Choosing Content That’s Worth Knowing

The questions of what, how, and why content in any academic discipline should be taught challenge educators. The fields of science, mathematics, and technology provide a framework for discussion.

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Most 3rd graders spend a fair amount of their science time exploring with batteries, wires, and light bulbs. Educators hope that they will learn about series, parallel electric circuits, and scientific inquiry. Students are likely to revisit these concepts in middle school and in high school. Yet research shows that, despite the time and effort spent teaching this lesson, students still don’t understand much about electricity (Osborne, 1983; Shipstone, 1984). A classic video shows Harvard and Massachusetts Institute of Technology (MIT) graduates unable to light a bulb with a battery and wire. One frustrated young man hands back the equipment with the comment “I’m a mechanical engineer, not an electrical engineer” (Private Universe Project, 1989).

In another video, an MIT graduate has failed to grasp the fundamental idea that plants make their own food from the carbon dioxide in air and water, using and storing energy from light in the process (Private Universe Project, 1989). “Carbon is not much of a building block from what I know of biochemistry,” he says. The same student tosses off the phrase “photosynthetic version of the electron transport chain” in a futile effort to explain where the matter in trees comes from. (It comes mostly from the carbon dioxide in the air.)

These two examples remind us that even our best students may not be learning what we think they are, whether in science or any other domain. Students engage in futile lessons that attempt to teach difficult concepts in too short a time or in classes that substitute facts and vocabulary for understanding. The examples call into question basic assumptions about what and how we teach and what and how students learn, and they challenge our notions about the goals of education and the roles of teacher and learner.

Consider these often-asked questions: What specific knowledge and skills should all students learn? How do we
decide what is in or out of the curriculum? Should all students learn the same content, or should it differ for those with different aspirations, abilities, and interests? And if we agree that we want students to have more than a temporary acquaintance with important concepts and skills, how do we modify the curriculum so that there is adequate time for in-depth learning? And how do we assess that kind of learning? Finally, how do we incorporate the growing body of research that indicates that the most effective teaching strategies are highly content-specific—that content and instruction are inseparable—into our decision making (National Research Council, 2000)?

Answering these and other difficult questions reveals the underlying tensions in the curriculum. Let's explore some of the issues that arise when deciding what and what not to teach. Examples come from Project 2061's area of expertise—mathematics and science—but the discussion applies equally well to any subject.

**Why Worry About Content?**

Before we can think about the what and the why of the curriculum, we need to be clear on the why. Stating exactly what the curriculum is supposed to achieve is essential to defining who should learn what. Curriculum goals might include more students achieving higher scores on the state-wide tests or increased acceptance rates to prestigious universities. Thinking more about students, we may expect the curriculum to prepare students to succeed in the workplace, help them become well-informed and thoughtful citizens, and allow them to participate in—or at least appreciate—the broad spectrum of human cultural activities, from exploring the ultimate fate of the universe to new directions in the arts.

Project 2061's goal has been to identify the knowledge and habits of mind that make up literacy in science, mathematics, and technology. Adults today need such literacy to live interesting, responsible, and productive lives. By defining the desired outcome first, we established that these learning goals should not be constrained by the traditional content that was reflected in the curriculum or textbooks in the United States and other countries, but should instead reflect the most useful content in broad personal and social contexts. To that end, we asked panels of experts from science, mathematics, and technology to recommend a common core of learning for every high school graduate that would meet five key criteria (American Association for the Advancement of Science, 1989):

- **Utility.** Will the knowledge or skill significantly enhance long-term employment or educational prospects and personal decision making?
- **Social responsibility.** Will the content help citizens participate intelligently in making social and political decisions?
- **Intrinsic value of the knowledge.** Does the content have pervasive cultural or historical significance?
- **Philosophical value.** Does the content help individuals ponder the enduring questions of what it means to be human?
- **Childhood enrichment.** Will the content enhance the unique experiences and values of childhood?

It would be interesting to see how these science-related criteria compare to those used to make decisions about content in other subject areas. Surely a common set of overarching criteria for making decisions across the curriculum would be enormously helpful to educators.

**Who Is "All"?**

Whatever the curriculum goals may be, we must be clear about which students the goals are to serve. When we say all students, do we mean the top 15 percent, the 50 percent who might go on to higher education—or do we really mean all students?

In *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993), Project 2061 states its expectation that all students will be able to reach the learning goals recommended as core content in science, mathematics, and technology. Some critics worry that benchmarks aimed at all students are not ambitious enough. But by virtually every measure available, we know that most students—even highly talented ones—are not reaching even basic literacy levels. A more popular strategy might be to fall back on current practice by asking for more than we think most students can achieve and then settling for less, but why not specify precisely what is intended, with the expectation that average students will eventually surpass these goals and outstanding students will leave them far behind?

