Assessment Primer

WHY DO ASSESSMENT?

Are your students approaching your course as hurdlers, barely clearing required levels of performance? Or are they approaching your course like high jumpers, pushing themselves under your guidance to increasingly more challenging heights? If your students aren't high jumpers, maybe it's because you aren't asking them to high jump. By using appropriate assessment techniques, you can encourage your students to raise the height of the bar.

There is considerable evidence showing that **assessment drives student learning**. More than anything else, our assessment tools tell students what we consider to be important. They will learn what we guide them to learn through our assessments.

Traditional testing methods have been limited measures of student learning, and equally importantly, of limited value for guiding student learning. These methods are often inconsistent with the increasing emphasis being placed on the ability of students to think analytically, to understand and communicate at both detailed and "big picture" levels, and to acquire life-long skills that permit continuous adaptation to workplaces that are in constant flux. Moreover, because assessment is in many respects the glue that links the components of a course - its content, instructional methods, and skills development - changes in the structure of a course require coordinated changes in assessment.

This Primer is designed to welcome you to the world of classroom assessment. The College Level One (CL-1) Team assumes you are here because you are interested in better ways to assess student learning in your class and in helping your students become more reflective and effective learners.

One goal of this website is to provide resources that enable you to begin this journey to more effective assessment of student learning. The first step is to articulate your course goals. Once you have identified your course goals, this website presents Classroom Assessment Techniques or CATs that are aligned with them. The CATs are a rich, eye-opening source of ideas and associated tools that have been extensively field-tested by your colleagues across the spectrum of SMET disciplines and post-secondary institutions. We encourage you to explore the CATs to see how you can work with your class to assess their understanding, skills, and attitudes through concept maps, conceptests, Fermi tests, interviews, portfolios, and other related techniques and tools. If you are not familiar with these forms of assessment, we are confident that you will discover, as we have, that they provide paths to a broader and deeper understanding of student learning for both you and your students.

We close by noting that assessment is undergoing exciting changes in college SMET courses. The overarching intent of this website is to capture the vitality of assessment. The CL-1 Team views

assessment as a moving target and this website as a living product, providing both a mechanism for rapid dissemination of assessment-related developments and a forum for their discussion. In this spirit, the CL-1 Team invites you to join the growing number of college SMET instructors who are identifying and developing new tools that can be used to assess student learning and to share your ideas and experiences with us. We welcome your feedback and encourage you to contact us.

AN INTRODUCTION TO ASSESSMENT: THE BASICS

What is assessment?

Why do it?

Why do it in a particular way?

This document addresses these important questions and provides an introduction to the basic concepts and terminology surrounding assessment. The discussion builds toward a generalized model for course development. Central to this discussion is the following key precept: **Assessment drives student learning**.

What Is Assessment?

Assessment is more than "just a grade"

To many, the word "assessment" simply means the process by which we assign students grades. Assessment is much more than this, however. Assessment is a mechanism for providing instructors with data for improving their teaching methods and for guiding and motivating students to be actively involved in their own learning. As such, assessment provides important feedback to both instructors and students.

Assessment is Feedback for Both Instructors and Students

Assessment gives us essential information about what our students are learning and about the extent to which we are meeting our teaching goals. But the true power of assessment comes in also using it to give feedback *to our students*. Improving the quality of learning in our courses involves not just determining to what extent students have mastered course content *at the end of the course*; improving the quality of learning also involves determining to what extent students are mastering content *throughout the course*.

Thus, in addition to providing *us* with valuable information about our students' learning, assessment should assist our students in diagnosing *their own* learning. That is, assessment should help students "become more effective, self-assessing, self-directed learners" (Angelo & Cross, 1993, p. 4). Various classroom assessment techniques (CATs) have been developed with this in mind. The CATs provided in the FLAG site have been field-tested and shown to be effective at both measuring student mastery of content and at providing students with the feedback they need to become active participants in the learning process. Indeed, such feedback can positively influence what our students learn because assessment drives student learning.

