

# Designing and teaching courses for 20-30 students (with a view toward the MAA Instructional Practices Guide)

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# Two Caveats

1. This talk reflects aspects of the current vision for the MAA IP Guide, in development.
2. This talk reflects an idealized vision for teaching — only on rare occasions does everything I'm going to mention work together to our satisfaction.

# Three Components of Effective Teaching

Course Design

Assessment

Classroom Practices

# Three Components of Effective Teaching

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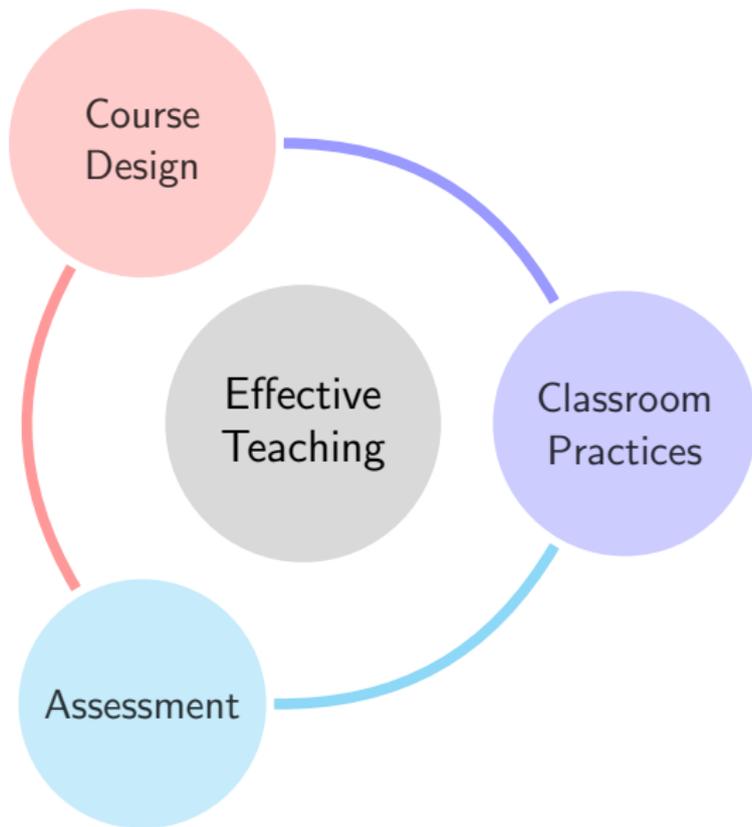
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# What is Course Design?

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*Course design* is the process that takes place *prior* to the start of a course. When designing courses we must:

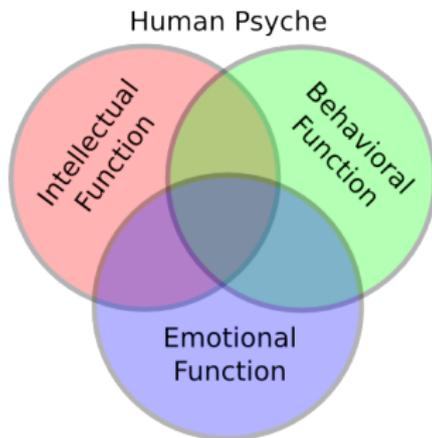
- ▶ begin by clearly articulating desired student learning outcomes,
- ▶ decide what activities/tasks we will use to guide students to reach these outcomes,
- ▶ decide the best way for us to assess student learning against these outcomes, and
- ▶ make clear how the whole will fit together.

# Key Ideas for Course Design

- ▶ Psychological domains for student learning
- ▶ Student learning outcomes (SLOs)
- ▶ Psychological aspects of student motivation and beliefs, e.g.
  - ▶ Stereotype Threat
  - ▶ Mindset
  - ▶ Attribution Theory
- ▶ Frameworks for mathematical proficiency, e.g.
  - ▶ 2015 MAA CUPM Curriculum Guide
  - ▶ 2001 NRC report “Adding It Up” — 5-strand model of proficiency
- ▶ Situational factors, e.g.
  - ▶ course size, classroom environment (tables vs desks etc)
  - ▶ course support (student graders, tutoring resources, etc)
- ▶ “Promising” Syllabus

# Psychological Domains

Modern psychology provides a basic framework of the human psyche with three domains. Our courses must be designed to engage students across all of these domains.



