Broadening Assessment Methods in Postsecondary Mathematics

Starring Rick Cleary as Benjamin Braun

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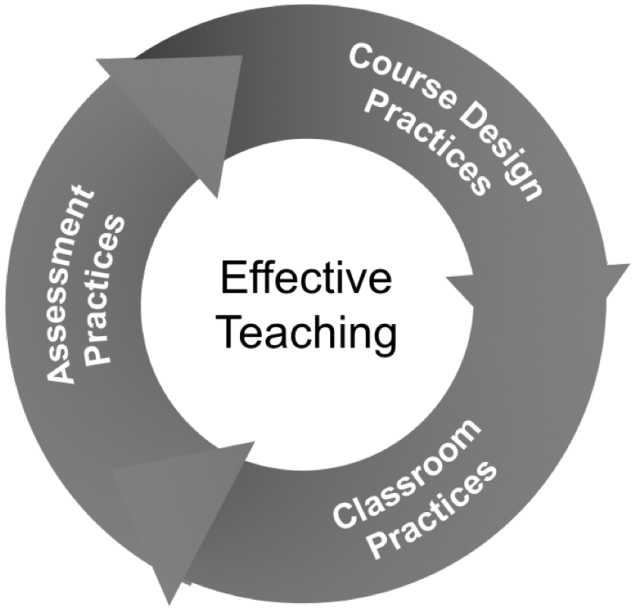
This talk is based on the *MAA Instructional Practices Guide*.



Rick Cleary and Ben Braun served on the IP Guide Steering Committee and were the two lead writers for the chapter on Assessment.

Thanks to the writing team Ben worked with:

- Bill Martin
- Ayse Sahin
- Milos Savic
- Claire Wladis

Three Major Takeaways for Faculty

Effective assessment occurs when we

1. clearly state high-quality goals for student learning,
2. give students frequent informal feedback about their progress toward these goals, and
3. evaluate student growth and proficiency based on these goals.

The purpose of this talk is to discuss how we can broaden our vision of assessment regarding these three key points.

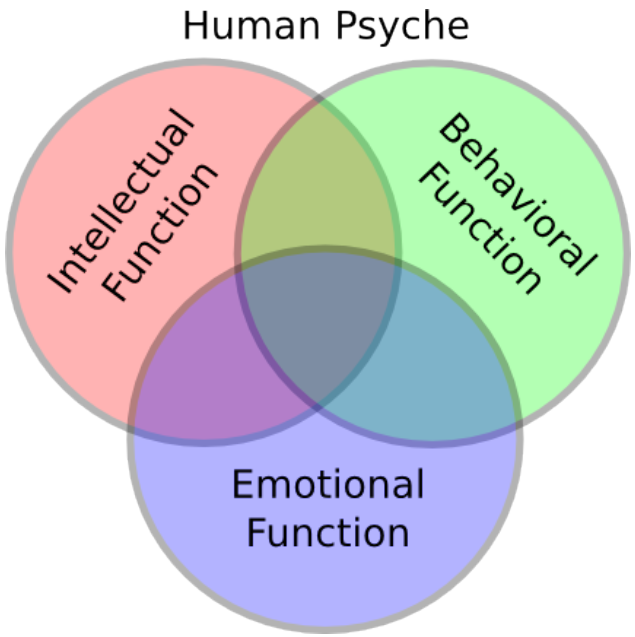
Student Learning Outcomes

Formative Assessment

Summative Assessment

Three Psychological Domains

Modern psychology provides a basic framework of the human psyche with three domains.



Many math courses focus primarily on "Intellectual" aspects of student learning. Effective teaching requires course design, classroom practices, and assessment practices that address all three domains.

Major Take-Away

A "comprehensive" set of SLOs needs to address all three of the intellectual, behavioral, and emotional domains of human functioning.

If you want to and are able to write SLOs that are fine-tuned to align with an existing framework for mathematical proficiency (such as those mentioned), go for it! If not, you can still design thoughtful and effective SLOs by keeping in mind the three-domain framework.

All assessment must be grounded in the learning outcomes for the course.

College Algebra SLOs, Part I

Students will:

- Use multiple perspectives (symbolic, numeric, graphic, and verbal) to explore elementary functions
- Algebraically solve linear, quadratic, exponential, logarithmic, and power equations
- Sketch polynomial and rational functions using a graphing calculator.
- Identify and algebraically find important characteristics of these graphs such as intercepts, vertical asymptotes, and horizontal asymptotes.
- Recognize and use standard transformations with graphs of elementary functions
- Use and solve systems of equations to model real world situations

College Algebra SLOs, Part II

Students will have opportunities to engage in the following mathematical practices:

- Being persistent, working through perceived failure
- Collaborating productively with a team
- Developing a personal framework of problem solving techniques (e.g. to make sense of problems, sketch and label diagrams, restate and clarify questions, identify variables and parameters, and use analytical, numerical, and graphical solution methods)
- Creating, interpreting, and revising real-world models and solutions of problems

Remark on Measurability

Many discussions about learning outcomes focus on issues of "measurability", e.g. writing learning outcomes that are able to be precisely evaluated/measured via student work. The importance of this varies depending on context.

- For the individual instructor looking to increase the quality of their teaching by clarifying learning outcomes for themselves and their students, measurability is not a critical issue, and can be a distraction. The key point in this case is to use informal SLOs as general goal markers, and as stepping stones toward more complex and nuanced approaches to teaching.
- For teams of instructors or departments writing SLOs that will be used for institutional- or program-level assessment, then careful attention to measurability should be given.

