Forum on Education

of the American Physical Society
Summer 2004

IN THIS ISSUE

Hello from the Chair!

Gay Stewart

Gay Stewart with Ronnie Toland, a former undergraduate who is now at NASA

The Forum has made excellent progress in furthering the mission laid out in its charter: to promote "the advancement and diffusion of knowledge regarding the inter-relation of physics, physicists and education" and to involve our members in activities related to physics education. Our members are from industrial, academic, research, and policy communities, and distributed fairly uniformly across the other topical divisions of the APS, showing that across the discipline, we realize the importance of education!

The FEd's new initiative to sponsor an annual session at a national meeting of the American Association of Physics Teachers (AAPT) kicks off with an invited session organized by the Division of Physics of Beams (DPB) at the 2004 AAPT summer meeting in Sacramento CA. This session, held on August 2, will present a wide-ranging comprehensive picture of different aspects of beam physics and accelerators and their applications to a diverse range of research areas. Free education materials will be provided. Outstanding experts in the field will give the five talks: Eighty Years of Particle Accelerators. (Andrew M. Sessler); Modern Accelerators: How they are

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built, why they are built and their future (Alvin V. Tollestrup); Medical Applications of Accelerators (Arlene J. Lennox); Accelerators to make Electricity-- An Overview of Heavy-Ion-Driven Fusion (C. M. Celata); Accelerator Mass Spectrometry: Isotopic Science Tools from Archaeology to Zoology (Jay C. Davis) The talks will be followed by a reception sponsored by the APS Forum on Education

If your division would like to participate in a future year, please contact me.

When I was first elected as a FEd Executive Committee Member-at-Large, I made a number of statements about what I thought we needed to do to strengthen physics in this country. I have been involved in a number of projects to address these needs (see my related article in this issue). The idea of these projects has been that a small number of institutions would put in a lot of work, so that other institutions could adopt ideas, methods or materials once the bugs were worked out. Everything eventually has to be fine-tuned to work locally, but it is a lot easier to fix something than to start from scratch. Basically physics is something everybody needs to know something about; we complain about the quality of the students who come into our classrooms, but we don't take every opportunity we can to improve the preparation of the teachers who send us those students. No matter how good the science methods class is that future teachers take, it is hard to believe it could undo the damage done in many institutions where the classes for non-majors are poor cousins to the classes for "our" students. As Rush Holt said a few years ago when he was the FEd Chair, developing a more "student-centered" learning tradition can only help physics as a discipline. He also admitted the changes might be difficult for us to accept and to implement.

As states work on mandated achievement testing, there need to be physics experts on the panels. If we want what was proposed in the APS Statement on Student Assessment and Science (passed by the Council back in 2001) to happen, we have to be willing to build a few bridges:

> *Science must be included in any mandated program of educational assessment. Science, well learned, is a requirement for the workforce of the 21st Century as well as for informed citizenship. Further, it is well documented that assessment influences what is taught, both in terms of hours spent and in the nature of classroom activity.*
> *Any testing or assessment should be designed so that it not only encourages time spent on science but also motivates teaching methods that recognize that science is more than a body of facts. Students must also learn the methods of observation and experimentation and the modes of thinking that are used to discover and test scientific knowledge.*

If the tests were actually to be so designed, the teachers would have to be well prepared, which means we would get more students interested in science in our classes.

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Words Matter

Art Hobson

Arnold Arons' *Guide to Introductory Physics Teaching* eloquently testifies, in subsections bearing such titles as "misleading terminology" and "what we say *can* hurt," to the need for instructors to use clear, consistent language.[1,2] Indeed we all attest that words matter every time we make careful distinctions between words such as "speed" and "velocity." Unfortunately, our vocabulary often does little to guide students toward proper concepts

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and occasionally even contradicts the desired concepts, making learning more difficult and misconceptions more likely.

Most ripe for change is the word "heat." As we all know, heat is a process, a form of energy *transfer,* and not a form of energy. But our usage belies this meaning. Since it is a process, we should treat "heat" as a verb, but instead we treat it as a noun. Following Arons' precept "idea *first* and name *afterwards*,"[3] we should begin with simple examples such as heating a pot of soup on the stove. Then a formal definition: Any spontaneous transfer of thermal energy (students should already understand thermal energy, i.e. internal energy) from a hot to a cold body because of a temperature difference is called "heating." We say that the flame "heats" the pot. This must be followed up with a consistent use of "heat" only as an action–"to heat" or "heating"–not a thing. If the instructor says for example "heat is transferred to the pot," students will conclude that heat is an entity that can be transferred the way that energy can be transferred. We should speak of “thermal energy flow” (or “thermal energy transfer”), never “heat flow” (or “heat transfer”). There's an important difference between thermal energy (a form of energy) and heating (one form of thermal energy *transfer)*.

"Heat" exemplifies physicists' unfortunate tendency to turn actions into things, i.e. to make nouns out of verbs. Another example is "work." As with heat, students often misconceive work to be a substance, similar to energy. But again work is a process, a way of transferring energy, not a form of energy. A body *does* work, and it *does* heating, but it *has* energy. The rule is that "to do work" and "to heat" are verbs, while "energy" is a noun. Logically, we should say "A works on B," a parallel construction to "A heats B." However the accepted form "A does work on B" is not bad, so long as we never let it degenerate into "A adds work (or provides work) to B."

There is a similar problem with "force." "Force" is an action, similar to work and heating, but physicists have turned it entirely into a noun, as in "A exerts a force on B." But force is an action, e. g. a push or a pull, and should be treated linguistically just like "push." We would normally say "A pushes B" rather than "A exerts a push on B." Unfortunately, the equivalent construction "A forces B" is never used. If we did use this construction (and I'm not necessarily advocating it), it would reduce misconceptions. "A exerts a force on B" reinforces the misconception that there is some entity, "a force," that A bequeaths to B and that B then carries with it. It would help if we instead used the terms "interact" and "interaction strength" whenever possible, as in "A interacts with B" or better yet "A and B interact." Since "interact" is clearly an action, this usage might resolve some conceptual problems while also more naturally suggesting Newton's third law.

Do we really need the term "centripetal force"? When we name it, students naturally conclude, wrongly, that this is a new kind of force. How many times have students told us, for example, that the forces acting on a satellite are gravity *and* the centripetal force? "Net force" and "acceleration" should be all that are needed to discuss circular motion.

It would be more descriptive, less boring, and historically more accurate, to replace the titles of Newton's first, second and third laws with the law of inertia (Descartes and Galileo, not Newton, first formulated it), Newton's law of motion, and the law of force pairs (or the law of interactions). "Potential" is overused and confusing. There are at least five common forms of potential energy: gravitational, elastic, electromagnetic, chemical (microscopic electromagnetic energy), and nuclear. But the adjective "potential" is usually applied only to the first three of these. To further confuse matters, there is an "electric potential" in electromagnetism, but it is not a form of energy; instead it is an electric energy per unit charge. Furthermore, students think of potential energy as only potential, as opposed to actual; this is a misconception, because the potential forms of energy are fully as "actual" or "real" as the kinetic forms. Why not drop the term "potential" in connection with energy, and instead use the more descriptive terms gravitational energy, elastic energy, etc.?

