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Fall 2012, Vol. 98, No. 4

## What Colleges and Universities Need to Do to Advance Civic Scientific Literacy and Preserve American Democracy

By Jon D. Miller

There are several fundamental requirements for democratic government.

First, there must be free and fair elections to elect leaders. Second, there must be freedom to express a wide range of views and positions, including criticisms of incumbent leaders. And third, the public discourse about elections and public policy issues must be conducted in a language that is accessible to all the citizens in any democratic system. During the first two centuries of its history, the United States met all three of these requirements and has been exemplary in many of its democratic practices. We have had periods when presses were closed or the freedom of speech restrained, but over our history we have done well on most indicators of democratic life (Dahl 1971, 1989).

But we are entering a period in which the third of these requirements is increasingly problematic. A growing number of public policy and campaign issues are now presented and argued in the language of science at a level that is incomprehensible to most American citizens. In the 2004 presidential debates, for example, George Bush and John Kerry tried to explain and defend their positions on stem cell research, with President Bush saying that adult stem cells could be used effectively for most medical purposes and Senator Kerry arguing that embryonic stem cells were necessary for many important biomedical purposes. Several national surveys—including some of my own—demonstrate that only about 20 percent of American adults could provide the most basic definition of a stem cell, and even fewer could explain the differences between an adult stem cell and an embryonic stem cell.

The ongoing public discourse over climate change illustrates the challenge of trying to explain scientific ideas in non-scientific language. Proponents and opponents of climate change continue to argue about the effect of carbon dioxide and other atmospheric gases on the retention of heat, and to try to explain the issue of burning fossil fuels without having to explain the role of carbon in our planetary ecology. In a series of national studies of students, young adults, and adults of all ages over the last twenty-five years, I have found that only about 15 percent of American adults can explain the idea of a molecule (Miller, 1997, 1998, 2000, 2010a, 2010b, 2010c). It may be disappointing that many Americans arrive at their views of climate change through their political partisanship, but it should not be surprising. When individuals are faced with a complex idea about which they have limited understanding, they tend to rely on the judgment of other adults that they trust to know more about that area. Patients rely on their doctors for advice about the treatment of a disease, and they appear to rely on political leaders to interpret complex climate information (Sternberg and Ben-Zeev 2001).

The solution is to increase the level of civic scientific literacy in our society. The idea of civic scientific literacy was first suggested by Benjamin Shen (1975), the distinguished astrophysicist from the University of Pennsylvania. Shen suggested that there are three kinds of scientific literacy—consumer, cultural, and civic. Consumer scientific literacy is applied and product oriented and increasingly necessary to shop in a drug store, a hardware store, or a computer shop. Cultural scientific literacy refers to a more epistemological understanding of science as a way of knowing in comparison with other ways of knowing. And civic scientific literacy refers to the level and kinds of information that a citizen needs to know in order to follow current and emerging public policy issues. Civic scientific literacy is critical to the preservation of our democratic principles, and I have suggested that civic scientific literacy represents the level of reading and comprehension skills needed to read the science section of the Tuesday *New York Times* or to watch an episode of *Nova* on public television (Miller 2010a, 2010b). I stress that this is the *minimal* level necessary to allow citizens to engage with science-related public

### About the PKAL Series

Intended to challenge the higher education community to think strategically about how best to advance the learning and success of all students in science, technology, engineering, and mathematics (STEM), this series of articles presents a broad array of perspectives on cutting-edge issues affecting contemporary undergraduate education in the STEM fields.

The full series is available online at [www.aacu.org/liberaleducation/pkal](http://www.aacu.org/liberaleducation/pkal).

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policy issues and that we ought to seek to elevate this level of understanding in the decades ahead.

**What is our current status in regard to civic scientific literacy?**

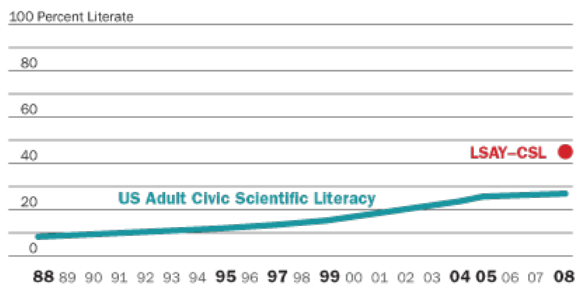
Using a pool of open-ended questions (What is a molecule? What is a stem cell?) and closed-ended questions (Agree or disagree that “antibiotics kill both viruses and bacteria”), I have measured civic scientific literacy in the United States since 1988. The proportion of adults who score seventy or higher on a scale of zero to one hundred increased from 10 percent in 1988 to 29 percent in 2008 (see fig. 1, page 30)—a substantial rate of growth (Miller 2010a). In a national longitudinal study of young adults (Generation X), I found that 44 percent are civic scientifically literate using the same measure—the red dot in figure 1 (Miller 2010a, 2010c).

