The Gentle Art of Questioning

CONNECTING LEARNING GOALS AND ASSESSMENTS

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Our approach to course transformation

What should students learn?

Establish learning goals

Apply research-based teaching techniques.

Faculty & Staff

Which instructional approaches improve student learning?

Using Research & Assessment

What are students learning?

Measure progress!
At the end of this workshop

You will be able to...
- Communicate your learning goals for a particular topic
- Use Bloom’s Taxonomy to characterize your goals
- Write and evaluate assessments that are aligned with your goals

Let’s get our brains on topic

Reflect on a session / course / teaching experience that was really good.

How do you know that the experience was good?

*What evidence do you use to back up the claims of effectiveness?*

5 minutes
Example... consider finals

For a typical Physics 1 course are Grades and the Final Exam effective forms of evaluation of the course?

a) Yes
b) No
(c) It Depends

(What does “effective” mean?)

In order to care about assessment outcomes, you first need to establish course goals. What do you want to accomplish?

Instruction without goals....

Ready?

Fire!

Aim.
Outcomes should drive assessment & instruction

"Backwards design"

Atkin, Black, & Coffey 2001; Otero & Nathan 2008

But how do we measure outcomes?

- How do you know when you know something?
- How do you know when your students know something?
- How do your students know when they know something?

Buzzword: Metacognition
People often don’t know what they don’t know

AND/OR
Think they know something but don’t!

MISCONCEPTIONS
Private Universe
× (http://www.learner.org/resources/series28.html)

Misconceptions can drive instruction

If a camera crew making a documentary on student misconceptions were to question your students at the end of your course or the end of your degree program, what would you be most embarrassed to find out that they didn’t know?

These should be your top goals
Learning goals

- **Definition:** What students should be able to do after completing a course

- **Requirement:** Must be measurable
  \[\Rightarrow\text{assessment and goals tightly linked}\]

  ✓ Your goals should reflect what you value in student learning

  ✓ Often, students never know what your goals are!

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Learning Goals are different than a syllabus

**Syllabus/ Topic List**
- Material covered (and time spent)

**Learning goals:**
- Outcome and student oriented:
  - Defines what students are expected to learn
  - Identifies what students will be able to do as a result of learning

**Learning Goals (for a whole course) can be broad. At the topic or lecture level, the learning objectives should be more specific**
Goals at different levels

Course-scale learning goals
(~5 to 10 per course)

Topic-scale learning goals
(~2-5 per topic)

Class-scale learning goals
(~2-3 per class period)

Consistent & aligned

But what does “understanding” mean?

How do we define goals?

1. What are the different types of knowledge we want students to have?

2. At what level do we want that knowledge to be?
#1: Types of knowledge (learning goals)

**FACTS:**
Terminology, information, details

**CONCEPTS**
Classifications, categories, principles, models, reasoning.
Analyze, explain, and predict the world around you

**PROCEDURES:**
Skills, techniques, methods, problem-solving.
Thinking like a scientist: Use alternative representations, compare and contrast, strategize, justify, design an experiment, create a graph.

**METACOGNITIVE**
Self-awareness about what helps you learn; studying & learning strategies.

**AFFECTIVE (attitudes & beliefs):**
Appreciate, enjoy, value. Recognize that the behavior of the world around you is not magical and mysterious, but rather can be understood and predicted using certain fundamental principles.

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**Attitudes and Beliefs**

Survey (CLASS) to assess the “hidden curriculum” - beliefs about physics and learning physics

**Examples:**
- “I study physics to learn knowledge that will be useful in life.”
- “To learn physics, I only need to memorize solutions to sample problems”

Can we affect students’ attitudes & beliefs about physics?

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#2: Levels of knowledge
Bloom’s Taxonomy, 1956

What level of understanding do you want them to gain?