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Turning to modern physics, "quantum mechanics" gives students the enormous misconception that this is a mechanistic theory, similar to Newton's mechanics. But the quantum world is not like a machine. It is not made of Newton's "solid, massey, hard, impenetrable particles" that "never wear or break in pieces."[4] It is non-deterministic, and it is deeply entangled and non-local rather than made of localized parts. "Quantum physics" would be a better term.

It can be misleading to speak of quantum "uncertainties," because it puts students in mind of a quantity having a definite value that is however unknown to the observer, a view of quantum physics that is demonstrably incorrect.[5] Heisenberg used the German "Unbestimmtheit" (usually translated as "indeterminacy" although it can also mean "uncertainty") rather than "Unsicherheit" (uncertainty).[6] The English "indeterminacy" seems to better capture the correct quantum concept that precise positions, momenta, etc. do not, in general, exist, i.e. there *is* no precise position or momentum for an object such as an electron.[2,7]

We should include exciting new topics such as string theory in our introductory courses. But we should be careful with the word "theory." "String theory" is a misleading term, since it is not yet an empirically tested theory but is instead a wonderful and well-developed hypothesis. The distinction between a plausible supposition or "hypothesis," and a well-tested body of ideas or "theory," is crucial in science education, especially when discussing scientific methodology and pseudosciences such as creationism and astrology. We should speak of the "string hypothesis."[8]

Wouldn't it be nice if the physics education community could come to a meeting of minds on improved usage for some of these terms, and recommend new standard usages that most textbooks, articles and teachers would then use consistently?

References

1. Arnold Arons, *A Guide to Introductory Physics Teaching* (John Wiley & Sons, New York, 1990)
2. See also M. Thomas Williams, "Semantics in teaching introductory physics," *Am. J. Phys.* **67**, 670-680 (1999).
3. Ref. 1, p. 23; italics in the original.
4. Alan L. Mackay, *A Dictionary of Scientific Quotations* (Adam Hilger, New York, 1991), p. 181.
5. Daniel F. Styer, "Common misconceptions concerning quantum mechanics," *Am. J. Phys.* **64**, 31-34 (1996).
6. Werner Heisenberg, "Die Rolle der Unbestimmtheitsrelationen in der modernen Physik," *Monatshefte für Mathematik und Physik* (Leipzig) **38**, 365-372 (1931).
7. Andrew Whitaker, *Einstein, Bohr and the Quantum Dilemma* (Cambridge, New York, 1996), makes the point (pp. 147-8) that we should speak of quantum indeterminacy rather than uncertainty.
8. However, I must admit that I have gone along with the crowd and called it "string theory" in my textbook *Physics: Concepts and Connections* (Prentice Hall, Upper Saddle River, NJ, 3rd edition 2003).

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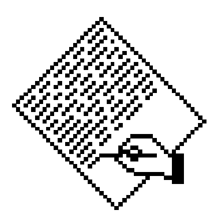
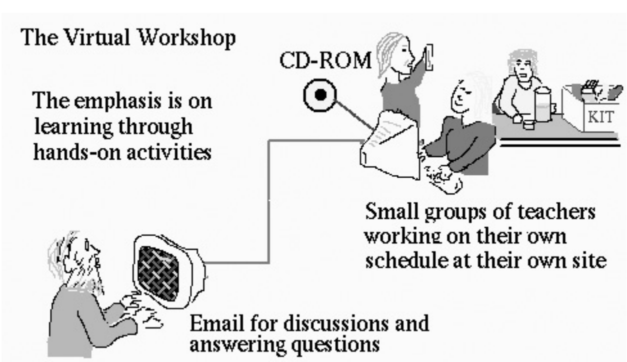


Promoting Science Teacher Education at the Univ. of Kentucky

John E. Christopher, Sally A. Shafer and Joseph P. Straley, Department of Physics & Astronomy, University of Kentucky

Over the last decade, physicists at the University of Kentucky have been developing courses for pre-service and in-service teachers that promote the inquiry approach to science teaching. For pre-service teachers we offer PHY 160, a three-credit course required of all pre-service elementary teachers. The *Physics by Inquiry* texts of Professor Lillian McDermott, et al, are used extensively in the standards-based and inquiry-oriented course meeting six hours per week in a laboratory setting. With support from the NSF through the Appalachian Mathematics-Science Partnership, similar courses are being developed at other Kentucky universities and colleges. Much of the leadership for this project comes from University of Kentucky science and mathematics departments including the Department of Physics & Astronomy. Better ways to help pre-service teachers is tied to better ways to help in-service teachers, and this aspect of the NSF project involves summer institutes and follow-up mentoring.



For in-service teachers, we also offer three one-credit-hour physics courses for professional development or graduate credit to intermediate and middle grade teachers (grades 4-9), on the topics *Light*, *Temperature and Heat*, and *Electricity and Magnetism*. The courses, developed with support from the fund for the Improvement of Postsecondary Education, U. S. Department of Education, emphasize content understanding of physics topics important for teachers, and promote learning through inquiry activities. Its elements are a kit of equipment, a manual of activities, a CD to provide instruction, and the use of email to communicate with the instructors.

Hands-on activities and learning through concrete experiences play a central role in these courses, even though they are delivered in a distance-learning format. Much of the instructional material is directly transferable to participants' classrooms. For previews of the courses and more description of how they work, visit http://www.pa.uky.edu/sciworks/intro.htm.

Lab-Aids, Inc is now rewriting these kits and activities at U.K. for national distribution. Already released are the modules *Investigating Light* and *Color and Spectrum*; a third module *Reflection and Refraction* is in the editorial process.

Students who have been taught by the teachers we have trained are already beginning to arrive at the university, and we are beginning to reap the benefits of our efforts to improve teacher preparation.

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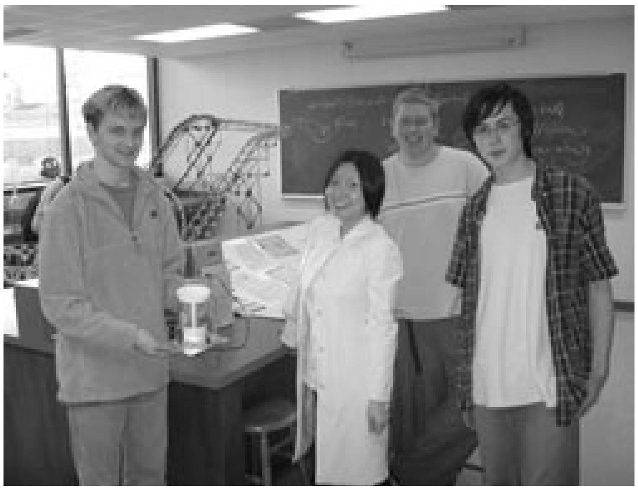
Practicing What I Preach (with helpful references)

Gay Stewart



Of course, at University of Arkansas, we started with a class for majors when we began trying to improve our program. We had so few majors that it was the class for engineers as well. With “Implementing Interactive Laboratory-Based Learning Techniques in Second-Semester Introductory Physics” (NSF DUE-9455732), we wanted to improve the level of student learning, confidence, and enjoyment of science, while maintaining the resource level common to large institutions (teaching assistants in labs, large lectures, etc.)

