The 95 Percent Solution

School is not where most Americans learn most of their science

John H. Falk and Lynn D. Dierking

The scientific research and education communities have long had a goal of advancing the public's understanding of science. The vast majority of the rhetoric and research on this issue revolves around the failure of school-aged children in the United States to excel at mathematics and science when compared with children in other countries. Most policy solutions for this problem involve improving classroom practices and escalating the investment in schooling, particularly during the precollege years. The assumption has been that children do most of their learning in school and that the best route to long-term public understanding of science is successful formal schooling. The "school-first" paradigm is so pervasive that few scientists, educators or policy makers question it. This despite two important facts: Average Americans spend less than 5 percent of their life in classrooms, and an ever-growing body of evidence demonstrates that most science is learned outside of school.

We contend that a major educational advantage enjoyed by the U.S. relative to the rest of the world is its vibrant free-choice science learning landscape—a landscape filled with a vast array of digital resources, educational television and radio, science museums, zoos, aquariums, national parks, community activities such as 4-H and scouting and many other scientifically enriching enterprises. The sheer quantity and importance of this science learning landscape lies in plain sight but mostly out of mind. We believe that nonschool resources—used by learners across their lifetimes from childhood onward—actually account for the vast majority of Americans' science learning. If this premise is correct, then increased investment in free-choice (also known as informal) learning resources might be a very cost-effective way to significantly improve public understanding of science. Taking this view, though, requires dismantling a widespread misconception that out-of-school educational experiences only support superficial science learning and the recreational interests of a limited percentage of the curious public, rather than the learning of real science by all citizens.

Traditional assumptions about the source of science knowledge are deeply held. Historian of science Steven Turner locates the beginning of today's Public Understanding of Science movement in the 1980s. Its hallmarks were "new, vigorous efforts to promote public knowledge of science and to instill confidence and support for the scientific enterprise." The major focus of this effort was a widespread reassessment of the content and goals of school science teaching and a shift of curricular reform efforts toward the needs of the substantial majority of students who would not pursue scientific and technological careers or postsecondary training in technical subjects. This reform movement went forward under the catchy slogan "scientific literacy," but its other motto, "science for all," better expresses its true political and pedagogical objectives.

The unquestioned focus was to increase the quantity of qualified science teachers and by doing so, the quality of teaching. This assumption shaped years of research on the public understanding of science, summarized biannually by the National Science Board in their *Science and Engineering Indicators* series. National organizations such as the American Association for the Advancement of Science and the National Academies of Sciences commissioned white papers focusing on the issue, and science-education reform efforts were funded by the National Science Foundation and the Department of Education.

Over the ensuing years, the content and approach to teaching science in schools has varied from year to year and from district to district. However, the general commitment to science for all has remained a basic tenet of school-based science education. Also fundamentally unchanged over the past 25 years is the assumption by virtually all within the science education community—scientists, science educators, science learning researchers, education policy makers and the public—that if science for all is the goal, then schools are the most effective conduit.

However, a range of data are emerging that suggest other interpretations that at the very least raise important questions about the prevailing paradigm that schooling is the primary mechanism for public science learning. For example, for more than a decade, performance by U.S. school-aged children on international tests such as the quadrennial Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) has followed a consistent pattern. Elementary-school-aged U.S. children perform as well as or better

