The Lingo of Learning

88 Education Terms Every Science Teacher Should Know

Alan Colburn

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He has taught high school classes in physical science, chemistry, and AP chemistry. Much as he enjoyed teaching on that level, he ultimately found working at the college level to be a better fit for his varied interests. In his current position, which he has held since 1995, he supervises student teachers and teaches courses for elementary, middle, and high school teachers, college students, and graduate students. He also spearheaded the development of a new master's program in science education. He has authored 22 publications—not including this book—and given 38 professional presentations. Five of the publications were in National Science Teachers Association journals.

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Preface

I am a university science educator. I spend my days communicating with other university science educators. I even married a science educator! As you might imagine, the language of professional education is commonplace to me. It sounds like gobbledygook to the rest of the world, but I'm not fazed to hear someone say, "Research supports constructivist teaching practices as a means to increase student achievement, when assessed authentically."

I know that I'm an exception to the rule, though. People hear this kind of talk and think of it as fancy language meaning little or obscuring commonsense ideas. Just between us, I've occasionally even thought this myself.

But I also know that the specialized vocabulary used by my colleagues represents important ideas. Sometimes I've felt this use of language was unfortunate because it created a virtual wall between the researchers who created new knowledge and the teacher audience for whom the work was ultimately intended. This book was born from that kind of thinking. I wanted to write something that would bridge that virtual wall, connecting those who do and don't regularly engage in what some have come to call "educational jargon."

The book that follows discusses 88 terms. It's meant to give readers an introduction to each of these ideas, providing more than a dictionary or glossary, but still something that can be read and understood quickly. The book is divided into chapters by topics, and I tried to write each chapter so that a reader could profitably read the chapter from start to finish and get an overview of a key area in science education.

I wrote the work with teachers in mind—prospective teachers in education courses, practicing teachers in workshops, all National Science Teachers Association (NSTA) members, and indeed anyone interested in better understanding professional education. I hope you find it understandable, useful, and enjoyable.

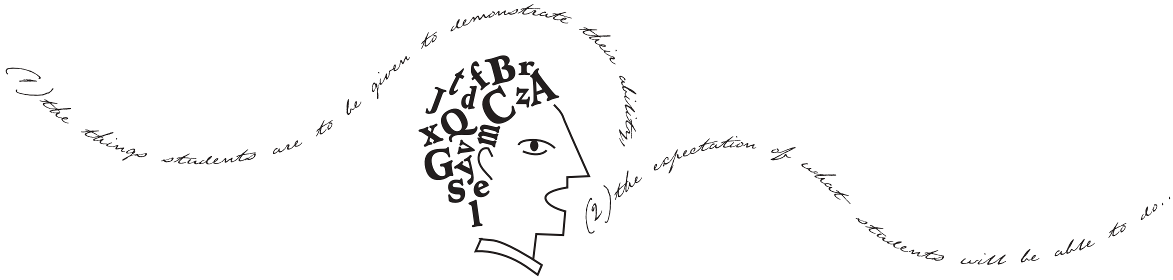
In each chapter I tried to include a few references that interested readers could turn to if they wanted to learn more about the chapter's topics. Many resources are available; I had to make decisions about what references to include. I tried to choose articles and books that would be relatively easy for readers to find. If you are reading this, then you are probably a member of NSTA, or know somebody who is. As such, I concentrated on NSTA-published resources in my suggestions for further reading—I thought they would be easier for you to find than other resources. I included many references that are available on *NSTA Pathways to the Science Standards: Resources for the Road CD-ROM*. (This CD contains copies of hundreds of articles.) Of course, many other equally good resources are also available. We live in an age where access to professional literature has never been easier.