The program has been very successful, based on all available indicators. Student confidence is up and women in particular are as confident as men at the end of the course. The confidence is well placed, with a strong correlation between confidence and performance. Our graduation rates went from less than four in the years before the students taking this new course University Physics II (UPII) were ready to graduate, to ≥10 concurrent with our first UPII students graduating (http://EducationalEngineering.uark.edu). Since then, the department made more changes, and we had 16 graduates last year, and 24 this year. Most of what we do is similar to what you would read about in the SPIN-UP report. For information on successful programs across the country, see this report, one of the outcomes of the APS/AAPT/AIP National Task Force on Undergraduate Education: http://www.aapt.org/Projects/ntfup.cfm

The State Department of Education liked what we were doing in our classes, so they gave us a little money to work on a joint venture with our College of Education. We used these resources to work some UPII material into a methods course, and build a middle level science teaching degree around some proposed physics course revisions.

When we first implemented the new UPII, it became clear that the first and greatest need for educational reform to be embraced and sustained was for our future faculty to be prepared to be as professional about their roles as educators as their roles as researchers. “Shaping the Preparation of Future Science and Mathematics Faculty (DUE-9813876) was the next NSF project in which we got involved (http://www.aapt.org/Projects/pfpf.cfm). New college faculty members may find themselves preparing to teach a class for the first time, with little or no guidance. The biggest complaints employers have about those hired for "pure" research positions involve interpersonal skills. Also, more researchers are being called upon to do outreach. Teaching and participating in outreach activities develop these skills, so everyone benefits, not just the students in the introductory course. Our focus was to add these kinds of activities to the graduate program, with the same sort of mentoring that accompanies the development of research skills, without extending the time needed to complete a degree. Also, a new masters degree was developed for those that find themselves insufficiently motivated to do research, but still loving physics, providing a route straight into teaching for these students at very low resource cost.

Of course, once you start wanting to get more, better-prepared teachers out there, you need to have the materials and the infrastructure to make it

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work. So, the University of Arkansas became a Primary Program Institution of the Physics Teacher Education Coalition (PhysTEC, NSF PHY-0108787), http://www.phystec.org/), an APS/AAPT/AIP program. PhysTEC provides dramatic improvement of science preparation of physics, physical science, and elementary teachers, developing programs to work at a wide range of institutions. Results of the previous support benefit all students, including future teachers, and this grant allowed us to expand these efforts to almost every class, as well as, to provide significant mentoring for our majors considering a career in teaching. Our students have a higher retention to degree than the rest of the university. The increased number of majors has impacted almost every aspect of the department. The students that want to go on to graduate school are going on to excellent programs where they do well, some go right into industry, and some go to medical school or law school; however, now about 10% of our graduates go on to a career in K-12 teaching!

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Invention and Impact: Building Excellence in Undergraduate STEM Education

A Report on a National Science Foundation Course, Curriculum, and Laboratory Improvement Program Conference

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If students in your physics department submit pre-class assignments over the web, collect data in their laboratory sessions using force sensors and motion detectors, use infrared transmitters to participate in interactive lectures, or complete collaborative exercises in recitation sections, chances are good that they are benefiting from NSF investment in undergraduate education through the Course, Curriculum, and Laboratory Improvement (CCLI) program. Advances in teaching science, technology, engineering and math (STEM) supported by the CCLI program were the focus of an April Conference in the DC area entitled *Invention and Impact: Building Excellence in Undergraduate STEM Education.* The conference, jointly organized by NSF and the American Association for the Advancement of Science, aimed to "inform the national audience about learning environments, course content, curricula, and educational practices that improve the learning and achievement of undergraduate students." In particular, the goals were to:

- Share and demonstrate the effectiveness of selected undergraduate STEM curricular improvements and innovations;
- Facilitate cross-disciplinary communication of innovative curriculum ideas;
- Foster interdisciplinary interest in emerging science fields; and
- Engage the larger STEM community in discussions about NSF's future priorities in undergraduate education.

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As befits the highly interactive nature of many of the educational innovations that were discussed, the 400 participants spent most of the three-day conference in workshops. Poster sessions provided plenty of opportunities for informal discussions while plenary speakers touched on major cross-cutting themes, including increasing diversity among STEM majors and professionals, and the challenges of creating and sustaining change on an institutional level.

Several workshops featured innovative physics curricula. Bob Beichner of North Carolina State University demonstrated the SCALE-UP (Student Centered Activities for Large Enrollment Undergraduate Programs) approach; Evelyn Patterson of the Air Force Academy introduced participants to *Just-in-Time Teaching;* Priscilla Laws of Dickinson College explored the common roots of a collection of activity-based undergraduate physics materials; and UW physics undergraduate Anne Durako and I led participants through an excerpt from *Tutorials in Introductory Physics.*

A number of posters featuring innovations in physics teaching reached a wide audience. Poster presenters included Jane Flood and Diane Follet of Muhlenberg College; Steve Thornton of UVa; Marty Johnston of the University of St. Thomas; Linda Fritz of Franklin and Marshall College; Tevian Dray and Corinne Manogue of Oregon State University; Enrique Galvez and Charles Holbrow of Colgate University; Kurt Hieggelke of Joliet Junior College along with David Maloney of IUPUI, Tom O'Kuma of Lee College and Steve Kanim of New Mexico State University; Nancy Beverly of Mercy College along with Robert Fuller and Vicki Plano-Clark of the University of Nebraska, Beth Ann Thacker of Texas Tech, and Mark Plano Clark and Christopher Wentworth of Doane College; Ruth Chabay and Bruce Sherwood of North Carolina State University; David Meltzer and Thomas Greenbowe of Iowa State University; Mario Belloni and Wolfgang Christian of Davidson College; and Ken Krane of Oregon State University.

Physics had a high profile at the Conference, in part due to the plenary talk given by Eric Mazur of Harvard. A temporary 400-unit personal response system was installed for the talk that allowed all attendees to experience interactive lecture techniques first-hand. During his talk Mazur presented findings from several experiments in cognitive psychology on human ability to discern visual information, including figures in popular introductory physics textbooks. Audience members participated in a few startling demonstrations that illustrated Mazur's main message: seeing is not, in fact, believing! Many attendees walked away with a renewed sense of how students, even in the largest lectures, can be engaged intellectually.

A unique feature of the conference was the presence of 40 undergraduate STEM majors who accompanied conference presenters. On the final day of the conference, the students presented their impressions of their education and made recommendations. The students made a strong case for involving undergraduates early and often in research. Most cited interactions with individual faculty as having played a critical role in their decision to major in a STEM discipline and in forming plans for the future. The impact of welcoming undergraduates into their department and discipline was clear.