Assessment Drives Student Learning

The types of assessment usually performed in first-year science, math, engineering, and technology (SMET) courses—giving students tests—merely inform students about their grade, or ranking, *after* they have received instruction. In addition, these common testing techniques—which typically test for fact-based knowledge and algorithmic problem solving—tell our students that this is the type of

knowledge we think is most important. That is, we appear to value the understanding of concepts at a relatively low level.

Given that this is the type of assessment our students most frequently encounter, and that it will eventually lead to their final course grades, students learn to study the content in our courses in an expeditious way that allows them to succeed in passing many first-year SMET courses without necessarily developing deep understanding of concepts. *It is our assessment that drives students learning*.

Unfortunately, assessment drives student learning whether we want it to or not. The consequences of relying upon our "tried and true" assessment methods are profound; these assessment methods may actively promote superficial learning. If we wish to actively steer what our students learn, and how well they learn it, we must (1) actually decide what we want our students to take away from the course, and (2) choose our classroom assessment techniques appropriately (Anderson & Sosniak, 1994; National Research Council, 1996; Tobias & Raphael, 1997; Wiggins, 1998). The importance of setting course goals—articulating them and writing them down—cannot be overstated. Evaluating the extent to which we have attained our stated course goals is the primary motivation for why we "do assessment". Furthermore, ensuring that our assessment techniques can measure our stated goals is the reason for why we "do assessment in a particular way".

Why do assessment?

To evaluate attainment of course goals
For every course we teach, we make decisions about what we want our students to know and be able to do by the end of the semester. Though we might not always formalize these goals by writing them down, we still make decisions about the curriculum, the instructional methods, and the assessment techniques we will employ. In terms of curriculum, we decide which topics to cover, and how they connect with previous and forthcoming topics. We also decide which instructional methods we will use to deliver the curriculum, be they lectures, group activities, readings, homework assignments, etc. Similarly, we decide what assessment techniques we will use (e.g., multiple-choice tests). Thus, the decisions we make reflect our goals for the course whether we state them or not. It is important, therefore, to formalize course goals while the course is still in its planning stage. The FLAG site includes a section on Aligning Goals CATs to assist with identifying course goals.

Formalizing our goals is only the first step, however. We must also measure the extent to which we are attaining these goals. This is why we do assessment. Logically, we must choose classroom assessment techniques that are appropriately suited to measuring our particular goals. That is, we must align our assessment techniques with our stated goals.

Why do assessment in a particular way?

To align assessment with stated goals
The most commonly employed CAT in first-year SMET courses is the multiple-choice test. Such tests are usually most effective at measuring fact-based knowledge and ability to perform algorithmic problem-solving. If our stated goals are that students be able to recite facts and to solve simple algorithmic problems, then in fact the chosen assessment technique is well aligned with the stated goals. However, if our goals include different student outcomes than these (e.g. an understanding of the scientific "process", a lifelong interest in the subject, the ability to critically

analyze science in popular media, etc.), then this assessment technique will not provide useful feedback about attainment of these goals.

Furthermore, misaligned assessment techniques convey to our students the wrong message about what we want them to take from the course. As suggested previously, our choice of assessment technique drives student learning (Anderson & Sosniak, 1994; National Research Council, 1996; Tobias & Raphael, 1997; Wiggins, 1998).
The FLAG site provides a facility for formalizing course goals and a suite of field-tested classroom assessment techniques that are well suited for a variety of course goals. In the following section we present a generalized model for course development that builds upon the precept that assessment drives student learning, including a scheme for translating goals into measurable student outcomes.