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An Informal Definition

Schoenfeld summarized previous literature, leading to a definition of formative assessment as

> *examinations or performance opportunities the primary purpose of which is to provide student and teachers feedback about the student's current state, while there are still opportunities for student improvement.*

Key point: feedback is provided prior to final (summative) evaluation of student performance/achievement.

Active Learning

In a given course, an *active learning method* is a classroom teaching technique in which *students complete a task or activity* directly supporting development in

1. one or more student learning outcomes, and
2. one or more psychological domains.

Active learning is a way to promote student engagement and provide formative assessment. Each course should include a balance of direct instruction and active learning techniques that collectively support development across all of the course SLOs.

AL Example #1: Think-Pair-Share in small-lecture Number Theory

Technique: Ask students to use Euclid's proof of the infinitude of primes to produce as many new prime numbers as possible starting with only the prime 5. Students have three minutes to compute independently, then three minutes spent comparing their results with one or two of their neighbors in class, discussing the reason for why their lists are the same or different. A subset of the students are then asked to share the results of their conversations in order to start a whole-class discussion.

AL Example #2: IBL-style small group activity

Technique: Assign students to small groups. Give each group a theorem (or problem) with a 15-line proof (or solution) where each line is separately cut out and mixed together, where the proof (or solution) has one fixable error. Students must first collaboratively reconstruct the proof, then identify and correct the error. The instructor spends the class time circling the room, listening to student conversations, offering clarification and answering questions, etc.

Unexpected Formative Assessments Exist

An example of formative assessment that is often not recognized as formative: online homework systems where students have unlimited attempts to answer the problem. This provides feedback to students (correct or incorrect) and can be used to support items #4 and #5 from Black and Wiliam's key strategies:

4. activating students as instructional resources for one another; and
5. activating students as the owners of their own learning.

It is a useful habit to reflect on your regular teaching practices to identify "secret" formative assessment you do. Viewing these practices explicitly as formative assessment techniques can make them more effective.

Writing Assignments: Reflective Essays

Short reflective essays about challenges in the course promote development in both the affective and enactive domains.

- Write several paragraphs on the following topic: what was the most challenging aspect for you regarding [TOPIC]? What made this difficult for you? Did you overcome the challenge, or are you still struggling with it?

This can be graded based on completion, i.e. if students write several paragraphs that address these questions then they receive full credit for the problem.

Writing Assignments: Critical Reviews of Reading

To promote critical analysis skills and develop students' reading abilities, have students write a review of selected readings from your course text.

- Write a three page critical review of [ASSIGNED READING].
- Imagine that you are writing your review for a journal for undergraduates in mathematics and the sciences.
- You must address the mathematical depth and mathematical style of [ASSIGNED READING] in addition to other topics.

Short essays should be graded using a rubric. References in the IP Guide provide various examples.

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Summative Assessment

Defining Summative Assessment

Summative assessment is conducted with the purpose of evaluating student growth and/or proficiency with regard to one or more learning outcomes.

Most of the assessments that we typically see in math courses, such as exams, quizzes, and homework (when graded after only one attempt) fall within this context.

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Two major challenges are:

- to design a meaningful overall evaluation scheme (i.e. course grading system).
- to create and select problems/tasks with a clear sense of what the problem/task:
  - is *intended* to assess (this can be done)
  - *actually* assesses (this is usually difficult to determine)

Course Grading Systems

There are several established course grading systems for postsecondary math courses:

- Point-Based Systems
- Specifications Grading, Standards-Based Grading, Mastery-Based Grading, Points-Free Grading, Etc
- Portfolio Grading

An in-depth discussion of these would take more time than we have, see the IP Guide for further discussion.

A Points-Based Example

Using a points-based system is a reasonable approach, as long as the average is created in a thoughtful manner that reflects the SLOs for the course.

Here is an example of a points-based scheme for a course using a broad range of assessment methods.

- Three Exams: 45% of course grade
- Weekly Quizzes: 15% of course grade
- Two Written Assignments: 8% of course grade
- Online Homework (unlimited attempts allowed on problems): 15% of course grade
- Three Reflective Essays: 12% of course grade
- Participation: 5% of course grade

Caveat: A system like this might be the end result of a 1-3 cycle of implementing and getting comfortable with unfamiliar assessment techniques.

An Important Aside About Course Design

Research by psychologists and educators has demonstrated that summative assessments are most effective when they are *frequent and low-stakes* rather than infrequent and high-stakes.

Warning!: An excellent selection of problems for quizzes and exams can be undermined by ineffective course design.

For example, in the system given on the previous slide, there are three exams at 15% of the course grade each, but also weekly quizzes which provide another 15% worth of the course grade. In effect, this takes a course with four high-stakes exams and distributes one of those exams into more frequent, lower-stakes summative assessments.

Creating and Selecting Effective Problems/Tasks

A well-known framework for analyzing problems given to students is Bloom's taxonomy. Bloom's taxonomy has been extended by researchers in educational psychology to more robust frameworks. Anderson et al. introduced a two-dimensional extension of Bloom's taxonomy.

The first dimension consists of a cognitive process dimension similar to Bloom's taxonomy (serving the behavioral domain), while the second consists of a knowledge dimension (serving the intellectual domain).

When evaluating a problem or task using this taxonomy, the cognitive process is represented by the verb used when specifying the task (what the student is doing) and the knowledge process dimension corresponds to the noun (what kind of knowledge the student is working with).

See the IP Guide for details regarding this taxonomy.