More information can be found at http://www.ccliconference.com/index.htm. Outcomes of the conference will be published in the near future. Ted Hodapp, Program Officer in the NSF Division of Undergraduate Education (DUE), played a central role in envisioning and organizing the meeting. Ted has been at NSF on leave from Hamline University in Minnesota and sharing responsibility for DUE physics and astronomy projects with Duncan McBride for the past two years.

Physical Review Focus

Physics Research Presented for Undergrads: On the Web and at APS Meetings

David Ehrenstein,
American Physical Society

College physics students need more than textbook physics. They need to hear about current research because it reveals the excitement of new questions and new discoveries. It also demonstrates that the elementary principles from their physics courses apply to experiments in today's labs. At the same time, PhD's enjoy a dose of fun and easily-digested physics from outside their specialty once in a while. For both of these audiences, we have been serving up undergrad-level descriptions of current research at APS's *Physical Review Focus* web site (http://focus.aps.org) for the past six years. I also organized a session at the APS April meeting in Denver this year and will present a similar one at next year's March meeting in Los Angeles (please contact me to suggest speakers.) My experience with writing and attending talks has led me to some rules for communicating science, which I describe at the end of this article.

On the web: Phys. Rev. Focus

http://www.focus.org

Physical Review Focus was originally conceived by the APS as a site for physicists to learn about hot research outside their specialty, so we could write stories assuming PhD-level knowledge. Right? Wrong. Being brutally honest about what most physicists remember about the Fermi surface or isospin, I realized early on that we needed to go down almost to the level of a typical college physics major. Besides, most physicists don't want to think too hard reading a short web story on a physics paper outside their specialty. They just want the gist of the paper.

So I geared the site toward undergrads, an audience that usually gets little exposure to current research in classes and textbooks. In fact, undergrads are a sort of in-between and underserved audience: they can go beyond the level of *New Scientist* but aren't ready for *Physics Today*. And presenting current research at their level seems like an ideal way to get them excited about physics, especially if the coursework isn't proving exciting enough. I hope that college physics teachers can use the site to point out connections between topics in the physics curriculum and the latest research results in *Physical Review Letters* (*PRL*.) (There is also an e-mail list that delivers weekly summaries of *Focus* stories, so students and teachers can keep up with the latest stories.)

I choose papers “of interest to outsiders.” That often means papers that are counter-intuitive, combine multiple fields, have some “cool” device application, relate to “everyday physics,” or relate to traditional undergrad-level physics problems. And of course, they can’t be too hard to explain. These characteristics appeal to non-specialist PhD’s but also to physics students and even journalists.

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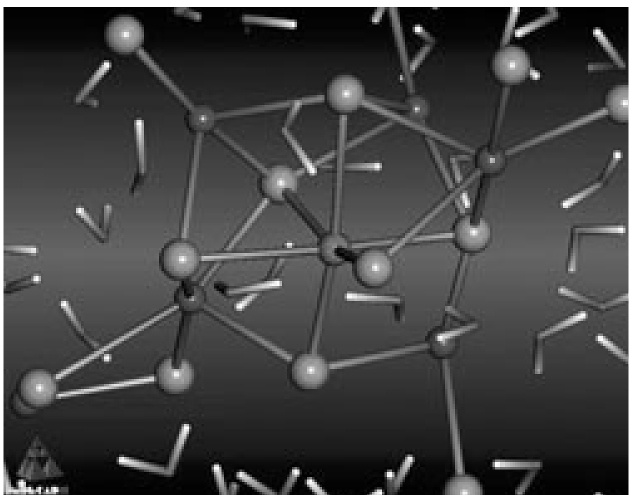
My writers and I try to write like journalists, not scientists. We try to avoid not only jargon, but also many of the abstract concepts that physicists find useful but readers find difficult, like the “energy landscape” picture. In this view of a system’s energy, hills and valleys represent energy maxima and minima encountered as one varies some system parameters. There just isn’t space in 500-600 words to describe this seemingly simple concept adequately. Instead, we rely heavily upon intuitive mental images, which can often do much of the work for us. We stick with “real” space and forces, rather than the energy space.



Baby picture. A sodium ion with six chloride neighbors (light gray) may be the first step in crystallizing salt from salt water, according to a computer simulation. Past simulations haven't been able to capture the extremely rare events in the first moments of crystal formation. See story at http://focus.aps.org/story/v13/st5. (From D. Zahn, Phys. Rev. Lett. 92, 040801(2004).)

One example of avoiding the energy landscape appears in a story from 4 February 2004 (http://focus.aps.org/story/v13/st5). The new computer technique we described could simulate the exceedingly rare early events in the formation of a salt crystal from salt water. We chose to discuss “sequences of water molecule motions” that bring a sodium ion and a chloride together, rather than “paths the system takes through the energy landscape” leading from one valley to another, which was the authors’ view of the problem. While it’s visual, the energy landscape doesn’t give you an intuitive sense of what is happening, especially if you’re a student--or physicist--not used to thinking in that world.

At APS Meetings

Attending an APS meeting can be hard on your brain, so just imagine how the handful of undergraduate students at the meetings feel. They are genuinely excited to be at such a prestigious physics conference, yet they have a hard time understanding the talks. They probably don’t realize that the PhD’s don’t understand a lot of what they hear, either. To help both groups, I invited four excellent communicators to speak at the APS April meeting in Denver in a Forum on Education session on presenting research at the undergrad level (http://www.aps.org/meet/APR04/baps/tocJ.html#SessJ14). I plan to organize a similar session for the March meeting in Los Angeles (and would *welcome* suggestions for good speakers.)

The speakers discussed complex systems in nature, ultrafast lasers, “taming” francium, and “asymptotic slavery” in high-temperature superconductors. Each speaker had had his or her work highlighted on the *Focus* web site or on AIP’s *Physics News Update* (http://www.aip.org/pnu). The students present learned about some fascinating areas of physics, and the PhD’s probably learned more than they would have at a typical colloquium-style talk aimed at physicists. During the Q&A, I asked the speakers about the challenges of speaking at such a low level, and it was clear that to do it well is a lot harder than it looks. It means avoiding almost all the math, but more importantly, paring down the topics to a sometimes painful minimum of information.

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Rules for Presenting Science to Students and Others

My rules for communicating science apply to teaching physics, telling a physicist friend about your latest results, or even explaining your work to your next-door neighbor.

Rule 1: No one knows as much as you think. You can never talk "too low" to your audience. In fact, most people are flattered when you say things they already know.

Rule 2: No one has the attention span you expect. The most common mistake in speaking to non-scientists is *not* using too much jargon but saying too much. Usually half of what you want to say is enough, as anyone who has accidentally bored a non-scientist with a long answer to an innocent science question knows.

Rule 3: No one cares about as many details as you do. There is always a temptation to go on to what you consider the "most interesting" part of an explanation, even though the background up to that point is often enough for your audience. Think of those colloquia where the first or second slide was enough for you, or papers where the abstract was all you needed to know.