ASSESSMENT WITHIN THE CONTEXT OF COURSE DEVELOPMENT
A GENERALIZED MODEL FOR COURSE DEVELOPMENT

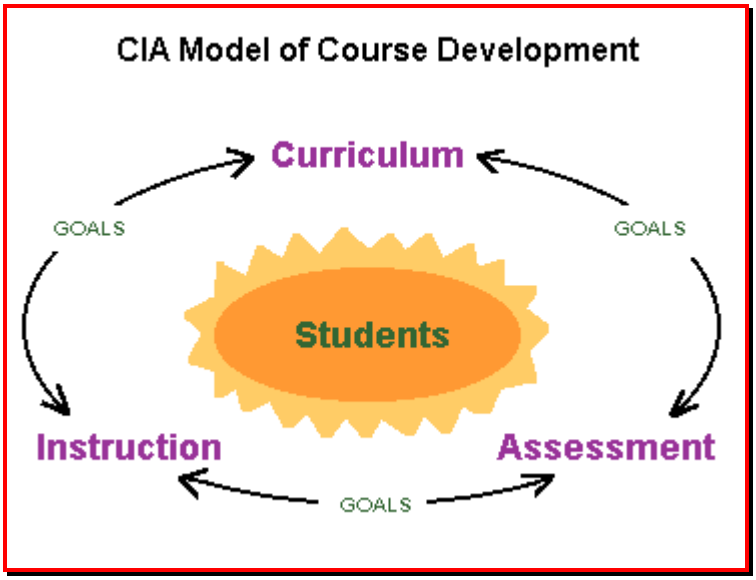

Figure 1

Curriculum, Instruction, and Assessment
The three primary components of any course are the curriculum (the "content"), the instructional methods used to deliver the curriculum, and the assessment techniques with which our success in attaining our course goals is evaluated. These three components (curriculum, instruction, assessment—CIA) are inextricably linked, and are bound together by the goals we set for the course (Figure 1).

The CIA model presented here requires that goals be formalized at the outset. Setting goals is the first and most important step in course development. Once goals are stated, we can connect our curriculum, instruction, and assessment to them. One way of beginning to think about how to align assessment with course goals is by grouping them into three broad categories: knowledge-based goals, skills-based goals, and affective goals (affective: i.e. values, attitudes, and interests). For example, a recent survey conducted by the American Astronomical Society Education Office

(Brissenden, Duncan & Slater, in preparation) found that a majority of the astronomy faculty respondents (n=29) have in common the following three goals for their introductory astronomy courses:

1. Students should understand the size, scale, and structure of the cosmos and the motions of the night sky. (*knowledge-based*)
2. Students should understand the nature of science and astronomy. (*knowledge-based*)
3. Students should gain an interest in studying current events in astronomy as a life-long learning activity. (*affective*)

In addition, one might have *skills-based* goals. An example of a skills-based goal might be for students to be able to set up a small telescope and point it at a given celestial body.

While the most common classroom assessment technique employed in introductory astronomy courses—the multiple-choice exam—tends to provide useful information about students' fact-based knowledge, it usually does not provide useful information about other types of knowledge (e.g. concept-based). These tests also rarely information about skills-based knowledge. Traditional course evaluations similarly do not generally provide useful information about changes in student values, attitudes, and interests. Thus, common assessment techniques, while providing a means for assigning grades, often do not provide us and our students with useful feedback for diagnosing student learning. We see that by grouping our course goals into knowledge-based, skills-based, and affective goals, we can more readily determine if our curriculum, instruction, and classroom assessment techniques are properly aligned with our goals.

A useful scheme for further grouping course goals into categories that can help identify appropriate classroom assessment techniques is provided by Bloom's Taxonomy of Educational Goals.

Bloom's Taxonomy

There is more to our students' knowledge than simply being right or wrong; rather, our students possess a continuum of knowledge with varying degrees of less or more sophistication. Hence, the criteria by which we measure student success in our courses—our choice of classroom assessment techniques—should vary in sophistication depending on the particular concept or skill we are assessing. To fully align our classroom assessment techniques with measurable student outcomes, we need to describe these outcomes in terms of the desired levels of expertise we want our students to achieve.

One of the most widely used ways of organizing these levels of expertise is according to Bloom's Taxonomy of Educational Objectives (Bloom et al., 1994; Gronlund, 1991; Krathwohl et al., 1956). Using Bloom's Taxonomy, we can express our desired measurable student outcomes along a six-level scale of student knowledge and ability. These levels represent a range of expertise (see Tables 1-3).

