

Writing Problem Sets and Exams

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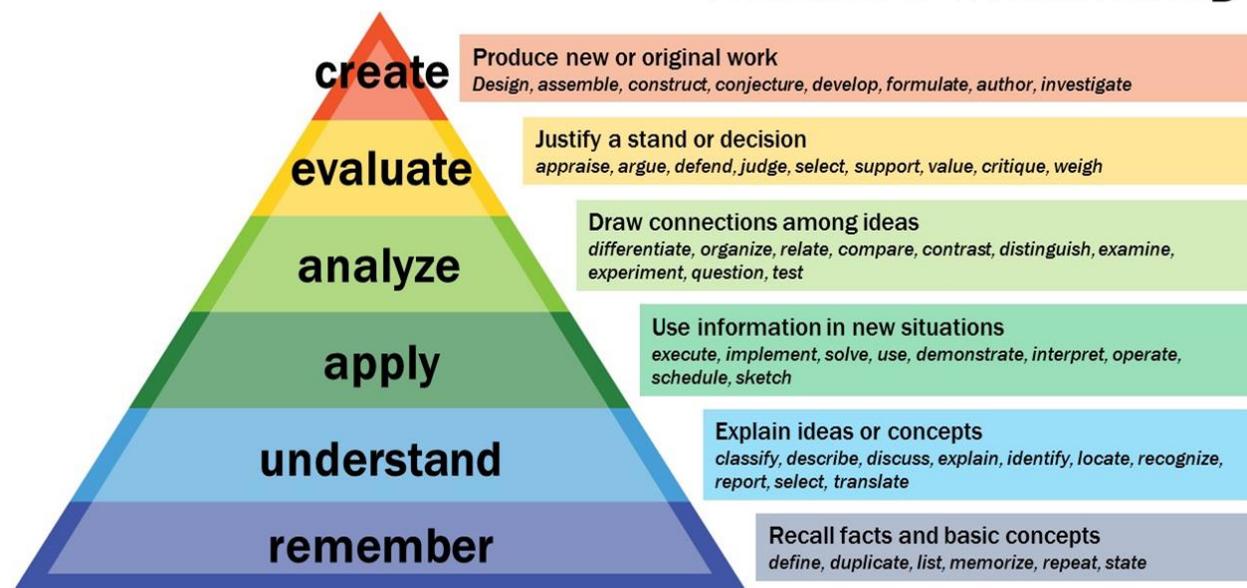
Outcomes: Session participants will become familiar with the following:

- Principles for designing effective problem sets and exams
- Guidelines for authoring problem sets and exams
- Practical tips for writing problems efficiently, selecting appropriate homework and exam problems, writing problems that are straightforward to grade

I. Designing well-rounded problem sets linked to the educational objectives

- There are various **types of the problems** (e.g. multiple choice, word problems, essay, design problems, proofs, computational/coding problems, etc.)
- Each problem is designed **to test a particular piece of knowledge**
- The problems are organized **into sets**. Each assignment has to be clearly linked to the [course goals and learning objectives](#).
 - convey the goal of each assignment
 - coordinate problem sets with course topics
- **The problem set should be well rounded.**
 - The homework or exam set should include the problems to test the acquired knowledge at the different cognitive levels;
 - There are six main categories of the Educational Objectives relevant to the **cognitive domain levels** in the **Bloom's taxonomy**:

Bloom's Taxonomy

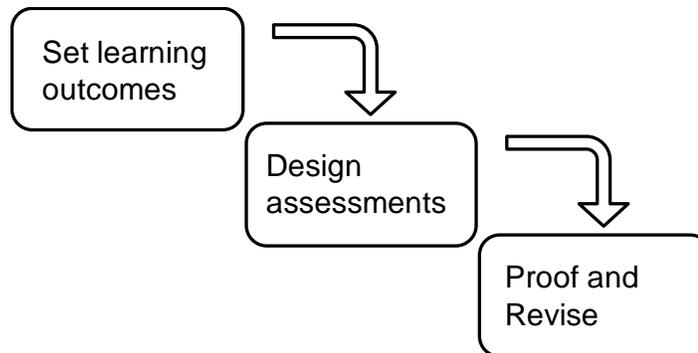


II. Guidelines for Authoring Problem Sets and Exams

Assessment can be used as a tool to help students reach learning outcomes and to check if students are reaching the set outcomes. Included below are guidelines on how to write assessment questions and how to choose questions that are appropriate for the assignment.

A. Backwards Assessment Design

One of the more systematic ways to author problems is through backwards assessment design:



In this reverse engineering process, the instructor begins by determining what topics require assessment and sets learning outcomes for the assignment (or even for the class). The instructor then writes questions that aim to assess those learning outcomes. After writing the assignment, the instructor then checks if the problems truly test for the learning outcomes and if the problem difficulty has been varied sufficiently.