I hope you will see these rules in action on the *Focus* web site and at the March meeting session next year.

David Ehrenstein is the Editor of Physical Review Focus (http://focus.aps.org/) and can be reached at ehrenste@aps.org.

ComPADRE and the Tools for Sharing Teaching and Learning Resources

Bruce Mason, University of Oklahoma ComPADRE Principal Investigator and AAPT Electronic Publications Editor

Warren Hein, Associate Executive Director, AAPT

Consider yourself in one of the following situations:

> You must teach a junior level quantum mechanics course for the first time in many years. You need new approaches to the topic, animations and simulations to help students develop an understanding of concepts, and research results that apply the material being studied.
>
> You have a CCLI project for introductory electricity and magnetism that combines interactive labs and online exercises and discussion. Initial assessments have been positive, and you want to deliver it to a wider audience for testing, feedback, and because it's very good.
>
> You are the outreach coordinator for a research center where your scientists and high school physics teachers created materials that bring research experiences into the classroom. These work well locally and you wish to disseminate this material to a much wider audience.

In all these cases, you probably turn to experienced colleagues, to point you to places to find or distribute resources, and the web. The ComPADRE project (Communities for Physics and Astronomy Digital Resources for Education), a collaboration of the AAPT, APS, AAS, and AIP/SPS, is designed to provide the resources, tools, and "space" to help meet these needs.

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What *is* a digital library?

ComPADRE (http://www.compadre.org) is a part of the NSF-DUE (Division of Undergraduate Education) National Science Digital Library (NSDL) program. This program supports the creation of collections for educational materials, services for users of these collections, research studying the collections, and the construction of a "Core" digital library that integrates all these efforts. A problem with digital libraries is the many different concepts that users may have about them. Although they vary quite a bit, digital libraries tend to have several characteristics in common. They are online, providing wide access to resources; they are distributed with both local materials and links to materials across the web; they are actively organized and maintained to meet specific needs; and they are more than just lists of links, providing services and tools that help users be more productive.

ComPADRE is both distributed and centralized. It is building multiple community-focused resource collections with the help of central support and services, analogous to the services provided by a professional society to publish diverse research journals. The focused ComPADRE collections address the needs of learning communities for quality resources selected and organized specifically for, and by, their members. These collections speak the users' language. They contain, for example, interactive simulations, novel curricula, and education research for teachers and students of a specific course. Building each of these collections from scratch would result in a great deal of repetition and waste. The ComPADRE central services streamlines and simplifies new collection creation by providing, out of the box, the information architecture, editorial processes, and user interface, communication, and organizational tools needed to make a collection run.

A common question asked when ComPADRE is discussed is: "Why can't I just use Google?" ComPADRE does not replace Google, but provides a different sort of information. The resources found on ComPADRE have been specifically selected for education, reviewed, and put into context of subject, user type, and use. The experience of others, both editors and general users, adds value to the resources in ComPADRE.

ComPADRE Collections

There are currently five community collections and one central repository interface:

- The Physical Sciences Resource Center (PSRC) (http://www.compadre.org/psrc) provides access to the full ComPADRE database. This is an updated, database driven version of a service provided by the AAPT for the past six years.
- The SPS-sponsored collection for physics and astronomy students, The Nucleus, (http://www.compadre.org/student) provides an information exchange, a virtual student lounge, a research opportunity bulletin board, and a showcase for compelling web resources. It is designed for and by undergraduate physics and astronomy majors.
- The Quantum Exchange (http://www.compadre.org/quantum) is a collection for teachers of quantum mechanics and modern physics. It augments standard textbooks with illustrations and simulations, tutorials, curricula, and relevant education research.
- The APS-sponsored collection of resources for the general public, Physics-to-Go, (http://www.compadre.org/informal) is built for those needing physics resources outside of formal educational settings. This collection includes virtual hands-on experiences with physics and astronomy, accounts of recent physics and astronomy research written for the general public, and information about physics road shows.
- The AAS-sponsored "Astronomy 101" collection, AstronomyCenter.org, (in testing at http://staging.compadre.org/astronomy) is a portal for teachers and students of introductory college-level astronomy. It contains links to activities, demonstrations, tutorials, images, raw data, lecture notes, assessments, news items, and curricula. Peer review of items will

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be an important aspect of this collection.

- The AAPT-sponsored collection for pre-college teachers, The Physics Front, (soon to be available) will focus initially on high school physics and the needs of new and crossover physics teachers. The language and organization of the collection are designed to be understandable to these new teachers. Along with lesson plans, student activities, and labs, this collection will highlight formal and informal professional development opportunities.

The ComPADRE Tools

The use of these collections, and the building of community around them, requires tools for users and editors. Users of ComPADRE can search or browse through the records in the database, and sort or filter the results to find what they need. More importantly, members (registration is free) can participate by recommending items and adding comments to the collections. Members also can organize materials through an online Filing Cabinet for later use. Editors have the tools and support needed to add materials to the collections, organize materials through annotations and by inter-relating resources, and to manage an online Peer Review process. Of course, all of these tools rely on the database and information infrastructure (metatagging) for all of ComPADRE. All these tools are being evaluated by users and continually improved by ComPADRE staff.

Future Developments

The most important technical development currently under way is the creation of a repository. This will allow ComPADRE, with the approval of author(s), to directly deliver materials to users. These resources, that might need more reliable hosting, will be available either from ComPADRE or from the original site. This will also provide a place for materials that an author may want to remain available but can no longer support. A related development is a link checker that will regularly search the database for links that are no longer available or with pages that have changed significantly. Attempts will be made to find and update materials with broken links, vital for providing reliable and useful collections.

ComPADRE growth involves both the addition of resources to current collections and the construction of new collections. ComPADRE is working with members of the PER community to provide an online annotated bibliography for the field. There are plans to add collections for the standard junior, senior, and introductory graduate classes in physics and astronomy, as well as unique or emerging topics. There are plans to extend the pre-college resources to conceptual physics courses, middle school, and then K-5. Collaborations will be pursued with authors, organizations, and other digital libraries. All of this growth is meant to provide more and better resources to the users.

The foundations for ComPADRE are constructed and the tools are available for use. The collections can be accessed, resources discovered, and materials added. The success of the effort will depend, in large part, on the users and uses of the collections. Recommendations for materials to include in the collections, both from authors and the user community, are vital for growth. Comments from the user community will help others better understand and use the resources. Reviewers, associate editors, and editors of new collections are needed to ensure quality resources and collections. The ComPADRE staff and the supporting societies welcome your suggestions and participation.

The American Institute of Physics Supports Education Efforts in Many Ways

Jack G. Hehn, Director, Education

It is a pleasure for me to work with the APS Forum on Education (FEd) to help make our community more aware of the many education efforts being undertaken predominately by scientists and engineers who volunteer their time and effort out of a true concern for the future of our scientific enterprise. The course that science in America takes is deeply dependent on the intellectual and skill base of the technological workforce and the attitudes about science of voters and decision makers. The effectiveness of the global educational systems that build the capacity of the labor pool plays a critical role in our future. These interests drive several cross-cutting issues in professional or learned organizations: (1) efforts to continually develop the talents and skills of the membership (Professional Development and Certification), (2) efforts to increase the quality and quantity of educational experiences for students (Preschool through PhD) in science, technology, engineering, and mathematics (STEM), (3) efforts to provide STEM outreach programs for the general public, (4) efforts to increase the diversity of the STEM workforce, and (5) efforts to positively influence public policy and increase support for STEM.