Ensuring Course Goals Are Measurable

Determining the extent to which course goals are being achieved can be hampered if goals are stated too abstractly. How does one assess whether students have "gained an understanding of the seasons", for example? To facilitate aligning our curriculum, instruction, and classroom assessment techniques with course goals, it is important to make sure that our goals are measurable. That is, course goals must be stated in concrete terms, with words that describe realistic, demonstrable student performance. The goal relating to understanding the seasons given above might be more effectively stated as, e.g., "defines seasons" or "distinguishes importance of different factors such as tilt and distance", depending upon the desired level of expertise with this particular goal. The Aligning Goals to CATs section helps you identify measurable goals.

Table 1: Bloom's Taxonomy of Educational Goals: Knowledge-Based

Classifications	Descriptions	Examples
1. Knowledge	Recall, or recognition of terms, ideas, procedure, theories, etc.	When is the first day of Spring?
2. Comprehension	Translate, interpret, extrapolate, but not see fill implications or transfer to other situations, closer to literal translation	What does the summer solstice represent?
3. Application	Apply abstractions, general principles, or methods to specific concrete situations	What would Earth's seasons be like if its orbit was perfectly circular?
4. Analysis	Separation of a complex idea into its constituent parts and an understanding of organization and relationship between the parts. Includes realizing the distinction between hypothesis and fact as well as between relevant and extraneous variables.	Why are seasons reversed in the southern hemisphere?
5. Synthesis	Creative, mental construction of ideas and concepts from multiple sources to form complex ideas into a new, integrated, and meaningful pattern subject to given constraints.	If the longest day of the year is in June, why is the northern hemisphere hottest in August?
6. Evaluation	To make Judgment of ideas or methods using external evidence or self-selected criteria substantiated by observations or informed rationalizations.	What would be the important variables for predicting seasons on a newly discovered planet?

Table 2: Bloom's Taxonomy of Educational Goals: Skills-Based

Classifications	Descriptions	Examples
Perception	Uses sensory cues to guide actions	Some of the colored samples you see will need dilution before you take their spectra. Using only observation, how will you decide which solutions might need to be diluted?
Set	Demonstrates a readiness to take action to perform the task or objective	Describe how you would go about taking the absorbance spectra of a sample of pigments?
Guided Response	Knows steps required to complete the task or objective	Determine the density of a group of sample metals with regular and irregular shapes.
Mechanism	Performs task or objective in a somewhat confident, proficient, and habitual manner	Using the procedure described below, determine the quantity of copper in your unknown ore. Report its mean value and standard deviation.
Complex Overt Response	Performs task or objective in a confident, proficient, and habitual manner	Use titration to determine the K_a for an unknown weak acid.
Adaptation	Performs task or objective as above, but can also modify actions to account for new or problematic situations	You are performing titrations on a series of unknown acids and find a variety of problems with the resulting curves, e.g. only 3.0 ml of base is required in for one acid while 75.0 ml is required in another. What can you do to get valid data for all the unknown acids?
Organization	Creates new tasks or objectives incorporating learned ones	Recall your plating and etching experiences with an aluminum substrate, Choose a different metal substrate and design a process to plate, mask, and etch so that a pattern of 4 different metals is created.

Table 3: Bloom's Taxonomy of Educational Goals: Affective

Classifications	Descriptions	Examples
Receiving	Demonstrates a willingness to participate in the activity	When I'm in class I am attentive to the instructor, take notes, etc. I do not read the newspaper instead.
Responding	Shows interest in the objects, phenomena, or activity by seeking it out or pursuing it for pleasure	I complete my homework and participate in class discussions.
Valuing	Internalizes an appreciation for (values) the objectives, phenomena, or activity	I seek out information in popular media related to my class.
Organizing	Begins to compare different values, and resolves conflicts between them to form an internally consistent system of values	Some of the ideas I've learned in my class differ from my previous beliefs. How do I resolve this?
Characterizing by a Value or Value Complex	Adopts a long-term value system that is "pervasive, consistent, and predictable"	I've decided to take my family on a vacation to visit some of the places I learned about in my class.