Preparing students for success in life and for getting into the "right" college, for example, need not be mutually exclusive. It is a shame that teachers must ask, as one teacher in a recent workshop did, "Should I be teaching for understanding or for achievement?" Research on learning encourages optimism, finding that there are new ways to introduce students to traditional subjects, such as mathematics, science, history, and
A classic video shows Harvard and MIT graduates unable to light a bulb with a battery and wire.

each subject each day adds up to 120 hours of useful instruction in each subject each year, which ideally would be optimized for each student’s developmental stage and learning style. Translate that into a typical adult context—three 40-hour work weeks dedicated to each subject each year—and the problem becomes clear. Few of us would be able to master complex subject matter so quickly. How much can we reasonably expect all students to learn in that time?

Research gives us some insight into how long it takes to teach for understanding rather than memorization, and it is a lot longer than our current ideas about learning lead us to think. For example, with six weeks of careful instruction, 50 percent of 6th graders could learn some concepts related to the fact that matter is made of very small atoms that are always in motion (Lee, Eichinger, Anderson, Berkheimer, & Blakeslee, 1993). In another study, most 8th graders were able to learn the difference between heat and temperature on a conceptual level after 13 weeks of dedicated instruction in thermodynamics concepts (Linn & Songer, 1991).

Coverage or Learning?
Nevertheless, many educators continue to cover the content in the books, and their students continue to memorize the related vocabulary and algorithms—an inefficient and ineffective mention-and-move-on instructional strategy. U.S. schools and colleges devote huge amounts of classroom time to reviewing and reteaching the same material every
year because students don’t learn it the first, second, or third time. In the batteries-and-bulbs lesson described earlier, for example, researchers found that students had learned very little, even after multiple exposures to the topic. Recent evaluations of science and mathematics textbooks reveal similar weaknesses; most texts ignored or obscured the most important ideas by focusing instead on technical terms and trivial details (American Association for the Advancement of Science, 2000).

Too often students engage in futile lessons that attempt to teach difficult concepts in too short a time or in classes that substitute facts and vocabulary for in-depth understanding.

If learning is the goal, and even the brightest students take more time to learn than is commonly thought, then the curriculum must be pared down to give students time to focus on a coherent set of the most important ideas and skills. Coherence is the key to helping students build the conceptual frameworks that help them retrieve knowledge and transfer knowledge to new contexts (American Association for the Advancement of Science, 2001a). These cognitive abilities provide a foundation for continuous learning that should be the goal of education in all subject areas. Unfortunately, according to a recent report from the National Research Council (2000), “many models of curriculum design seem to produce knowledge and skills that are disconnected rather than organized into coherent wholes” (p. 138). In differentiating between novice learning and expert learning, the report notes that “it is the network, the connections among objectives, that is important” (pp. 138–139). Research also finds that superficial coverage of many topics of major topics, subtopics, and technical vocabulary taught, and eliminating needless redundancy can free valuable time for students to learn more important ideas and skills (American Association for the Advancement of Science, 2001b). Paring down the content and focusing on achieving a common set of learning outcomes does not in any way prescribe a boring, back-to-basics curriculum. There are many ways to get at the important ideas. Creative curriculum design can actually increase local curriculum diversity, while achieving common learning goals.

Where Are We Now?

Today’s education policies, as embodied in state standards and tests, university admission requirements, teacher education programs, and textbook adoption decisions, take little advantage of the insights that research and experience can provide in addressing the questions raised here. There is a disconnect between what we know about effective teaching and learning and the policies that govern them. As a result, many talented and dedicated teachers try hard on their own to make improvements, with little support or encouragement. These are the very teachers we can least afford to lose, and yet their efforts go unrecognized and unrewarded.

A teacher who has worked with Project 2061 and has received extensive professional development in teaching for understanding wrote to us:

I’m trying to teach so my students really get key concepts. As a result, I’m way behind... Because I haven’t become the master teacher of my dreams yet, I’m spending significant amounts of time reteaching skills and content and am frustrated at how little my students actually understand. Had I used the old model exclusively, I would have had a more predictable year, and I could have soldiered along never knowing how little my students actually knew. This frustration and lack of success is a good thing... Seeing the truth of my students’ understanding can be the start of my own classroom reform efforts.

As science, mathematics, and technology educators, we know that this teacher’s experience is not unique. Teachers in other disciplines have to struggle daily with these same teaching and learning issues. The fact is, these are policy issues—not classroom issues—and need to be resolved in the university admissions office and the statehouse, not the schoolhouse. By working toward uniformly clear goals and expectations across the disciplines, taking into account all of the constraints and trade-offs, and bringing to bear the necessary resources—time, materials, and professional development, for example—we can educate all students for a deep understanding of important content. Such policies can help all students achieve the basic literacy that prepares them to lead interesting and productive lives, whether they choose to go into the workplace or to college. Our best students will also benefit—
there is no excuse for an engineer who can't light a light bulb.

References


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