OBJECTIVELY SPEAKING*

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Student A: "*Buffo's first test is next Monday. I haven't had him before—can you just plug into formulas on his exams or does he make you do derivations and stuff?"*

Student B: "*There's no telling—last fall most of his questions were straight substitution but a couple of times he threw in things I never saw in the lectures."*

Student C: *"Yeah, and if you ask him what you're responsible for on the test he just gets mad and gives you a sermon on how bad your attitude is…we had a 600-page textbook and according to Buffo we were supposed to know everything in it."*

Student A: "*Forget that—no time. I'll just go through the homework problems and hope it's enough*."

You can often hear conversations like that in the student lounge, and if you step across the hall to the faculty lounge you'll hear their counterparts.

Professor X: "*All these students can do is memorize—give them a problem that makes them think a little and they're helpless*."

Professor Y: "*I don't know how most of them got to be sophomores. After my last exam some of them went to the department head to complain that I was testing them on things I never taught, even though the chapter we just covered had everything they needed to know.*"

Professor Z: "*It's this whole spoiled generation—they want the grades but don't want to work for them!"*

Things are clearly not going quite the way either group would like. Many students believe that their primary task in a course is to guess what their professors want them to know, and if they guess wrong they resent the professors for being unreasonably demanding, tricky, or obscure. Professors then conclude that the students are unmotivated, lazy, or just plain dumb.

There is another way things can go. Suppose you hand your students a preview of the kinds of problems they will be expected to solve, including some that require real understanding, and then include such problems on homework assignments and tests. Since they will know up front the things you want them to do and will have had practice in doing them, most of them will be able to do them on the tests—which means they will have learned what you wanted them to know. Some professors might regard this process as "spoon-feeding" or "coddling." As long as you maintain high expectations, it is neither. It is successful teaching.

Instructional Objectives

An effective way to communicate your expectations is by giving your students *instructional objectives,* statements of specific observable actions they should be able to perform if they have mastered the course material. An instructional objective has one of the following stems:

* *Chem. Engr. Education, 31* (3), 178-179 (1997).

- *At the end of this [course, chapter, week, lecture], you should be able to* ***
- *To do well on the next exam, you should be able to* ***

where *** is a phrase that begins with an action verb (e.g., *list, calculate*, *solve*, *estimate*, *describe*, *explain*, *predict*, *model*, *design*, *optimize*,…). Here are some examples of phrases that might follow the stem of an instructional objective, grouped in six categories according to the levels of thinking they require.[1]

1. **Knowledge** (repeating verbatim): *list* [the first ten alkanes]; *state* [the steps in the procedure for calibrating a gas chromatograph].
2. **Comprehension** (demonstrating understanding of terms and concepts): *explain* [in your own words the concept of vapor pressure]; *interpret* [the output from an ASPEN simulation].
3. **Application** (applying learned information to solve a problem): *calculate* [the probability that two sample means will differ by more than 5%]; *solve* [the compressibility factor equation of state for P, T, or $\hat{V}$ from given values of the other two].
4. **Analysis** (breaking things down into their elements, formulating theoretical explanations or mathematical or logical models for observed phenomena): *derive* [Poiseuille's law for laminar Newtonian flow from a force balance]; *explain* [why we feel warm in 70^{o}F air and cold in 70^{o}F water].
5. **Synthesis** (creating something, combining elements in novel ways)**:** *formulate* [a model-based alternative to the PID controller design presented in Wednesday's lecture]; *make up* [a homework problem involving material we covered in class this week].
6. **Evaluation** (choosing from among alternatives and justifying the choice using specified criteria): *determine* [which of the given heat exchanger configurations is better, and explain your reasoning]; *select* [from among available options for expanding production capacity, and justify your choice].

Why Bother?

Well formulated instructional objectives are more than just an advance warning system for your students. They can help you to prepare lecture and assignment schedules and to spot course material that the students can do little with but memorize and repeat. They also facilitate construction of in-class activities, out-of-class assignments, and tests: you simply ask the students to do what the objectives say they should be able to do. A set of objectives prepared by an experienced instructor can be invaluable to someone about to teach the course for the first time and can help instructors of subsequent courses know what their students should have learned previously. If objectives are assembled for every course in a curriculum, a departmental review committee can easily identify both unwanted duplication and gaps in topical coverage, and the collected set makes a very impressive display for accreditation visitors.

[1] The six given categories are the levels of Bloom's Taxonomy of Educational Objectives [B.S. Bloom, *Taxonomy of educational objectives. 1. Cognitive domain*. New York, Longman, 1984]. The last three categories—synthesis, analysis, and evaluation—are often referred to as the *higher level thinking skills.*

Tips on Writing Objectives

- *Try to write instructional objectives for every topic in every course you teach*. Take a gradual approach, however—you don't have to write them all in a single course offering.
- *Include some objectives at the levels of analysis, synthesis, and evaluation.* They are not that hard to write, even in undergraduate courses,[2] but if you don't consciously set out to write them you probably won't.
- *Avoid four leading verbs in instructional objectives: know, learn, appreciate, and understand*. You certainly want your students to do those things but they are not valid instructional objectives, since you cannot directly see whether they have been done. Think of what you will ask the students to *do* to demonstrate their knowledge, learning, appreciation, or understanding, and make those activities the instructional objectives for that topic.

Formulating detailed instructional objectives for a course or even for a single course topic takes effort, but it pays off. When we have asked alumni of our teaching workshops to rate the usefulness of the instructional methods we discussed, instructional objectives ranked second only to cooperative learning. Many professors testified that once they wrote objectives for a course—sometimes one they had taught for years—the course became more interesting and more challenging to the students and more enjoyable for them to teach.[3]

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[2] Examples of higher-level questions are given by Felder ["On Creating Creative Engineers," *Engr. Education, 77*, 222 (1987)] and Brent and Felder [Writing Assignments—Pathways to Connections, Clarity, Creativity," *College Teaching, 40*(2), 43–47 (1992)].

[3] For more information about objectives, see N.E. Gronlund, *How to write and use instructional objectives* (4th ed.) New York, Macmillan, 1991. For examples of their use in engineering education, see J.E. Stice, "A first step toward improved teaching," *Engineering Education, 66*(5), 394 (1976).