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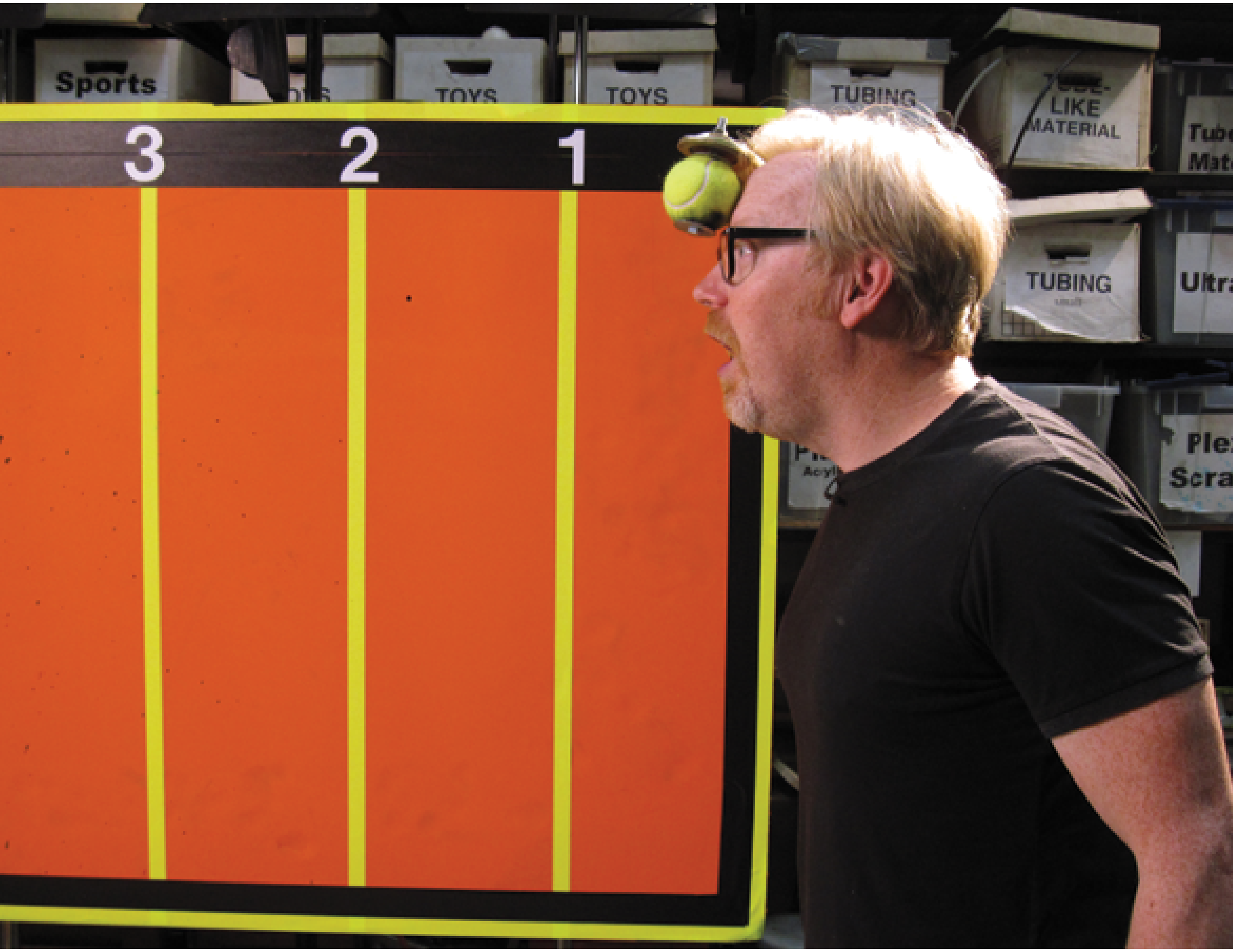

Figure 1. Recent findings challenge the longstanding belief that the place for science knowledge acquisition is the classroom. International comparisons of trends in science knowledge over lifetimes suggests that much if not most science knowledge is acquired outside of school. This raises important questions about where our efforts should be spent if we want to improve public understanding of science. A powerful example of free-choice exposure to science is the highly praised *MythBusters* television program, which exemplifies the central aspects of scientific exploration: hypothesis, experiment and measurement. Here cohost Adam Savage takes on the folk knowledge that sneezes are expelled at 100 miles per hour. A bit of snuff, a high-speed camera, a spirit of inquiry and a calculation of distance over time yields an engaging lesson in science. And an answer: Sneezes travel about 40 miles per hour. (Photograph courtesy of The Discovery Channel.)

than most children in the world, but the performance of older U.S. children has been mediocre at best. Interestingly, however, for more than 20 years, U.S. adults have consistently outperformed their international counterparts on science literacy measures, including adults from South Korea and Japan, as well as Western European countries such as Germany and the United Kingdom. If schooling is the primary causative factor affecting how well the public understands science, how do we explain these findings?

