COMMENTARY

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STEM as a Curriculum

An Experiential Approach

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It seems as if the topic of student performance in the STEM subjects—science, technology, engineering, and mathematics—has been with us forever. The level of rhetoric may have diminished somewhat, as the economy's free fall leaves us wondering what the employment future will look like, but concern about STEM education is a constant. While some may question current workforce needs for highly trained people in these fields, no one doubts that an education in STEM subjects is the ticket to a decent-wage-paying career in the economy of the 21st century.

Because of this economic reality, access to a high-quality STEM education is no longer simply an academic issue, but a matter of equity as well. And how the country responds to it is important for us all.

Unfortunately, too much of the nation's resolve in this area has amounted to arm-waving about the need for more students to be moving through the STEM pipeline toward graduation, and tsk-tsking about the poor performance of American students in the individual STEM subjects on international assessments. Very little energy has gone into determining how to do things differently in schools.

That's not to say there isn't a general understanding about how to teach STEM subjects more effectively; there is. But it struggles to be heard. It is an understanding, moreover, that encompasses *all* students, including those considered to be nontraditional science and math candidates—precisely the group we must draw from for growth in the STEM pipeline.

This understanding of how best to teach STEM subjects to all is based on the proposition that experiential learning is the ideal instructional vehicle and will appeal in particular to students who ask: "Why do I need to learn this stuff? What's it for? What can I do with it?" Lacking good answers to these questions, such students may tune out school entirely. But effective STEM teaching can counter this impulse. It recognizes that learning occurs most easily when students genuinely interact with ideas.

We must first recognize STEM as a unitary idea, not simply a grouping of the four disciplines in a convenient, pronounceable acronym. The University of Maryland engineering professor Leigh R. Abts has used the term "metadiscipline" to describe STEM, meaning a realm of knowledge that speaks to the presentation of technical subjects as they exist in the natural world, part and parcel of each other. This approach breaks down the boundaries of disciplines devised by and for academia, our historical taxonomy of learning reinforced by Charles W. Eliot and the National Education Association's Committee of Ten in the late 1800s.

Organizing knowledge into disciplines may be useful for research, for delving deeply into the secrets of any natural phenomenon, or for dividing up knowledge into teachable chunks. But it does not reflect the reality or convey the excitement of the world we live in. Neither does it help lead students toward inquiry's counterpoint: solving problems by applying knowledge to design solutions. This is what students will be called on to do in the workplace and in life.

This important point—that problem-solving is interesting to most students—reflects John Dewey's thoughts on the value of experiential learning, and runs counter to the viewpoint prevalent in the 1950s that experiential learning equals career education equals vocational education. Parents railed against that vocational bent, believing their children were all college material and needed to learn in so-called Carnegie units, as required for college admission. Their kids were certainly not in school to be prepared for a career down at the plant.

So our second essential point is this: Effective teaching and learning in both STEM and career and technology education are, practically speaking, the flip sides of the same coin.

Examples of successes in career and technical education, or CTE, include, most notably, the Philadelphia public schools, where students in 34 career academies have achieved a 90 percent graduation rate, 60 percent of those graduates going on to college. An evaluation of the career-academy approach by the research organization MDRC suggests that these schools produce "substantial and sustained improvements in the post-high-school labor-market outcomes of youth."

Another example is the Ford Partnership for Advanced Studies program, launched in 2004 by the Ford

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Motor Company Fund to help communities develop career-academy networks. It enlists the kind of community support that is needed for career academies to succeed, and its efforts are beginning to show remarkable results.

A recent issue of *Maryland Classroom*, a publication from the Maryland Department of Education, reports that more than half of those who completed a CTE program in that state "also completed a rigorous academic program that meets the University System of Maryland's entrance requirements." Of equal interest were findings that students in some career clusters—health occupations, graphic design and commercial art, pre-engineering, business-systems analysis and design, and computer programming—outperformed all students, taken as a whole, in Algebra 2, and that students in environmental science/natural resources, pre-engineering, and health occupations outperformed all students in completion of four science credits.

For parents concerned that their career-minded children are being tracked into "voc ed," these results suggest that student engagement in STEM-related career-and-technical education does not come at the cost of academic coursework, and may actually enhance achievement in those courses.

Some states have begun the Herculean effort required to embed this kind of STEM education in their school systems. And Herculean is the right word, for putting in place a multidisciplinary, experiential approach to learning can be as difficult as cleaning the Augean stables.

Our group, the Teaching Institute for Excellence in STEM, or TIES, has been involved in the creation of the Texas STEM network, a system of seven centers for innovative instruction in STEM subjects and 35 (soon to be 43) STEM schools. We also participated in the development of the Ohio STEM Learning Network, and are working in California, Maryland, New York, and North Carolina. Our observation is that these efforts must be homegrown to succeed. Success will demand, for example, that the community make internships available to all students who need or want them, which requires a level of business and community engagement in local schools beyond what we have experienced in this country before.

It's worth the effort. Research tells us that students in career academies outperform their non-academy peers in a number of categories, including grade point average, test scores, and graduation rates, and that they have lower "scores" in such attitudinal categories as dropout rates, suspensions, and expulsions.

Educators know how to teach STEM. Were they to put this knowledge into action, transforming our instructional approach to these related subjects throughout the nation's schools, the pipeline issues would take care of themselves. And access to STEM careers would open up for those long discouraged and excluded by a tradition of rigidly disciplinary, stand-and-deliver pedagogy.

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