AIP is a federation of ten Member Societies (http://www.aip.org/aip/societies.html) representing a wide spectrum of the physical sciences. AIP supports their efforts with print and e-publishing services, as well as a range of membership services and physics-related resources. In these ways AIP is able to amplify its Member Societies' common activities and create a united front to achieve shared goals. AIP carries out the program services primarily through the AIP Physics Resources Center (PRC) with five divisions: the Center for the History of Physics, the Statistical Research Center, the Media and Government Relations Division, the Career Services Division, and the Education Division. (http://www.aip.org/resources.html)

The Education Division provides information and services for students, alumni, academic departments, and corporate research interests in the physics and allied science communities. It also acts as a catalyst for the efforts of the AIP Member Societies associated with education and human resources. The mission of the division is stated as follows:

> **Support the highest quality science education for <u>all students</u>.** To provide student services and support programs within the broad physics community that will identify, promote, and enhance high-quality, student-centered, and societal-relevant educational practices and initiatives that positively impact students and their learning of physics, astronomy, and allied sciences and technology.

AIP directly supports three "other member organizations:" the Society of Physics Students (SPS), Sigma Pi Sigma, the National Physics Honor Society, and the Corporate Associates program (http://www.aip.org/education). AIP staff members maintain close and productive relationships with several federal agencies and Congressional interests that support the STEM enterprise and with other national umbrella organizations with mutual interests.

The Society of Physics Students (SPS) is a professional association explicitly designed for students and their mentors. Membership, through collegiate chapters, is open to anyone interested in physics. SPS offers awards programs, outreach opportunities, social activities, and extensive web services, encouraging a diverse population of students to study physics. SPS has over 700 chapters on campuses across the country. About 5,000 national members and thousands more local mem-

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bers take part in chapter activities each year (http://www.spsnational.org/). Within SPS is Sigma Pi Sigma, the national physics honor society, which inducts members on the basis of outstanding academic achievement. There are 450 chapters of Sigma Pi Sigma, with over 75,000 inductees throughout its history (http://www.sigmapisigma.org/). You may want to learn more about the 2004 Quadrennial Congress of Sigma Pi Sigma that will meet with the APS 4-Corners Section. (http://www.sigmapisigma.org/congress.htm)

The AIP Corporate Associates program serves the industrial physics community by improving the effectiveness of people and organizations in advancing corporate goals through the use of physics; and it facilitates interaction between the industrial, academic, and federal segments of the larger physics community. The Corporate Associates program sponsors the annual Industrial Physics Forums that examine relevant interests of industry, policy issues, and cutting-edge research. (http://www.aip.org/ca/2004/04mtg.htm).

Each AIP Member Society has one or more committees, councils, or fora that focus on education and human resources issues. Some organizations have professional staff dedicated to work on education and human resources issues. AIP works hard to support the projects and programs of its Member Societies including consultation and direct help in proposing and securing extramural funding and managing large projects. Examples of large scale efforts include PhysTEC (The Physics Teacher Education Coalition) lead by APS; ComPADRE (the Community of Physics and Astronomy Digital Resources in Education) lead by AAPT, the National Task Force on Undergraduate Physics (NTFUP) and its report entitled “SpinUP,” and the Joint Society Conference on Increasing Diversity in the Earth and Space Sciences (IDEaSS Conference) lead by AGU.

The AIP Liaison Committee on Physics Education meets annually to provide a forum to share information and examine mutual benefits of overlapping goals and learn from shared experiences (http://www.aip.org/handbook/educ_lia.htm). The committee is always pleased to hear about the wide variety of education and outreach efforts of APS including those of the FEd. Prepared for APS FEd members, the following set of articles provides information about and promotes awareness of efforts and successes in four AIP Member Societies other than APS. These are examples of the many excellent projects, services, products, and programs that you might find by exploring the websites and publications of all ten AIP Member Societies.

I hope that you will learn about various programs from these articles, be encouraged to learn about other programs from professional organizations, and be encouraged to work with the APS FEd in collaborative efforts. Please contact me at the AIP Education Division (jhehn@aip.org) with comments or questions when you think that I can help.

ASA Education and Outreach

Thomas D. Rossing and Uwe J. Hansen

The Acoustical Society of America, one of 12 member societies in the American Institute of Physics, was founded in 1929 at the Bell Telephone Laboratories in New York City. Its 7000 members represent all fields of acoustics. It holds general meetings every spring and fall, and it recently celebrated its 75th anniversary by meeting in New York, where it was founded. From its beginning the ASA has had strong ties with education.

Sessions on Acoustics Education

The Committee on Education in Acoustics arranges special sessions on acoustics education at nearly every meeting of the Society. Often these sessions are co-sponsored by one of the technical committees (co-sponsorship by musical acoustics and architectural acoustics appear to have been the most common). These sessions have focussed on a wide range of activities in acoustics education. We mention examples of a few of these.

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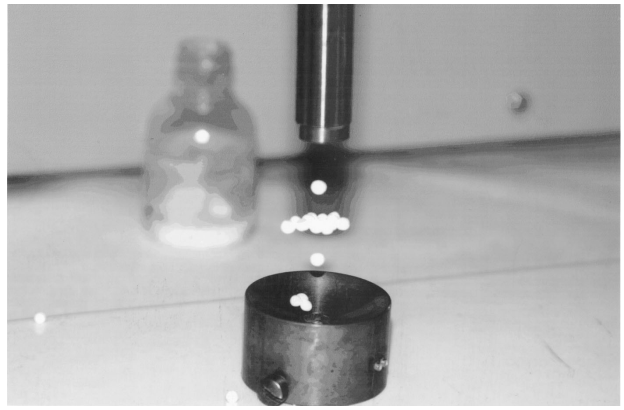
Laboratory experiments in acoustics. Science is best taught (and learned) by hands-on experience.

"I hear, I forget. I see, I remember. I do, I understand."

Laboratory instruction has always been an important part of physics teaching, and the teaching of acoustics is certainly no exception. The Committee on Education in Acoustics has arranged several successful sessions at ASA meetings on laboratory experiments in acoustics. For example, a session in 1985 featured personal computers for laboratory instruction, while a session in 1987 focussed on project laboratories. Sessions in 1993 and 1999 dealt with undergraduate laboratory experiments in acoustics, while a session in 2001 looked at low-cost laboratory experiments.

Demonstration experiments in acoustics. Demonstration experiments rank next to hands-on laboratory experience as effective ways to learn acoustics and vibrational physics. From the time of Pythagoras, demonstration experiments have been used to demonstrate acoustical phenomena. Faraday and Helmholtz and Rayleigh and Tyndall were famous demonstrators. Sessions on demonstration experiments in acoustics often draw standing-room-only crowds.