![Diagram of Bloom's Taxonomy]

**Higher-level cognitive skills**
- Synthesis & Evaluation
- Analysis
- Application
- Comprehension
- Knowledge

**Lower-level cognitive skills**
- Knowledge

EXERCISE #1

- Take one of your exams
- Or one of the ones I’ve provided
- Work in pairs to assign the questions on the exam to a Cognitive (Bloom’s) Level, and a Knowledge Type
- Put a tickmark in the box for each question in that category

**Type of Knowledge** | **Cognitive Process Level (Bloom’s)**
---|---
| 1 Remember | 2 Understand | 3 Apply | 4 Analyze | 5 Evaluate | 6 Synthesize |
A. Factual knowledge |
B. Conceptual knowledge |
C. Procedural knowledge (skills) |
D. Meta-cognitive knowledge |
E. Attitudes and beliefs |
**Intro Astronomy**

<table>
<thead>
<tr>
<th>Course-level learning goal</th>
<th>Class-scale learning goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content: Explain the role of natural forces in the universe</td>
<td>Analyze the phases of the moon by using computer simulations and constructing a model.</td>
</tr>
<tr>
<td>Skills: Interpret simulations and data</td>
<td></td>
</tr>
</tbody>
</table>

**Sophomore Mechanics**

Students should be able to...
Recognize equilibrium points on a plot of potential energy, U, and determine if these points are stable given the function U(x)

**Junior E&M**

Students should be able to sketch the physical parameters of a problem (e.g., E or B field, distribution of charges, polarization), as appropriate for a particular problem.
Check-list for creating **class-scale** learning goals:

- Is goal expressed in terms of **what the student will achieve** or be able to do?
- Is the **Bloom’s level** of the goal aligned with your actual expectations?
- Is the goal **well-defined**? Is it clear how you would measure achievement?
- Do chosen verbs have a **clear** meaning?
- Is **terminology familiar/common**? If not, is the terminology a goal?
- Is it **relevant and useful** to students? (e.g. connected to their everyday life OR does it represent a useful application of the ideas).

### Intro Physics

<table>
<thead>
<tr>
<th>Original L.G.</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand how energy, frequency and wavelength are related.</td>
<td>Low level. What is understanding? Explicitly encourages memorization.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New L.G.</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compare and contrast electromagnetic waves (e.g., gamma and radio) in terms of energy, wavelength, frequency, and relevant applications.</td>
<td>Higher level. Defines understanding. Encourages critical thinking as well as memorization.</td>
</tr>
</tbody>
</table>
Work on Learning Goals

- Individually, using an exam question that you brought with you (or simply a question in your head or one of ours), write a learning goal that this question would assess. (Keep a copy of this first try).

- Find a partner. Share your learning goals and questions with each other.

Does the level of your goal match the level of your question?
- Compare the current wording of the LG to the guidelines provided: identify the level of this LG
- If they do not match, revise the learning goal

Optional (if you finish)... Do you still like the question you started with?
- Is it at too high or too low a level?
- Write a variation on this question, and a complementary variation on the learning goal
- Aim for a higher level of Bloom's
- If your level was already high, aim for a lower level

Use handouts to help

How do we align goals and assessment?

Outcomes should drive assessment & instruction

Atkin, Black, & Coffey 2001; Otero & Nathan 2008
What assessments should I use?

To find the answer to that, you need to consider:

- What are assessments that align with my learning goals and key concepts?

- What kinds of outcomes can I measure?

“What are good questions?” is no longer a good question!?

Why do we assess / question?

- Gather evidence on student learning (evaluation)
- Improve a course
- Improve our teaching
- Improve society
- Get feedback on student understanding
- Elicit misconceptions
- Guide your own instructional decisions
- Make expectations clear to students
- Provide feedback to students
- Give students an opportunity to gauge their progress
- Help guide student studying and learning behavior
Some quotes on assessment

Assessment is more than grades, it is feedback for students and instructors and it drives student learning

(National Institute for Science Education, 1999)

Ongoing assessment plays a key role – possibly the most important role – in shaping classroom standards and increased learning gains”

– Black and Wiliam, 1998

THE MONTILLATION AND USES OF TRAXOLINE

It is very important to learn about traxoline. Traxoline is a new form of zionter. It is montilled in Ceristanna. The Ceristannians found that they could gristerlate large amounts of fervon and then bracter it to quasel traxoline. This new, more efficient bracterillation process has the potential to make traxoline one of the most useful products within the molecular family of lukizes snezlaus.

QUIZ:
1. What is traxoline?
2. Where is it montilled?
3. How is traxoline quaseled?
4. Why is traxoline important?