For starters, most in the U.S. science learning community agree that the quality of school science education is better at the secondary level than at the preschool and elementary levels. Recent statistics show that only about 4 percent of U.S. school teachers of kindergarten through second grade (K–2) majored in science or science education as undergraduates, and many took no college-level science courses at all. However, the quality of science instruction at that level is almost a moot point because science instruction itself so rarely occurs. Indicative of the situation nationwide, a 2007 study of San Francisco Bay–area elementary schools found that 80 percent of K–5 multiple-subject teachers who are responsible for teaching science in their classrooms reported spending *60 minutes or less per week* on science; *16 percent of teachers reported spending no time at all on science*. Consistent science instruction in U.S. schools only begins at the middle-school level, when every student takes at least one or two science courses, usually taught by individuals with some

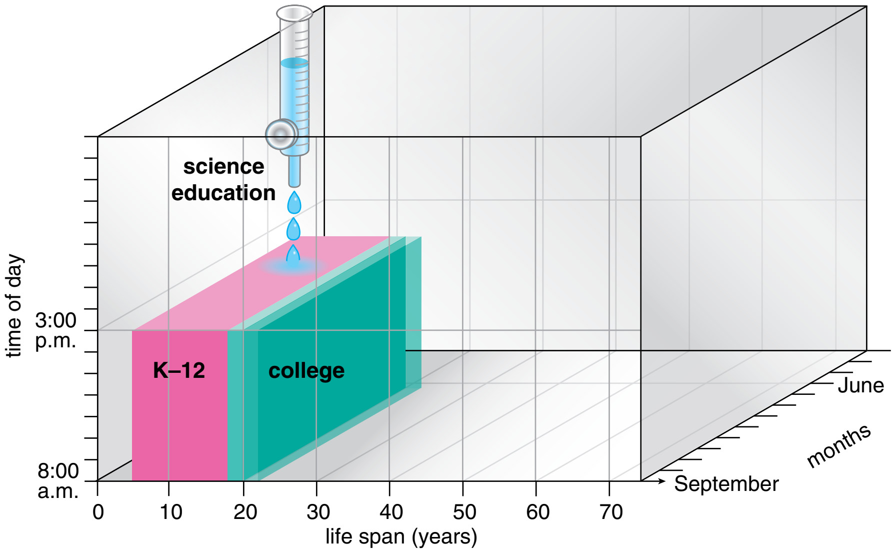

Figure 2. On average, only about 5 percent of an American's lifetime is spent in the classroom, and only a small fraction of that is dedicated to science instruction. Emerging data suggest that the best way to increase the public understanding of science is to reach people during the other 95 percent of their life.

science background. Interestingly, it is just at the point when school-based science instruction begins in earnest that American children start falling behind their international peers. Meanwhile, what accounts for the high performance of American adults?

Although data show that taking college-level science courses dramatically improves public science literacy, only about 30 percent of U.S. adults have ever taken even one college-level science course. Thus, the superior science literacy of the U.S. general public relative to other countries cannot be easily explained by schooling either at the precollege or college levels. Developers of the large-scale national science literacy tests, the results of which are compared internationally, claim that these measures reliably measure the knowledge of representative samples of target populations, so it follows that other factors beyond schooling must explain or at least significantly contribute to the U-shaped pattern of Americans' comparative performance on science literacy measures.

Science in the Wild

A growing body of evidence supports the contention that the public learns science in settings and situations outside of school. A 2009 report by the National Research Council, *Learning Science in Informal Environments: Places, People and Pursuits*, describes a range of evidence demonstrating that even everyday experiences such as a walk in the park contribute to people's knowledge and interest in science and the environment. Adults visit settings such as national parks, science centers and botanical gardens not only to relax and enjoy themselves, but equally to satisfy their intellectual curiosity and enhance their understanding of the natural and human-made world. Even more common is the science people learn while engaged in efforts to satisfy their personal need to know. Sometimes the need is fleeting. For example, individuals may choose to watch a nature show on television, or invest time, energy and money in supporting their children's science learning by taking them to national parks, science centers and zoos, or encourage their children to participate in a wide variety of extracurricular experiences such as scouting and summer nature camps.