Styrofoam balls levitated in a sound field

At the 141st meeting in Chicago (2001), Tom Rossing and Uwe Hansen presented a tutorial lecture on Demonstration Experiments in Acoustics, at which a group of Chicago-area physics teachers joined ASA regulars in doing acoustics demonstration experiments in rapid succession.

Take-Fives At these sessions, which have become very popular, participants present short demonstration experiments, videos, or innovative ideas for teaching acoustics. The term "take-fives," borrowed from physics teacher meetings, refers to the 5-minute time limit imposed on the speakers in order to maintain the pace of the session. The

Session on acoustics demonstration experiments at an ASA meeting

Chicago-area physics teachers participate in an ASA tutorial on demonstration experiments in acoustics

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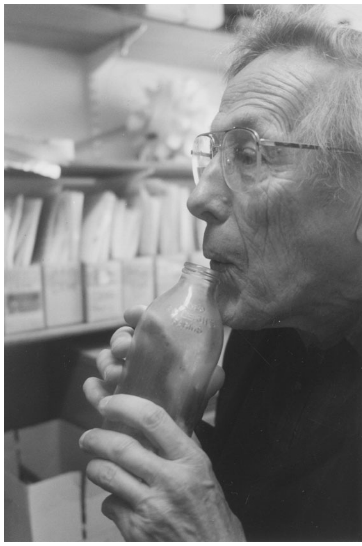
popularity of take-five sessions results partly from their spontaneity, and most attendees agree that they return home with new teaching ideas as well as enthusiasm to try them out.

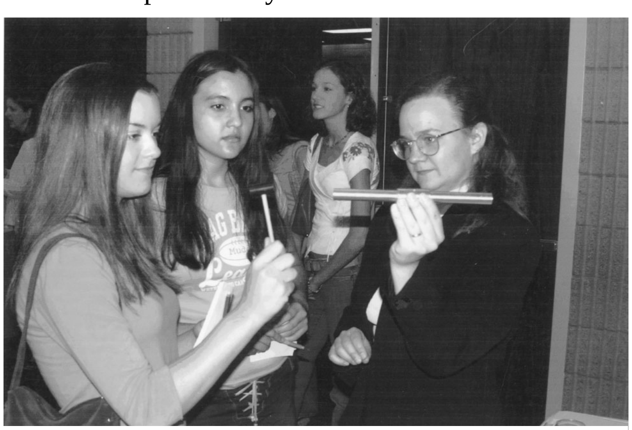


Milk bottle from Rayleigh dairy

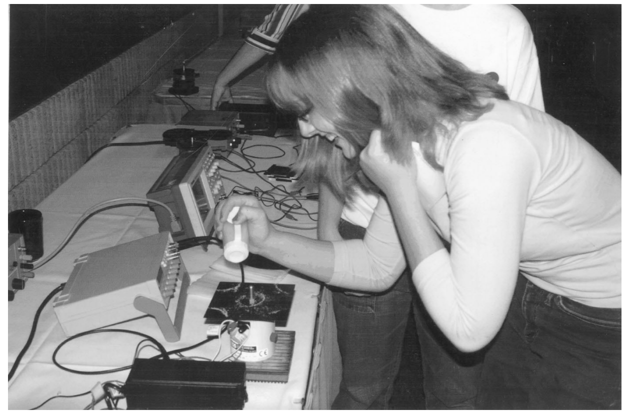
ASA reaches out to high school students

Outreach to high school students has become an important activity of the Acoustical Society of America. Special sessions for high school students are now frequently scheduled at ASA meetings. Sometimes they are sessions at which acoustics demonstration experiments of particular interest to high school students are presented (although these sessions are well attended by ASA members as well!). Sometimes they involve hands-on experiments that high school students can perform with advice from ASA members acting as docents.

Since ASA meetings are often held in large cities, it has been particularly effective to invite students from inner city high schools with large numbers of minority students. Special effort has been made to have female and minority members of ASA as docents. Sometimes a pizza lunch is provided by ASA. At some future date, we hope to hear a testimonial from an acoustician whose first contact with acoustics came by visiting such a session at an ASA meeting.



High school students observe longitudinal waves in a rod



High school students observe Chladni figures

In addition to inviting high school students to hands-on sessions, we have taken demonstrations into high school classrooms. These class visits usually take the form of an introductory acoustics lesson with numerous demonstrations designed to augment regular physics curricula. Principles frequently demonstrated include resonances on stretched strings and in air columns, normal mode vibrations on plates illustrated with Chladni patterns, and spectral analysis and synthesis. One such visit was conducted during the 147th ASA meeting in May 2004 in New York in the context of the 75th Anniversary celebration with a very successful visit to a science class of the Professional Performing Arts School in Manhattan.

Workshops for teachers

The ASA Technical Committee on Musical Acoustics (TCMA) has sponsored a series of workshops for high school teachers and for elementary school teachers. Support has come from the Department of Education by way of "Eisenhower" grants as well as from ASA in the

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form of technical initiatives. Uwe Hansen and other members of TCMA have organized these very successful workshops.

Emphasis at the high school teacher workshops is on construction of inexpensive equipment for doing laboratory and demonstration experiments on sound. For example, teachers build their own monochords and air column resonators, using precut lumber, do experiments with this equipment, and take it home for use in their own classes. In one workshop, the teachers used computer-based data acquisition systems to do spectral analysis of sound. Some of these workshops have been held in conjunction with ASA meetings, some at universities (University of Maryland, University of Houston, Brigham Young University, and Indiana State University), and some in local school districts.

The workshops for elementary grade and middle school teachers have emphasized using music as a vehicle to introduce science concepts in the classroom. Basic acoustical principles are presented, followed by a session on practical classroom applications using tools given to the teachers to take back to their schools. The tools have included a spring and slinky for wave demonstrations, a monochord to relate the harmonic series to audible tones, an air column resonance device, a self-resonant tuning for, and a corrugated whirling tube resonator. Workshop venues have included ASA meetings, state science teacher conventions, local school districts, and universities. Over a dozen of such workshops have been held over the last ten years.

ECHOES

One of the authors (TDR) edits *ECHOES*, a quarterly newsletter, for the ASA. *ECHOES* aims to keep ASA members informed about acoustics news, but it also reaches out to students and to the general public. *ECHOES* is sent to schools and teachers that request it, and it is also available online at http://asa.aip.org/echoes.html.

Thermoacoustics and sonoluminescence

Two interesting acoustical phenomena that have been in the news recently are thermoacoustics and sonoluminescence. Thermoacoustics deals with the conversion of heat to sound and vice versa. Thermoacoustic engines and refrigerators use acoustical components and networks to produce mechanical power or to pump heat, or both, without the use of traditional mechanical contrivances such as pistons, linkages, and valves. Thermoacoustic refrigerators have been developed for NASA to use in space and for Ben & Jerry's to freeze ice cream in an environmentally friendly way.