Bloom's Taxonomy is a convenient way to describe the degree to which we want our students to understand and use concepts, to demonstrate particular skills, and to have their attitudes affected. Just as it is vitally important to formalize our teaching goals, it is equally critical to assign the desired levels of student achievement to each stated goal. Though the most common form of classroom assessment—multiple choice tests—might be quite adequate for assessing *knowledge* and *comprehension*, this type of assessment often falls short when we want to assess our students knowledge at the higher levels of *synthesis* and *evaluation* (Bloom et al., 1994; Tobias & Raphael, 1997). We might not expect, or even desire, that our students will achieve these higher-order levels of understanding for all of our course goals, but it is important to identify to which level we do expect them to achieve.

Bloom's Taxonomy need not be applied exclusively *after* course goals have been defined. Indeed, Bloom's Taxonomy and the words associated with its different categories can help in the goals-defining process itself. Thus, Bloom's Taxonomy can be used in an iterative fashion to first state and then refine course goals. Bloom's Taxonomy can finally be used to identify which classroom assessment techniques are most appropriate for measuring these goals.

If assessment is to support student achievement in addition to being the process by which we assign grades, Bloom's Taxonomy provides a way to focus our instructional and assessment activities at the appropriate levels for our desired student outcomes. In addition, there are a variety of innovative strategies we can use to move curriculum, instruction, and assessment to the higher levels we often desire our students to reach. In the final section, we provide a brief description of several classroom assessment techniques designed to do just this. Links to extended descriptions and implementation procedures are included. You may also be interested in the NISE Collaborative Learning site.

How Assessment Fits Into the CIA Model of Course Development

A Roadmap for Course Development

Every SMET course has three components: curriculum, instruction, and assessment. Before we can focus on any of these components, we must (a) formalize our course goals and (b) categorize each goal via Bloom's Taxonomy. Once we have completed this task, we can focus on the curriculum and instructional methods we think will best lead to our desired student outcomes. Stopping here is not enough. We must choose appropriate classroom assessment techniques—those techniques that are aligned with our course goals. Then we will be in the position to evaluate the worth of our curriculum and instructional methods at producing our desired goals.

The terms *assessment* and *evaluation* are often incorrectly used interchangeably. Assessment is the collecting of data to inform both the instructor and the student as to how the course is progressing or how it has ended. Assessment involves using one or more classroom assessment techniques. Evaluation is what we do with this data once we have it. Once we have acquired the assessment data, it is up to us to judge the efficacy of our instructional methods, the content of our course, and the achievement of our students.

The FLAG site provides the opportunity to investigate and clarify course goals via the section Aligning Goals CATs. Once you have clarified your goals, you will be directed to specific innovative classroom assessment techniques that are aligned with your course goals. Within each CAT you will also find information about "how to turn your data into something useful." It is this important, evaluative step that allows you to determine the extent to which you are reaching your course goals or to decide if there are changes you would like to make. This is the role of Assessment within the CIA model of course development (Figure 2).