Assessments communicate your intent:
If you test them on facts, that is what they will study
EXERCISE #2: Frustrated Student

• Read the case study
• Discuss questions in groups of 4-5

• What issues might be contributing to this situation?
• Do the assessments give the student any feedback about what they understand while they are learning about this topic?
• What do the assessments motivate the student to learn?
• What effect this professor’s assessment will have on student behavior for the next test? Do you think that was the intention?
• What suggestions do you have for the professor?
• Have you faced a similar challenge?

Adapted from Handelsman, Miller & Pfund, 2007

When can we assess students?

• Course-scale: Before or after a course.
• Class-scale: Before, during, or at the end of a class

A bit of Jargon:

Formative vs. Summative Assessment
The various goals of questioning or assessing during class

**BEFORE**
Setting up instruction
- Motivate
- Discover
- Predict outcome
- Provoke thinking
- Assess prior knowledge

**DURING**
Developing knowledge
- Check knowledge
- Application
- Analysis
- Evaluation
- Synthesis
- Exercise skill
- Elicit misconception

**AFTER**
Assessing learning
- Relate to big picture
- Demonstrate success
- Review or recap
- Exit poll

Credit: Rosie Piller and Ian Beatty.

What are some assessment methods?

**FORMATIVE, IN-CLASS**
- Concept Tests / Clickers
- Minute Papers
- Just in Time Teaching
- Listening to student discussion in class
- Weekly / Daily Surveys
- White-boarding activities
- In-class work / Tutorials
- Case studies
- Ranking / ordering tasks
- Think-pair-share.
- Student-designed reading assessments

**SUMMATIVE EVALUATION**
- Quizzes
- Exams
- Oral presentations
- Poster symposia

**SUMMATIVE FEEDBACK**
- Conceptual surveys
- Attitude surveys

**FORMATIVE, OUT OF CLASS**
- Homework
- Discussion boards

OTHERS
EXERCISE #3: Compare and Contrast

- Work with 1-2 others to compare and contrast what students experience during two different types of assessment activities

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
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<tbody>
<tr>
<td>Each week, students are assigned a reading. All students take a 10-minute quiz that tests factual knowledge. Quizzes are handed in for points.</td>
<td>Each week, students are assigned a reading. All students generate a diagram or concept-map to illustrate the concept from the reading on their own. They explain their figure to each other in small groups for 10 minutes at the start of class. After discussion, they write a one-minute paper to explain what they learned. Diagrams and papers are handed in for points.</td>
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How does the assessment motivate students to learn the material or figure out the concepts they don’t understand?

How does the assessment capitalize on the diversity of learners?

Does the assessment help students gauge what they know (how well) they understand the key learning goals?

Does the assessment build skills in giving and receiving critical feedback (learning how to learn)?

Write your own questions here:

Example alignment:  Sophomore mechanics

LG:
Recognize equilibrium points on a plot of potential energy, U, and determine if these points are stable given the function $U(x)$

Assessment:
Below is a plot of potential energy in Joules, of a particle free to move in 2D.

For which of these points (A-F) is the particle in stable equilibrium? Please explain how you arrived at that answer.
Alignment—an example:

**Broader Learning goals:**
- Use graphs as part of thought processes
- Recognize equilibrium points & determine if stable

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<tr>
<th>Measurable Outcomes</th>
<th>Formative Assessment (Instruction)</th>
<th>Summative Assessment (Exams)</th>
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<tbody>
<tr>
<td>Interpret graphs of potential energy</td>
<td>Tutorial with topographic maps. Where will dislodged boulder roll? Relate to U.</td>
<td>Which of these points is stable? Why?</td>
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How do we align goals and assessment?

Atkin, Black, & Coffey 2001; Otero & Nathan 2008
What should we do last?

A. Work on writing aligned questions, assessments, & instruction

B. Talk about grading

EXERCISE #4: Alignment

Use the exam questions and learning goals you used before to draft two aligned learning goals, activities, and assessments.

<table>
<thead>
<tr>
<th>Learning goal (where are you going?) From previous activity</th>
<th>Likely student prior knowledge/ misconceptions (Where are you at?)</th>
<th>Example learning activity = formative assessment (How are you going to get there?)</th>
<th>Summative / formative assessment question (Are we there yet?) From exam or write a new one</th>
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10 minutes
EXERCISE #5. Case: Grading

Work in groups of 3-4 to discuss the case study and associated questions.

10 minutes
Questions?

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Much more at:

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