*Aside:* Many math courses focus primarily on “Intellectual” aspects of student learning. Most active learning and inquiry-based learning techniques engage students across two or three of these domains.

# Student Learning Outcomes

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Every course should have clear *Student Learning Outcomes* (SLOs) that represent all of the psychological domains and all of the components of a robust framework for mathematical proficiency.

For example, at the University of Kentucky, Number Theory serves as an “intro to proof” course. Our department voted to recommended the following SLOs to faculty teaching the course.

Students will deepen their understanding of the following topics and improve with regard to the following practices:

1. Divisibility, Division Algorithm, Euclidean Algorithm
2. Fundamental Theorem of Arithmetic, Infinitude of Primes
3. Linear Congruences, Chinese Remainder Theorem
4. Fermat's Little Theorem, Wilson's Theorem
5. Direct Proof, Proof by Contradiction, Mathematical Induction
6. Being persistent, Working through perceived failure, Strategic self-questioning
7. Productive collaboration with others, Asking good questions
8. Constructing examples and non-examples to investigate and understand new definitions and theorems
9. Reading and understanding existing proofs, Recognizing incorrect proofs
10. Developing and communicating original proofs

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# Key Ideas for Assessment

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- ▶ Formative and Summative Assessment
- ▶ Levels of Cognitive Demand, Cognitive Load Theory, Zones of Proximal Development
- ▶ Cognitive Taxonomies, e.g. Bloom's and variants
- ▶ Models for intellectual development, e.g. Perry's and variants
- ▶ Conceptual and Procedural Understanding

# Formative and Summative Assessment

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As described by Carnegie Mellon's Eberly Center for Teaching Excellence:

- ▶ *Formative assessment* is intended to monitor student learning, helping students identify their strengths and weaknesses and target areas that need work. These assessments are low- or no-stakes, e.g. incorporated as a required activity during class time or assigning a grade based only on completion of the task.
- ▶ *Summative assessment* is intended to evaluate student learning at the end of an instructional unit.

Note that *both* types of assessment can be used to assign a course grade, but formative assessments should generally be graded in a participatory manner rather than in an evaluatory manner.

# Examples of Assessments

Group Projects, Gateway/Mastery Testing, Writing Assignments, Oral Presentations, Online Homework Systems, “Clicker” systems, Procedurally-focused problems, Conceptually-focused problems, Service Learning reports, Independent study project reports, Undergraduate research project reports, Portfolios, Quizzes and exams, Scaffolded assignments

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# Example of formative writing assignment

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Short reflective essays about challenges in the course promote development in both the behavioral and emotional 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 will be graded based on completion, i.e. if you write several paragraphs that address these questions then you will get full credit for the problem.

# Example of summative writing assignment

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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 graded using a rubric with five criteria: Writing Style, Arrangement and Development, Editing and Conventions, Mathematical Depth, Mathematical Style.

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# Key Ideas for Classroom Practices

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- ▶ Balancing Direct Instruction and Active Learning
- ▶ Inquiry-Based Learning
- ▶ Inclusive Learning Environments
  - ▶ Equitable participation
  - ▶ First-generation students
  - ▶ Race/gender/socio-economic-status issues
- ▶ Mathematical Task Selection
  - ▶ Individual, small group, whole class
- ▶ Communication
  - ▶ Reading, writing, presenting, visualizations

# Active Learning

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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.

Each course should include a balance of direct instruction and active learning techniques that collectively support development across all of our SLOs.

## Example: Think-Pair-Share in a lecture-based course

**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.

# Example: IBL-style small group activity

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**Technique:** Assign students to small groups. Give each group a theorem with a 15-line proof where each line is separately cut out and mixed together, where the proof has one (fixable) error. Students must first collaboratively reconstruct the proof, then identify and correct the error.

# Three closing comments

1. Start small and plan for gradual change
2. Expect to eventually develop a large toolbox of “teaching moves” that you can pick and choose from
3. As with learning mathematics, plan for productive struggle as you learn to use new techniques

Discussion time!