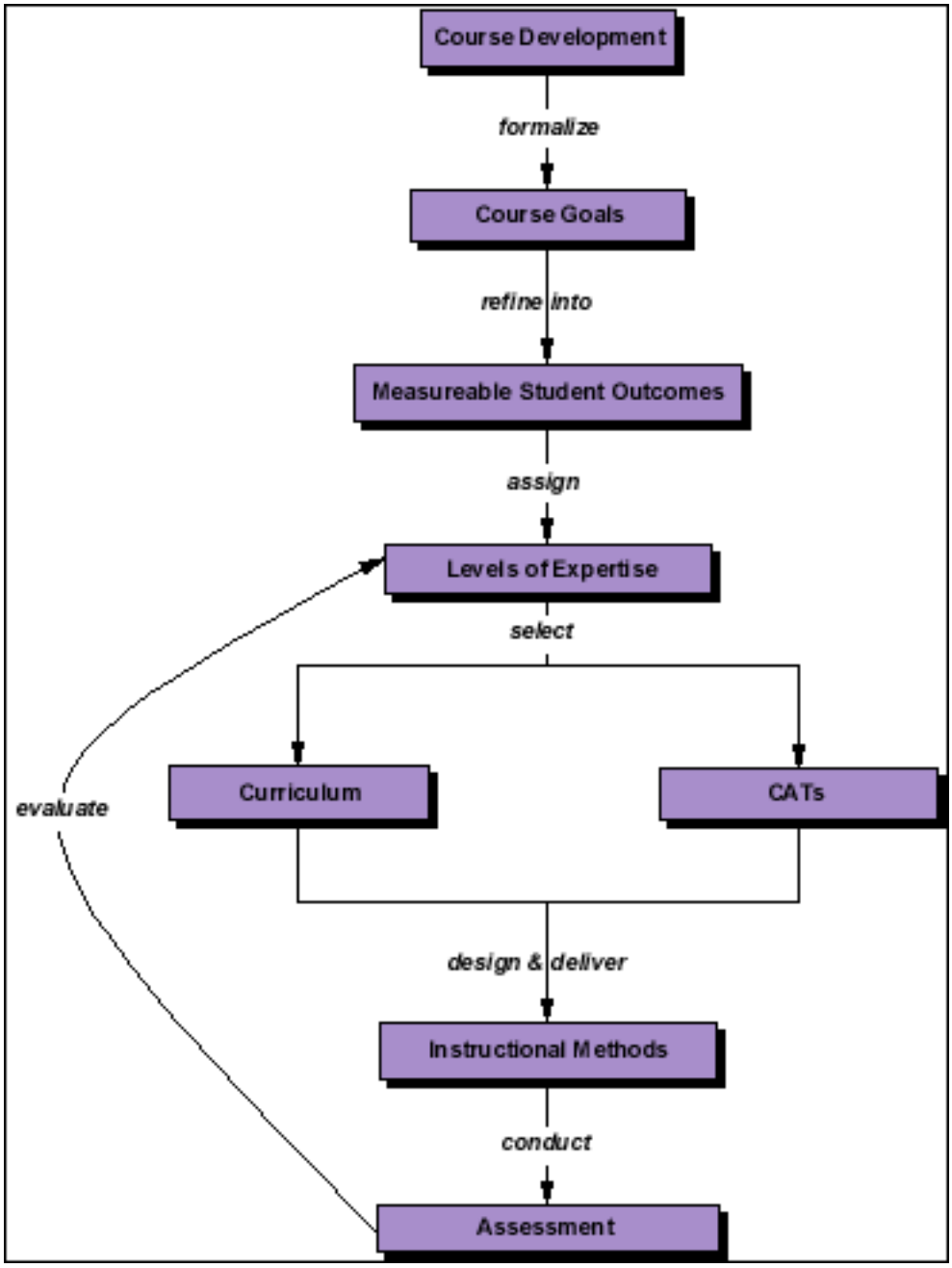

Figure 2: Road Map of Course Development

Assessment Is Feedback for both Students and Instructors

The perspective advocated here is that we can use carefully constructed classroom assessment techniques as a means of determining whether or not we are meeting our stated course goals, in addition to assigning our students grades. For us, classroom assessment can help us answer the following questions:

- To what extent are my students achieving the stated course goals?
- How should I allocate class time for the current topic?
- Can I introduce this topic in a more effective way?
- What parts of this course are my students finding most valuable?
- How will I change this course the next time I teach it?
- Which grades do I assign my students?

For our students, classroom assessments answers a different set of questions:

- Do I know what my instructor thinks is most important?
- Am I mastering the course content?
- How can I improve the way I study in this course?
- What grade am I earning in this course?

Answering these questions and others can inform and improve the quality of student learning in our classes.

A Charge to Change

Over the years, we have observed that many heated discussions over assessment are actually arguments about curriculum. We can not emphasize enough how important it is to actually write down your course goals and share them with your students. Once your course goals are set, questions about instruction, assessment, and grading will be much more focused. This is a small step beyond the assessment strategies that most faculty are already doing; yet with a small investment in planning, the data acquired can provide valuable information about improving the quality of student learning.

Resources

- Aligning Goals CATs
- Classroom Assessment Techniques (CATs)

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GLOSSARY

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