Science Education Initiative (EOS-SEI) http://www.eos.ubc.ca/research/cwsei/
3. Good examples of learning goals developed by departments involved in the Science Education Initiatives at both University of British Columbia and Colorado University. http://www.cwsei.ubc.ca/resources/files/Learning_Goals_at_UBC_and_CU%205-08.pdf
4. *On the Cutting Edge* workshop on effective and innovative course design: http://serc.carleton.edu/NAGTWorkshops/coursedesign/index.html
5. "Course Goals/Syllabus Database" consisting of 88 courses with examples of goals: http://serc.carleton.edu/NAGTWorkshops/tools/syllabus.html This is one of many excellent resources in the NAGT/DLESE **On the Cutting Edge** project.
6. Gronlund, N., (2004). *Writing Instructional Objectives for Teaching and Assessment (7th ed)*. Upper Saddle River: Pearson/Merrill/Prentice Hall. (There is now an 8th edition.)
7. 50 CATs - Classroom Assessment Techniques: "Classroom Assessment Techniques: A Handbook for College Teachers: Amazon.ca: Thomas A. Angelo, K. Patricia Cross: Books,"; search "Angelo and Cross" at amazon.com. Or Google "Angelo and Cross" for related web resources.
8. Two resources about goals and assessments at "Teambasedlearning.org":
   a. Writing well constructed learning objective http://teambasedlearning.apsc.ubc.ca/?page_id=653
   b. Writing Multiple Choice Questions: http://teambasedlearning.apsc.ubc.ca/?page_id=163

| **Bloom's taxonomy of the cognitive domain**[1] | |
|---|---|
| **Cognitive Level** *(typical verbs in italics)* | |
| 1. Factual Knowledge: remember and recall factual information<br>*Define, List, State, Label, Name, Describe* | Lower level thinking (often achieved through memorization/recall, especially Level 1) |
| 2. Comprehension: demonstrate understanding of ideas, concepts<br>*Describe, Explain, Summarize, Interpret, Illustrate* | |
| 3. Application: apply comprehension to unfamiliar situations<br>*Apply, Demonstrate, Use, Compute, Solve, Predict, Construct, Modify* | Higher level thinking (require deeper conceptual understanding). |
| 4. Analysis: break down concepts into parts<br>*Compare, Contrast, Categorize, Distinguish, Identify, Infer* | |
| 5. Synthesis: transform, combine ideas to create something new<br>*Develop, Create, Propose, Formulate, Design, Invent* | |
| 6. Evaluation: think critically about and defend a position<br>*Judge, Appraise, Recommend, Justify, Defend, Criticize, Evaluate* | |

Be sure to Google "Bloom's Taxonomy" for many useful lists of verbs and question-stems.

[1] Bloom B. S. (1956). *Taxonomy of Educational Objectives, Handbook I*: The Cognitive Domain. New York: David McKay Co Inc.