Finally, some thanks are due. Writing a book, no matter the length, is a daunting task. Judy Cusick and the folks at NSTA Press have been very supportive throughout the process. Besides offering occasional editing and advice, my wife has also been my biggest cheerleader—seemingly happy to hear endless recitations about how many words I wrote each day. And, finally, there are my parents. My dad wrote *Physical Science Made Easy* more than 50 years ago. Somehow it seems fitting that I would write this book, which bears a few similarities, since he has been my life template in so many ways. This book is better, though—and my mother's influence has something to do with that. As she would be the first to tell you, I've come a long way since the sixth-grade report where I tried to tell readers everything there was to know about the U.S. Air Force in five pages. In the pages that follow I certainly don't try to tell you everything—just enough to get you started.

Chapter

1

Educational Outcomes



At the beginning of the 21st century, education seems dominated by talk about educational outcomes and their assessment. This chapter, along with the chapter on assessment, serves to demystify these topics.

In truth, outcomes are easy to understand. Several related terms describe what students should learn—how they should be different at the end of a lesson, unit, or course when compared to the beginning of the instruction. Terms about outcomes simply differentiate types of learning and specificity levels—from broad outcomes down to specific "factoids."

objective The idea of an objective in education comes from the concept of the *behavioral objective*. Behavioral objectives grew out of the 20th century learning theory called *behaviorism*. One of the theory's major tenets is that the only things that can be assessed educationally are those that can be directly observed. Thus, behavioral objectives represent observable educational outcomes—what students should do.

The traditional behavioral objective, as taught to a generation of teacher education students, has three parts: (1) the things students are to be given to demonstrate their ability, (2) the expectation of what students will be able to do, and (3) how well the students are expected to perform to be considered competent. Example behavioral objectives might be "Given a periodic table, students will be able to determine the formulas for ionically bonded compounds with 80 percent accuracy" or "Given experimental data and graph paper, students will be able to construct a graph with all data plotted accurately." (In the latter example, the "all" serves as the criterion for how well students are expected to perform.)

Behavioral objectives stated this rigorously are less common today than they used to be. However, the concept is still alive and well. Objectives are statements about what students should know or be able to do, usually after a relatively brief period of instruction, such as a teacher-led lesson or the silent reading of a passage in a textbook. Because objectives help you think through what you want your students to be able to do, they're helpful as a starting point for thinking about how to teach a lesson. They're also helpful as a place to begin thinking through how you want to assess students after a lesson or unit. Ideally, the various objectives, teaching methods, and assessments should be highly congruent.

benchmarks The concept of the benchmark (or bench mark) has, of course, existed on its own for a long time. In recent times, in science education, the term has been most closely associated with *Benchmarks for Science Literacy* (AAAS 1993), a publication of the American Association for the Advancement of Science. In that publication, the authors note a dictionary's definition for "bench mark"—"a standard or point of reference in measuring or judging quality, value, etc." (317). They go on to say that their benchmarks "are offered as reference points for analyzing existing or proposed curricula in the light of science-literacy goals" (317) and that they are using the word for the goal statements in their report.

It's difficult to distinguish benchmarks from standards. To AAAS, at least, the distinction between a standard (see next entry) and a benchmark is that the benchmark is essentially a goal *statement*, whereas the standard is closer to a *measure* indicating that a learner has minimum competency in understanding or mastering the benchmark. Thus, a benchmark about students understanding the content of a science discipline might correspond to a standard of students earning some minimum score on a standardized test.

Readers must understand, however, that many people use the terms "standard" and "benchmark" synonymously. Others talk about benchmarks as being checkpoints to be assessed or mastered along the way toward mastering larger standards. Thus, when people are talking about standards and benchmarks, it may be useful for listeners to ask speakers to clarify what they mean by the two terms.

Clarification may also be needed to distinguish benchmarks from objectives. Again, people sometimes use the terms synonymously. However, objectives (or behavioral objectives) often refer to a smaller or more specific educational out-come; a benchmark could be subdivided into a number of objectives. Thus, as used by many, standards are broader than benchmarks, and benchmarks are broader than objectives.

standards At the dawn of the 21st century, the word "standard" is probably the most often heard educational term around. Everyone seems to talk about standards, often with the adjective "higher" placed before the word. With so much use, the term's meaning has become somewhat diffused. For this book, I turned to the two most important among the current national science teaching reform documents.