Many people wonder how these results are possible, given the United States’ flat and unimpressive scores in international school comparisons, such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). The answer is college science courses. The United States is the only country that requires all college students to take one or more science courses as a part of a general education requirement. In a series of statistical analyses using structural equation analyses of both cross-sectional and longitudinal data, I have shown that exposure to college science courses is a strong predictor of civic scientific literacy in young adults and in adults of all ages (Miller 2010a, 2010c). More than fifty years ago, C. P. Snow (1959) made a strong argument that all students in Britain should study both physics and Shakespeare—his version of general education—based in part on the US experience, but neither Britain nor any other major country has followed his advice. Our national commitment to liberal education is the single most important factor in our current level of civic scientific literacy.

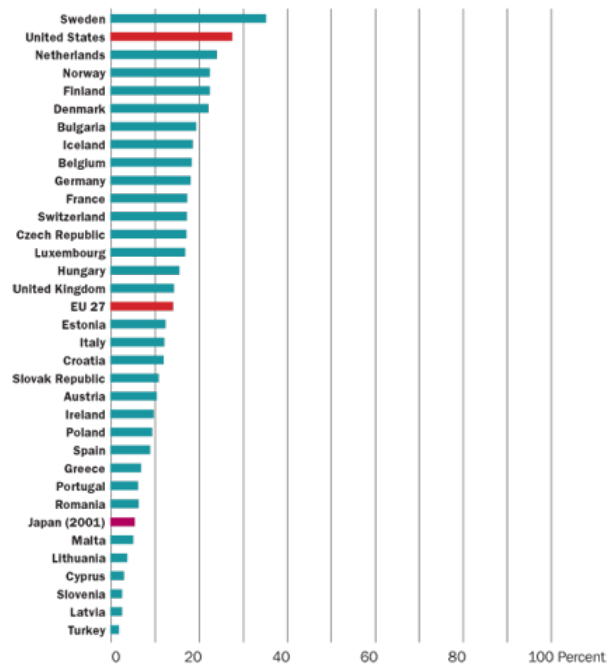
It is also useful to note that the United States does well in comparison with other countries using the same measure of civic scientific literacy (see fig. 2, bottom left). In a comparison of thirty-four countries in 2005–8, the United States ranked second to Sweden and ahead of thirty other European countries and Japan (Miller 2012).

If the United States is second in the world in civic scientific literacy, why should we be concerned? The answer is that our basic commitment to meaningful democracy—as opposed to ritual democracy—is at stake. The important message from this comparison should not be our relatively strong showing, but the pervasiveness of scientific illiteracy in major democratic systems throughout the world. We should take little comfort in the idea that our democracy is slightly less at risk than that of several European and Asian nations.

**Figure 1: Civic scientific literacy in the United States, 1988–2008**



*The Longitudinal Study of American Youth (LSAY) is a national study of about five thousand students that I have been following since 1987, when the students were in the seventh and tenth grades in public schools throughout the United States. The Civic Scientific Literacy (CSL) data point shown in this figure represents findings from 2008, when young adults in the LSAY were aged 36 to 39 years.*

**Figure 2: Civic scientific literacy in 34 Countries, 2005–7****What are the problems, and what do we need to do?**

There are several problems, and we need to understand all of them, even if they are not the primary responsibility of higher education.

First, our current systems of elementary and secondary education are broken in the majority of states and school districts. There is no reason that every high school graduate in the United States should not be civic scientifically literate. The failure of American secondary schools to produce civic scientific literacy is the result of (1) the absence of a strong advocacy group to push schools and teachers toward that objective, (2) a political system that has turned the teaching of modern biology (evolution) and physics (Big Bang) into a political litmus test, and (3) an acceptance by too many political leaders that the precollege education system is hopelessly broken and that a system of charter schools may provide enough high-quality education for the most talented (i.e., advantaged) young people. The solutions require courage and resources. Political leaders must confront the anti-science agenda inherent in current US fundamentalist movements. Corporate leaders need to decide that the advancement of science and technology in the United States is worth more than the tax breaks they get from right-wing anti-science politicians. And the American people need to recognize that good education costs money and that a system of school financing built on property taxes (a reasonable tool for eighteenth-century agricultural societies) will never have the resources to attract and retain outstanding teachers. It is easy for colleges and universities to blame the failure of precollege education, but the leadership of higher education needs to recognize the problem and to begin to bring some of the intellectual and political resources of higher education to bear on these issues.

Second, there is always pressure on colleges and universities to produce more "job-ready" graduates, and this pressure is growing in the aftermath of the Great Recession. It is important for the leadership of higher education to speak candidly about the educational needs of the twenty-first century and to seek to educate political leaders on these issues. There is a good deal of truth in Goldin and Katz's (2008) argument that we are in a race between history and technology, and that economic prosperity in the twenty-first century will be higher in those countries that do the best job in providing more advanced education to their citizens. Our students and our citizens will need more advanced technical education, and they will need it periodically throughout their lifetimes. But we would be negligent not to argue for the necessity of a strong liberal education component to advance civic scientific literacy and similar levels of social and cultural understanding in the humanities and social sciences.