One specific example of the role that out-of-school institutions play in the support of the public's science learning comes from more than a decade of research at the California Science Center in Los Angeles. Findings from one part of this series of studies—large-scale, random telephone surveys—found that more than 60 percent of Los Angeles residents had visited the Science Center since it was renovated in 1998, including residents of all races/ethnicities, neighborhoods, incomes and education levels. Findings also showed that a majority of former visitors (95 percent) self-reported that the experience increased their understanding of science and technology as well as piqued their interest in science and prompted further inquiries after the visit.

These data were validated by a "conceptual marker" in the form of a specific scientific concept—homeostasis. Prior to the opening of the new science center, only 7 percent of the Los Angeles public could define this term (including first-time visitors to the California Science Center). However, because of a popular exhibition experience designed to teach this concept—a 50-foot animatronic woman—a majority of Science Center visitors could define the term upon exiting the museum. The ability to correctly explain this one scientific concept has increased nearly threefold in Los Angeles over the decade following the reopening of the Science Center. By tracking this conceptual marker, we can directly attribute the increase in understanding to visits to the Science Center. These data, along with data from other science centers and comparable free-choice science learning settings, have shown that the majority of visitors significantly increase their conceptual understanding of science on a variety of levels—basic information, breadth and depth of understanding—immediately following a visit, and for most of these individuals this understanding persists and grows for two or more years after the experience. Similar science learning outcomes have been found for youth and after-school program experiences, and both print and broadcast media sources have long since been shown to be vital to both children's and adults' understanding of health, science and environmental issues.

Historically, the majority of attention paid to out-of-school science learning, including most academic research, has been directed to experiences like visiting a museum, science center, zoo or aquarium, or watching broadcast media such as NOVA shows and the like. Although, as suggested above, these free-choice science learning experiences are undoubtedly important contributors to the public's science literacy, they represent only the most conspicuous part of the free-choice science learning landscape. Equally important but much less discussed and studied are education situations that support long-term, more in-depth opportunities for science learning. A wide range of adolescents and adults are engaged in hobbies that involve science, including model rocketry, raising ornamental fish, gardening, rock collecting and star gazing. Hobbyists such as these often possess deep specialized knowledge of science and invest considerable amounts of money in equipment, travel, education and training to refine their craft. Equally important are the many events in life, often highly personal, which demand increased understanding of science "right now." For example, when individuals are diagnosed with leukemia or heart disease, they and their loved ones invest large amounts of time researching websites and medical reports in order to learn as much as possible about the particular disease. Similar behaviors arise when an environmental crisis occurs such as a toxic spill or the discovery of radon gas seeping from the rock on which one's home is built. With an increasingly accessible Internet, becoming informed about such issues is easy, even routine.

A small but compelling set of data is beginning to emerge showing that the nonstudent public also gathers in-depth science knowledge outside of school. Our research shows that free-choice learning experiences represent the single greatest contributors to adult science knowledge; childhood free-choice learning experiences also significantly contributed to adult science knowledge. Schooling ranks at the bottom of significant sources of adult science knowledge. Specifically, our research shows that science information sources such as books, magazines, discussions with experts, and the Internet represented the primary mechanisms the public uses to delve more deeply into a topic. During the recent dramas surrounding the deep-water oil spill in the Gulf of Mexico, news websites such as CNN and CNBC, information websites such as www.theoildrum.com and even the government's own NOAA website were humming with activity as the public tried to get below the superficial headlines of the six o'clock news. These and other data suggest that the importance of school as a source of science learning is actually declining among the public as citizens utilize an ever-broadening range of information resources, including most dramatically the Internet, which now represents the major source of science information for all citizens, including young children. According to research conducted by the Pew Internet & American Life Project, 2006 was the tipping point when the Internet exceeded even broadcast media as a source of public science information. The medical profession has come to appreciate that the public today is far more likely to seek medical information online than from a "live" healthcare professional; as stated earlier, individuals with serious ailments use the Internet for continued, deep learning about their illnesses.