According to the *National Science Education Standards* (NRC 1996),

> *[t]he term "standard" has multiple meanings. Science education standards are criteria to judge quality: the quality of what students know and are able to do; the quality of the science programs that provide the opportunity for students to learn science; the quality of science teaching; the quality of the system that supports science teachers and programs; and the quality of assessment practices and policies. Science education standards provide criteria to judge progress toward a national vision of learning and teaching science….* (12)

The other major science education reform document, the American Association for the Advancement of Science's *Benchmarks for Science Literacy* (1993), has a more specific definition of the term:

> *A standard, in its broadest sense, is something against which other things can be compared for the purpose of determining accuracy, estimating quantity, or judging quality. In practice, standards may take the form of* requirements *established by authority,* indicators *such as test scores, or* operating norms *approved of and fostered by a profession.* (322)

The concept of a standard is closely related to other assessment concepts. Whether assessing summatively or formatively (see Chapter 5, "Assessment"), the assessor needs *something* against which to compare the "assessee's" performance. Standards represent that "something." (However, note the previous entry on benchmarks, too. People often use the terms "standards," "benchmarks," and "objectives" interchangeably. "Goals," "aims," and "outcomes" are other terms people sometimes use synonymously with those just mentioned.)

Bloom's taxonomy has its origins in the same era that brought behavioral objectives. It was established as a taxonomy of cognitive knowledge—a way to distinguish "lower-order" thinking from "higher-order" thinking. It is still a popular way to categorize knowledge and think about educational outcomes. When people talk about "higher-order thinking" they are often speaking about the three or four highest levels within Bloom's taxonomy.

Although Benjamin Bloom originally discussed other kinds of knowledge, the taxonomy that bears his name is concerned specifically with cognitive (thinking) knowledge. Bloom's taxonomy divides knowledge into six categories. From lowest to highest order, the categories are *knowledge, comprehension, application, analysis, synthesis,* and *evaluation.*

Knowledge, or rote-level knowledge, describes information that has, essentially, been memorized. The knowledge may or may not mean much of anything to the learner. Knowing that the letters Hg on a periodic table stand for mercury, that salamanders belong to the class Amphibia, or that the Greek letter μ stands for one millionth is each an example of information at the rote knowledge level of Bloom's taxonomy. Reciting a memorized definition of the term "benchmark" also represents knowledge-level understanding.

Comprehension, on the other hand, represents understanding at a slightly deeper level. It means being able to explain an idea in one's own words—rather than, say, repeating a memorized definition (which would still be knowledge-level learning). Being asked to define a benchmark in one's own words would be an example of a comprehension-level question. The idea is that using one's own words to define or explain something represents a higher level of understanding than merely repeating a memorized definition.

Application refers to understanding something well enough to apply it to a new situation. Many educators consider this to be the true test of whether students really understand concepts. Problem solving is often application level. Making predictions about what one thinks will happen in a particular situation is also considered to require application-level understanding.

Analysis, in this case, implies the kind of understanding required to take a complex idea or issue and break it down to component parts. *Synthesis,* on the other hand, is about combining ideas to come up with new conclusions, implications, or other ideas. Finally, *evaluation* is about critically appraising a complex idea or issue—not merely saying something is "good" or "bad," but having well-thought-out justifications for the evaluation.

As an example, here are sample questions about frogs at each level of Bloom's taxonomy:

Knowledge	To which kingdom, phylum, and class do frogs belong?
Comprehension	How are frogs able to live in water (as tadpoles) and on the land (as adults)?
Application	How would you prepare an environment to grow frogs?
Analysis	How are frogs and fish alike? How are they different?