Third, assuming the continuation of the standard requirement that all students take one or more college courses in science, it is important that we look carefully at how we conceptualize this responsibility and how it operates in our institutions. Too often, science courses for nonmajors have been treated as onerous duties or as a source of credit hours to allow a department to teach needed courses to its majors. The "rocks for jocks" and "physics for poets" labels reflect real perceptions by both students and faculty. But this is a flawed conceptualization of the task. The University of California recently renamed its introductory physics course "Physics

for Future Presidents" and rewrote the curriculum to make the title more than a marketing effort. It is essential for university scientists and administrators to recognize that a science course for nonmajors may be the last time they have a chance to talk to their future senator or congressman about science before he or she is elected. And it is the only chance they will have to talk to the millions of voters who will ultimately make electoral choices that have an impact on the future of their university and of the nation. It is a serious responsibility that needs to be taken seriously by science faculty, department chairs, deans, provosts, and presidents. And it should not continue to be at the bottom of the budget totem pole.

Finally, many colleges and universities have a lifelong relationship with their graduates. Traditionally, this relationship may have resided primarily in an alumni office that is a part of the university development function, but higher education institutions and leaders need to see this as an ongoing educational linkage. Although some colleges and universities have started to offer online and summer courses in various subjects to their alumni, there is an opportunity to use this linkage to foster civic scientific literacy among alumni. Many alumni may be receptive to opportunities to improve their understanding of scientific ideas ranging from the climate debate to changes in cognitive function during the lifecycle to genetic modification. The objective should be genuinely educational and not a thinly disguised development effort to generate additional revenue. I believe that there is a strong (and largely unmet) market for this kind of information and material, and we need to bring our full creativity to thinking about ways to address it. Some alumni may need or want to do a course, but others may want easy access to a college website that provides information resources and links on important topics. The possibilities and opportunities in the rapidly emerging wireless world of tablets and mobile devices are vast and largely unexplored.

#### **Liberal education and the challenge of complexity**

The problems of civic scientific literacy illustrate a more basic problem for liberal education in the twenty-first century. There is broad agreement that many occupations and professions now demand a strong understanding of complex scientific, social, and economic systems, and the growing length of graduate, professional, and post-graduate education reflects this reality.

There has been less awareness or concern about the growing need for individuals to understand a variety of complex scientific, social, and economic constructs in order to perform their duties as parents, patients, and citizens. The inability of most American citizens to understand and make sense of complex arguments about stem cell research or climate change is only the tip of the iceberg. There can be little doubt that the number and complexity of science-related issues that reach public policy agendas at all levels of government will continue to grow in the twenty-first century.

The challenge for educators is to recognize that our task is to help our students acquire a core set of scientific constructs that will enable them to read the science section of the *New York Times* today *and* to read it twenty, thirty, and forty years from now. The key is to avoid teaching details about the West Nile virus and to teach the nature of viruses generally. We know that adults who have a sound understanding of the meaning of a molecule are substantially more likely to make sense of subsequent news stories about nanotechnology, but that adults with a limited understanding of the nature of matter are almost universally unable to understand the idea of a nanoparticle. It is impossible to imagine the breaking genetic news thirty years from now, but it is a safe bet that those adults who understand genes and DNA will have a far better chance of making sense of that news and those issues than citizens without this core knowledge. This conceptualization of understanding core scientific and technological constructs is fully consistent with our longer tradition of liberal education, and we need to embrace it.

Complexity is not wholly owned by the biological and physical sciences. Economists, psychologists, and sociologists increasingly speak in *social science*, reflecting the complexity of their fields. This is a language that is not included in my measure of civic scientific literacy, but the same principles would apply. And there are compelling arguments that citizens in the twenty-first century will need to understand complex economic arguments to make sound public policy judgments.

As educators committed to liberal education, we need to recognize that the advancement of civic scientific literacy is not icing on the cake; it is a basic insurance policy for the preservation of American democracy in the twenty-first century.

#### **About Project Kaleidoscope**



Since its founding in 1989, Project Kaleidoscope (PKAL) has been a leading advocate for building and sustaining strong undergraduate programs in the fields of science, technology, engineering, and mathematics (STEM). With an extensive network of over seven thousand faculty members and administrators at over one thousand colleges, universities, and organizations, PKAL has developed

far-reaching influence in shaping undergraduate STEM learning environments that attract and retain undergraduate students. PKAL accomplishes its work by engaging campus faculty and leaders in funded projects, national and regional meetings, community-building activities, leadership development programs, and publications that are focused on advancing what works in STEM education.

In 2008, the Association of American Colleges and Universities (AAC&U) and PKAL announced a partnership to align and advance the work of both organizations in fostering meaningful twenty-first-century liberal education experiences for all undergraduate students, across all disciplines. This new partnership represents a natural progression, as nearly 75 percent of campuses with PKAL community members are also AAC&U member institutions. Together, AAC&U and PKAL apply their collective expertise in undergraduate learning, assessment, leadership, and institutional change to accelerate the pace and reach of STEM transformation.

For more information, visit [www.aacu.org/pkal](http://www.aacu.org/pkal).

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**Jon D. Miller** is research scientist and director of the International Center for the Advancement of Scientific Literacy in the Institute for Social Research at the University of Michigan.

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