Science on the Side

Another emerging area of research investigates science-related hobbies. Research conducted by Marni Berendsen, education researcher and project director of the NASA Night Sky Network, showed that amateur astronomy club members lacking college-level astronomy training often knew more general astronomy than did undergraduate astronomy majors. Research by others has also shown hobbyists, many with little formal training, exhibiting high levels of knowledge and depth of understanding. Such hobbyists often have collegial relationships with experts in the field and some, having put themselves in the right place at the right time, have contributed scientific discoveries. For example, on March 18–19, 2010, amateur astronomer Nick Howes was working from his desktop computer in Great Britain using a remotely controlled 2-meter telescope located in Hawaii and operated by the Faulkes Telescope Project. He dialed up the coordinates of a comet he had been observing, calibrated his camera and snared a set of six photos showing an object moving away from the icy nucleus of the comet. What he captured was the breakup of comet C2007 C3, an observation hailed by the International Astronomical Union as a "major astronomical discovery."

Investigations of everyday science literacy have yielded other interesting data. For example, a series of studies by Canadian science-education researcher Wolff-Michael Roth and colleagues found that members of an environmental activist group working on the revitalization of a local creek and its watershed acted and learned using knowledge derived from a wide variety of resources, virtually none of which required or drew from school-based sources. Similar research by others reinforces that much of what is learned in school actually relates more to learning for school, as opposed to learning for life. One study found that the number or level of mathematics courses taken in school correlated poorly, if at all, with mathematical performance in out-of-school, everyday-life situations. In another study of mathematics learning, even individuals who did not do well or were not formally trained in school mathematics demonstrated the ability to use math successfully in everyday life—for example, sellers of candy in street markets and shoppers selecting good deals. Success in technical and scientific training courses for ship officers was shown to be unrelated to the relevant knowledge required onboard. As observed by Roth and his colleagues in their investigation of adults working on a local environmental issue, "There was little that looked like school science, and there was little done in school science that prepared these adults for this or any other similar kinds of problematic situations in life."

Although the role of free-choice learning experiences remains contest-

Figure 3. Tess, the 50-foot animatronic body simulator, is part of the World of Life permanent gallery at the California Science Center in Los Angeles. When she arrived, 7 percent of Angelenos could define the term *homeostasis*. That figure had almost tripled by a decade later. (Photograph courtesy of the California Science Center.)