Synthesis	What could you do to find out how many frogs live around a particular lake?
Evaluation	Which of your classmates do you think had the best method to find out how many frogs live around a lake? Why do you think so?

affective domain This phrase refers to students' attitudes, interests, and values. Generally applied to particular subject matter, or school in general, the affective domain is that part of education concerned with emotion. The affective domain is often contrasted with the cognitive domain when thinking about assessment or teaching. "Cognitive domain" (or "cognitive outcomes") refers to thinking—things such as learning facts or concepts, applying ideas to new situations, and thinking critically.

"Affective domain" (or "affective outcomes"), on the other hand, refers to things such as the extent to which students like science (or school), aspects of science students like or dislike most, thoughts about the place of science in society, and appreciation of the values of science.

Affective outcomes are quite difficult to assess meaningfully for individual students, because students will respond in ways to please their teachers. In most classrooms it wouldn't be an accurate assessment to have an exam question that read, "Do you like science? (a) yes (b) no." Students might say yes, even if they would more honestly respond no.

However, affective outcomes can be assessed honestly and accurately. Teachers can find out, for example, whether students tended to like science more at the end of a class than they did at the beginning of the class. Teachers can also use affective data to improve their instruction. For example, teachers can determine students' attitudes toward different instructional activities, such as those that are conducted in the science lab. Armed with information, teachers can tailor classes to best fit their students' attitudes.

science literacy is a catchall term used by many educators and scientists. As such, no single definition fits perfectly. However, I think "science literacy" is best defined as the knowledge, skills, and dispositions needed by all informed citizens to function effectively in our society.

Notice that the definition includes "knowledge, skills, and dispositions." This means science literacy is not only about facts, concepts, and their application, but also about science-related skills and the affective domain (see above entry). A scientifically literate individual understands what science is and likes it, or at least appreciates it.

Note also that the definition mentions "all informed citizens." The implication here is that scientific literacy is about the science required by everyone—not just college-bound students or future scientists, for example. People can argue whether the college-bound student or prospective scientist should have a different kind of K–12 science education than others, but scientific literacy refers to science appropriate for and required by all.

REFERENCES & FURTHER INFORMATION:

Just about any science methods textbook will include discussion about various educational outcomes, as well as Bloom's taxonomy. A good place to learn more about standards, benchmarks, and other aspects of science education outcomes would be the key national documents on this topic, Project 2061's Benchmarks for Science Literacy *and the* National Science Education Standards. *Both documents are discussed in Chapter 10, and both are available online:*

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for Science Literacy*. New York: Oxford University Press. [available online at *http://www.project2061.org/tools/benchol/bolframe.htm*]

National Research Council (NRC). 1996. *National Science Education Standards*. Washington, DC: National Academy Press. [available online at *http://search.nap.edu/html/nses/html/*]

For a shorter introduction to these documents, see:

Close, D. et al. 1996. National Standards and Benchmarks in Science Education: A Primer. *ERIC Digest*. [available online at *http://www.ed.gov/databases/ERIC_Digests/ed402156.html*]

The January 2000 issue of Science and Children *(vol. 37, no. 4) had several articles related to standards, including the following:*

Demers, C. 2000. Analyzing the standards. *Science and Children* (Jan.): 22–25.

Dillon, N. 2000. Sowing the seeds of the standards. *Science and Children* (Jan.): 18–21.

Kelly, C. A. 2000. Reaching the standards. *Science and Children* (Jan.): 30–32.

Stearns, C., and Courtney, R. 2000. Designing assessments with the standards. *Science and Children* (Jan.): 51–55.

Finally, the concept of science literacy is discussed at length in Science for All Americans, *the AAAS book that preceded* Benchmarks*:*

American Association for the Advancement of Science (AAAS). 1991. *Science for All Americans*. New York: Oxford University Press. [available online at *http://www.project2061.org/tools/sfaaol/*]