B. Additional Guidelines

Instructor Preferences and Outside Resources

Discuss the instructor's expectations about how many original problems need to be generated for problems sets and exams and how many problems can be re-used (or modified) from previous years. If instructors are expecting new problems to be generated, there are many resources available to help expedite the process. For example, problems from lecture can be expanded upon and main textbook problems can be used directly or converted into better problems if necessary. Additionally, problems from other textbooks, advanced textbook problems, and examples from the literature can be used as well. If possible, it can also help to consult with former teaching assistants for advice on how to prepare assignments and exams.

Get Feedback on the Problem Design

Once assignments or exams have been prepared, it is important to do the problems before distributing the assignment and, if possible, ask another TA or graduate student to look over/do the assignment as well to check for errors and timing. As a general rule, students take 3-4 times longer than instructors to complete assignments and exams.

Communicate Expectations with Students

Instructors can also maximize how much students learn from homework and exams by preparing students for the types of assessment they will encounter and highlight how the assessment is related to learning objectives. Grading rubrics and feedback can also be used as tools to highlight the learning objectives that need to be met.

C. Homework – **Students spend the majority of their time completing homework assignments and learning from the feedback on those assignments.** As such, there is ample opportunity to draw student attention to the most important topics, coordinate the homework assignments with other forms of assessment, and give students practice solving different types of problems.

1. Scope – Assignments generally cover 1-3 weeks of material and are usually given regularly as a formative form assessment. In this way, students are given practice interacting with new material and feedback on their progress.
2. Objectives – The objective(s) of any homework assignment can be determined by a combination of factors, such as the instructor, class level, and the discipline. Below are some common objectives that can help guide assignment:
 - Require students to interact with material at some or all cognitive domain levels
 - Test recall/understanding of prior knowledge (diagnostic)
 - Give students practice interacting with new material
 - Relate course material to primary literature
 - Relate lectures to readings
 - Challenge students to integrate old and new information to solve unfamiliar problems (especially true for capstone courses)
 - Prepare students for other courses or for research

D. Exams

1. Scope – Exams cover several weeks to all of the course material, and are a summative form of assessment to measure cumulative learning.
2. Format – Exams are generally timed, but the time allotted (and question type) can vary. Exams are often non-collaborative, but large projects-based assessments can be group endeavors. Depending on the assessment, the exam can be qualitative, quantitative, or a combination and open/closed book/internet use.
3. Objectives – As with assignments, the objective(s) of an exam can vary. Below are some common objectives that can guide what types of questions are given to students
 - Test for understanding and recall of the fundamentals
 - Test for higher order thinking skills

- Check if students are achieving learning objectives and content mastery
- Gauge how a class is progressing overall

E. Authoring Problems Outside of Homework and Exams

Throughout a term, there may be other opportunities to author problems for quizzes, recitation session, or active learning exercises. The same principles of backward assignment design apply in all of these cases.

III. Practical tips for designing individual problems

Design problems to have a range of difficulty

- Control breadth (spanning through multiple concepts), depth (requiring knowledge of the details), and definition (provided information/constraints).
- Use both qualitative and quantitative problems.
- Well-defined problems are easier to grade (but sometimes less defined problems are good to challenge students or give them a chance to be creative).
- In a well-balanced problem set, the struggling students will have somewhere to start, and the best students will still be able to be challenged.
- One way to balance a problem set is by breaking large, high-stakes assignments (or problems) into multiple, low stake assignments (or problems).

Think about your audience

- Undergrads and grads can read problems differently, so think about the language you use and try to relate it to their lives or make it relevant.
- Aim the assignment just slightly above students' current expertise.

Apply Conceptual scaffolding:

- Have students practice relevant concepts on simple problems first, and then ask a complex problem that requires the concepts from the simple problems.

References

Bloom, B. (1973). *Taxonomy of Educational Objectives*

Davis, B.G. (2009) *Tools for Teaching* (2nd Edition).

Lord, T. and Baviskar, S. (2007) *Moving Students From Information Recitation to Information understanding: Exploiting Bloom's Taxonomy in Creating Science Questions*. *Journal of College Science Teaching*. March/April 2007, 40-44.

Lorin W. Anderson, David R. Krathwohl; et al. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. (Addison Wesley Longman.)

Online References and Resources

Center for Research on Teaching and Learning, University of Michigan, Best Practices for Designing and Grading Exams

http://www.crlt.umich.edu/P8_0

Chicago Center for Teaching, Designing Problem Sets

<http://teaching.uchicago.edu/teaching-guides/designing-problem-sets/>

Eberly Center for Teaching Excellence & Educational Innovation, Carnegie Mellon University

<https://www.cmu.edu/teaching/assessment/assesslearning/index.html>

Transparency in Learning and Teaching Project

<https://www.unlv.edu/provost/transparency>

Vanderbilt University Center for Teaching, Bloom's Taxonomy

<https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/>