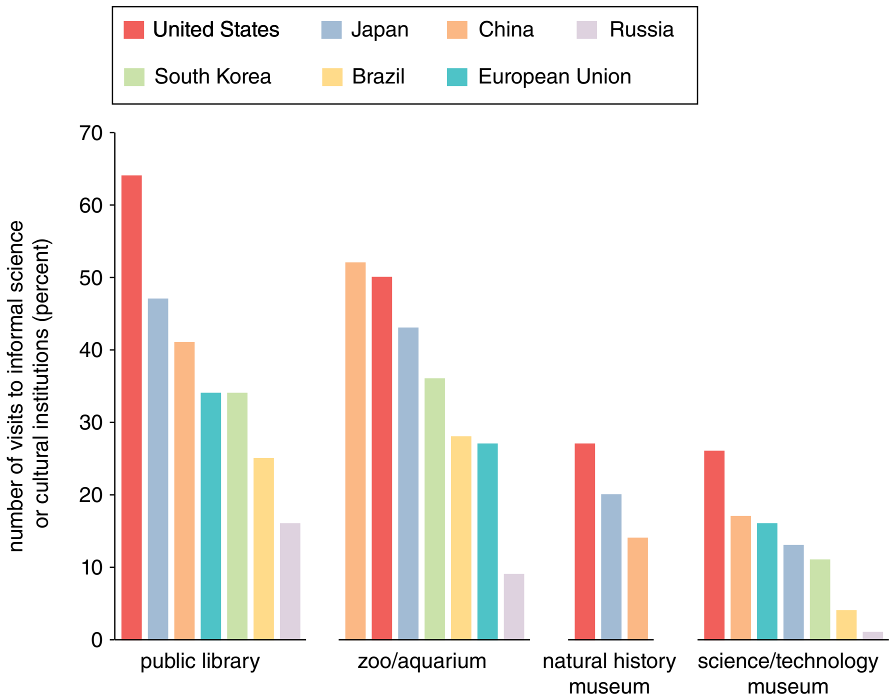

Figure 4. The U.S. public has a lush endowment of free-choice opportunites to learn science, which it uses extensively. The relative patronage of science-oriented institutions shown above may explain why the disappointing gap in science proficiency of U.S. youngsters compared to their most advanced peers worldwide disappears as the youngsters become adults.

ed, few would argue that out-of-school experiences support the public's science interest and attitudes. However, recent research by Robert H. Tai and associates, utilizing data from the National Educational Longitudinal Study (NELS), pushes the potential importance of this role far beyond what most have assumed. Tai's research group found that attitudes toward science careers, formed primarily during out-of-school time in early adolescence, appeared to be the single most important factor in determining children's future career choices in science. Among a random sample of 3,359 NELS participants who finished college, those who expected at age 13 to have a science career, compared to those with other career expectations, were two times more likely to have graduated with a degree in the life sciences and three times more likely to have a degree in the physical sciences or engineering. Interestingly, achievement in school mathematics, considered a critical filter and a major focus of today's high-stakes testing, was not as important a predictor as was interest in the topic.

Despite alternative interpretations for U.S. adults' higher science literacy scores internationally and the growing body of evidence supporting the critical role of free-choice learning experiences, most still consider such experiences a nicety rather than a necessity, an adjunct to the serious business of learning that takes place in classrooms. Most policy and funding initiatives continue to be directed towards improving in-school performance based on the rarely questioned assumption that classroom-based education is the exclusive route to achieving desired educational outcomes.

A major justification for these arguments is the issue of equity. After all, schooling is the "great leveler," the mechanism for eliminating socioeconomic disparities. If only, the argument goes, schools could all be brought up to comparable levels of quality, historic inequalities could be overcome. A recent study on the "performance gap" in reading between advantaged and disadvantaged children in Baltimore was designed to highlight just this issue; however, the results ran counter to expectations. Data from this major longitudinal study showed that over the first five years of schooling, the in-school performance gains in reading of low-income, inner-city Baltimore children was completely equivalent to that of affluent, suburban Baltimore children; in fact in some cases the inner-city children's gains were greater than those shown by their more economically and socially advantaged suburban counterparts. However, each and every summer of the study, the inner-city children fell woefully behind; the suburban children continued to gain in performance while the inner-city children stagnated or even declined in performance.

The authors concluded that much of the "gap" in performance between disadvantaged and advantaged children appeared to be the consequence of what happened outside of school. Interestingly, these authors, and many others who have read this research, interpret the findings as evidence that disadvantaged children need to spend more time in school! Of course, an alternative interpretation could be that what happens in school is not sufficient to ensure equity among all children and adults. If, as we've argued all along, school is *not* where Americans learn much of what they know, including science, then it follows that what happens outside of school profoundly influences learning. Rather than increasing school time, perhaps we should be investing in expanding quality, out-of-school experiences for disadvantaged children.

Nonacademic Academics

Supporting evidence for the important role that out-of-school experiences have on children's learning is emerging from a variety of fronts. For example, a recent meta-analysis of experimental and quasi-experimental evaluation findings for after-school programs showed that such programs need not be academically focused in order to have academic impact. In fact, because the authors were interested in programs with a socio-emotional learning focus, academic-only after-school programs were not included in the study, and investigators still observed gains overall in the grades children earned. Similarly, a recent evaluation of Chicago's After-School Matters found that programs without an explicit academic focus (they focused instead on career awareness and development) had a positive effect on several school-related outcomes, including graduation rates and attendance. On a completely different front, data from the Programme for International Student Assessment showed that a major predictor of high achievement on the test was participation in out-of-school, free-choice learning

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Figure 5. The ubiquity of opportunities for informal science learning is often underestimated. Informative interludes range from strolling with a birdwatching manual to touring the hydrosphere at one of the nation's great aquariums. Knowledge seekers can enter the boundless Web or curl up with the iPad app *The Elements*—sound, scholarly and hugely popular. (Bottom left image from WebMD.com; bottom right image courtesy of Touch Press.

experiences such as visits to science museums.

As the Baltimore study and other research cited above make clear, not just summer experiences but all kinds of free-choice childhood experiences significantly contribute to a person's science literacy; early childhood experiences form a particularly critical foundation for all future science learning. The 2009 report on learning science in informal environments from the National Research Council, cited earlier, found that not only do free-choice science learning experiences jump-start a child's long-term interest in science topics, they also can significantly improve science understanding among populations typically underrepresented in science. The report recommended that to make informal science relevant to children and youth within a community, the development of programming and experiences should be a collaborative effort between the informal science organization, local education institutions, and other entities within the community such as science-related industries and businesses.

Similar ideas have recently been voiced by a range of organizations, such as the National 4-H Council and the American Youth Policy Forum. None has stated it so clearly and forcefully as the Harvard Family Research Project, which stated:

> The dominant assumption behind much current educational policy and practice is that school is the only place where and when children learn. This assumption is wrong. Forty years of steadily accumulating research shows that out-of-school, or "complementary learning" opportunities are major predictors of children's development, learning, and educational achievement. The research also indicates that economically and otherwise disadvantaged children are less likely than their more-ad-

Figure 6. A great favorite of young and old: combustion chemistry. "When I talk to my Nobel colleagues," said Sir Richard Roberts, winner of the 1993 Nobel Prize in Physiology or Medicine, "More than half of them got interested in science via fireworks." (Photographs courtesy of Bryan Jackson and Zambelli Fireworks.)

vantaged peers to have access to these opportunities. This inequity substantially undermines their learning and chances for school success.

Fortunately, there are increasing opportunities for youth and families from poor and underserved communities to engage in out-of-school-time (OST) science experiences, driven by such efforts as the NSF Informal Science Education program, which invests in community-based science education efforts. According to the Harvard Family Research Project's 2007 Study of Predictors of Participation in Out-of-School-Time Activities, participation rates in before- and after-school programs have increased at all levels of family income, with the greatest increase among the lowest-income youth. They attribute this trend to an increasing policy focus on the benefits of OST, along with extensive funding for the 21st Century Community Learning Centers, a program of the U.S. Department of Education. They suggest that policymakers and the public need to continue to focus on equity to ensure that this trend continues.

Serious Fun

However, as the potential beneficial relationship between science learning and OST becomes better understood, there is a temptation to hand these programs over to schools. This would be a huge mistake. It is exactly because free-choice learning is *not* like school that it has such value. What is important is that children and youth perceive the free-choice learning experiences that often occur in typical OST programs as personally meaningful, engaging and, dare we say, *fun*—what educator David Alexander calls, "the learning that lies between play and academics." The inclusion of free-choice science learning experiences in the lives of children is essential because young children in particular learn through play. The prevalence of a play-oriented medium for educational delivery, which is very common in the free-choice parts of the science education landscape, has been shown to encourage children to interact with each other, adults and the objects surrounding them in ways that significantly support the development of science inquiry skills.

If OST programs are merely devices to extend the school day with more hours of the same pedagogical experiences, they are unlikely to be successful, particularly in the long term. In fact, it's quite likely that they will do more harm than good by reinforcing stereotypes of science and science professionals as dry and boring and schoollike. Our skepticism and concerns revolve around the fact that current discussions about increasing the scope and quality of OST programs, though well-intentioned, almost always focus on how such programs can support children and youth's achievement in school, rather than how such programs should support children and youth in life.

It seems reasonable to assume that out-of-school science-learning experiences are fundamental to supporting and facilitating lifelong science learning. We would argue that the current state of science literacy in America cannot be explained otherwise. One of the major ways that U.S. adults and children under the age of 12 differ from their counterparts in other countries is their access to and use of free-choice science learning opportunities. Compared with other countries, the U.S. has a luxurious endowment of such destinations. In the same studies that demonstrated high correlations between adult science literacy and levels of schooling, utilization of the free-choice science learning landscape was a strong correlate, as was shown in the Los Angeles findings discussed earlier in this article. In other words, utilization of these resources could be a primary or at least a highly important causal factor in U.S. adults' relatively high performance on international measures of science literacy and interest.

Similarly, the simplest explanation for why American 8-year-olds do so well compared with their counterparts in other countries on the TIMSS and PISA tests is that young American children have greater exposure to free-choice science learning opportunities than do children in any other country. Unfortunately, utilization of these learning opportunities declines precipitously after age 12 in the U.S. As has been shown repeatedly, the best predictor of student success in school is family life. The quality of parenting is more important than socioeconomic factors, race/ethnicity or quality of school. Children with parents who support their learning at home do better than children with parents who do not. A logical and perhaps more effective way for parents to support their children's learning beyond providing homework help is through free-choice learning experiences. However, as the Baltimore research cited above so clearly highlights, the availability and opportunities for accessing free-choice science learning experiences are *not* independent of income and geography.

By challenging the assumption that school is the primary place where Americans learn science, our goal is not to diminish the importance and value of schooling, but rather to suggest that what goes on in the other 95 percent of a citizen's life may be equally important, and possibly more important to increasing science literacy among the public. Although we are not advocating any diminishment in the efforts to improve and expand school-based science education, we do strongly propose that it is time to seriously question whether, in the 21st century, schooling should continue to be viewed as the most important and effective mechanism for advancing the public's scientific interest and understanding.

Jacques M. Chenet/Corbis

Figure 7. This child at play receives lessons in the physiology of hearing, the physics of sound, and the mechanics of biological adaptation, as well as the chance to pretend to be a fox.

Insufficient data exist to conclusively demonstrate that free-choice science learning experiences currently contribute more to public understanding of science than in-school experiences, but a growing body of evidence points in this direction. There certainly are insufficient data to refute the claim that free-choice learning is vitally important. Surely the best informed and most science-literate citizens are those who enjoy maximal benefits from both in- and out-of-school science learning opportunities. Thus, we would argue for increased efforts to measure the cumulative and complementary influences of both in- and out-of-school science learning. However, given that at present school-based science education efforts receive an order of magnitude more resources than free-choice learning options, even a modest change in this ratio could make a huge difference. The data suggest it would be a wise investment.

Bibliography

Bell, P., B. Lewenstein, A. W. Shouse, and M. A. Feder, eds. 2009. *Learning Science in Informal Environments: People, Places, and Pursuits.* The National Academies Press, Washington. D.C.

Bowles, A., and B. Brand. 2009. *Learning Around the Clock: Benefits of Expanded Learning Opportunities for Older Youth.* Washington, D.C.: American Youth Policy Forum.

Dierking. L. D. 2007. Linking after-school programs and STEM learning: A view from another window. Commissioned position paper for the Coalition for After-School Science. New York, NY.

Dorph, R., et al. 2007. The Status of Science Education in the Bay Area: Research Brief. Lawrence Hall of Science, University of California, Berkeley.

Ferreira, M. 2002. Ameliorating equity in science, mathematics, and engineering: A case study of an after-school science program. *Equity and Excellence in Education* 35(1):43–49.

Fox, S. 2008. The engaged E-patient population. Washington, D.C.: Pew Internet & American Life Project.

Harvard Family Research Project. 2007. Findings from HFRP's study of predictors of participation in out-of-school time activities: Fact sheet. http://www.hfrp.org/content/download/1072/48575/file/findings_predictor_OSTfactsheet.pdf

Horrigan, J. 2006. The Internet as a resource for news and information about science. Washington, D.C.: Pew Internet & American Life Project.

Rahm, J., J. C. Moore and M.-P. Martel-Reny. 2005. The role of afterschool and community science programs in the lives of urban youth. *School Science and Mathematics* 105(6):283–291.

Taylor, S. 2008. School science and its controversies; or, whatever happened to scientific literacy? *Public Understanding of Science* 17:55–72.

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