In the Summer 2000 issue of *ECHOES*, Penn State physicists Steven Garrett and Reh-lin Chen described a simple thermoacoustic engine kit, easily constructed by high school students that would use heat to generate sound. How many of these "acoustic lasers," as they called their device have been built in high school science classes is anyone's guess. At the moment, no thermoacoustic ice cream freezer kits are available.

Sonoluminescence is the conversion of sound into light. It is a mysterious process in which sound waves aimed at a container of liquid nucleate, grow, and collapse gas-filled bubbles to create ultrashort light flashes. The violent collapse of the bubbles is associated with temperatures that momentarily exceed those of the sun. According to a report in *Science* in 2002, scientists at the Oak Ridge National Laboratory saw evidence of nuclear fusion in a small cylinder of deuterated acetone by means of sonoluminescence.

A physics apparatus company (TeachSpin) now sells a sonoluminescence apparatus for use in student physics laboratories.

Audio and video materials

The ASA co-sponsored (with the Institute for Perception Research and Northern Illinois University) production of a Compact Disc with 39 auditory demonstrations designed for teaching the science

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of hearing and perception. This CD is widely used in the teaching of musical acoustics (physics of music), hearing, and perception.

ASA also has produced several videotapes for teaching speech acoustics. A three-tape set on speech production includes demonstrations of use of MRI, ultrasound, and velotrace in speech acoustics. A video on *Speech Perception* includes demonstrations of spoken language processing, phonetic interpretation, developmental speech perception, and cross-modal speech recognition.

Thomas Rossing is Professor Emeritus of Physics at Northern Illinois University. He is a Fellow of ASA as well as APS and edits the fall issue of the Forum on Education newsletter. Uwe Hansen is Professor Emeritus of Physics at Indiana State University. He is a Fellow of ASA and chairs its Committee on Education in Acoustics.

Optics Education – Hands-On Optics and More!

Jason Briggs, Optical Society of America Education Program Manager

Mission

The mission of the Optical Society of America (OSA) is to promote the generation, application and archiving of knowledge in optics and photonics and to disseminate this knowledge worldwide. OSA was organized in 1916 to increase and diffuse the knowledge of optics, pure and applied; to promote the common interests of investigators of optical problems, of designers and of users of optical apparatus of all kinds; and to encourage cooperation among them. The purposes of the organization are scientific, technical and educational.

Education Portfolio

The organization's activities work to raise the level of understanding and awareness about optics in a number of areas:

- Elementary, secondary and post-secondary education
- Education policy and public awareness
- Outreach and academic preparation
- Professional development

As of September 2003, OSA was funded by the National Science Foundation (NSF) to launch a collaborative optics education program linking the professional optics and the informal education communities to reach under-represented middle school cohorts in science and technology.

The Hands-On Optics (HOO)[1] program is a unique informal science program that brings together two professional societies (SPIE - The International Society for Optical Engineering and OSA - Optical Society of America), a mathematics and science education program serving educationally disadvantaged students (MESA - Mathematics, Engineering, Science Achievement), and a national observatory (NOAO - National Optical Astronomy Observatory) to provide a new model for informal science education activities in optics.

HOO Project Goals

The primary goals of Hands-On Optics are to:

- Create links from the professional optics community to the informal science education community.
- Reach underrepresented middle school cohorts in science and technology, and connect with their parents and teachers, school districts and communities.
- Provide opportunities for the target populations to succeed in collaborative learning and problem solving through inquiry-based, hands-on applications of optical and engineering skills and knowledge.
- Increase science and technology knowl-

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edge for students, and increase awareness of optics as a discipline and career that crosscuts numerous fields.

"We are going to go into those areas where kids don't have access," HOO PI Anthony Johnson explains to *Physics Today,* "You've been hearing about the 50th anniversary of *Brown v. Board of Education*" — the 1954 Supreme Court decision to integrate schools — "and just how separate and unequal it still is. I've been doing this for years, but it's great that we've been able to set up a more formal structure."

Targeting kids before high school is key, Johnson adds. "A few years ago, I was in Detroit and gave a seminar at an inner city high school. Their eyes glazed over. After they hustled out, two young ladies snuck back into the auditorium. They didn't want their peers to know they were interested in the science. It wasn't cool to be smart. Then I gave the same talk at an elementary school. The bright young faces were all excited. That's the difference between high school and elementary school."

Resource Agents

SPIE and OSA are tapping into the thousands of industry, college, and university professionals who make up society membership in the geographic areas where the MESA teacher trainings and program rollout will take place. The societies are recruiting Optics Resource Agents (volunteers) from both individual member rosters and corporate partners. The program's first Intensive Training Institute for Resource Agents and teachers from Southern California and Washington State will be held July 9-11 at the University of Southern Californi

For this summer's Intensive Training Institute, a minimum of 15 volunteers are expected to participate; additional volunteer members will be matched, one per teacher, at each MESA HOO site. Other volunteers will be invited to contribute by participating in Saturday Academies, Industry Shadow Days, career awareness events and on local industry advisory boards.

It is this resource that the societies bring to the program that makes it valuable, to teachers, students and parents. Most societies have engaged their respective memberships in various education or outreach activities. However, the training and support systems provided to the volunteers are based on best practices from the successful NSF-supported program Project ASTRO (http://www.astrosociety.org/education/astro/project_astro.html). Project ASTRO improves the teaching of astronomy and physical science in 4-9th grade classrooms, and in youth groups, by linking professional and amateur astronomers with local educators.

Training and Development

The July 9-11th 2004 training will be held under the sponsorship of MESA of California with help from the USC Department of Electrical Engineering. This professional development experience will increase the content knowledge of the teachers and will also help the teachers with optics teaching pedagogy. More importantly, it will give the teachers a strong sense of the playful, exploratory atmosphere we are trying to create in the HOO modules. During the workshop, HOO teachers will interact with the three modules in much the same way as the students will.

The optics volunteers will receive training on working in schools and on the nature of science teaching today, including some material on the National Science Education Standards. The volunteers will learn how to effectively interact with students in ways that support HOO educators and will receive a draft copy of the HOO "How To" manual describing a number of different educational situations and giving advice for the volunteer in these situations.

A major goal of the workshop is to develop a respectful and collegial relationship between the volunteer and educator. To achieve this goal, the partners will interact and work together on the modules as well as participate together in the social settings of the workshop. The building of mutual understanding and respect in the educator/

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volunteer partnership is critical for the long-term success of the project.

Project Outcomes

By leveraging the existing infrastructure at 12 diverse MESA host sites in California and in six other states with successful MESA programs the HOO program will gain a “jump-start” in reaching the target audience. HOO also will reach other students by disseminating the project to science-technology centers, other informal learning environments and service providers and through both optics societies’ many volunteer outreach programs nationwide.

Access to optics will be created for tens of thousands of students by the end of program year 3 (now in year 1), of which over 80% of the students will be from traditionally underserved groups in science and engineering. Also by year 3, alliance formation and sustainability among the stakeholders, education institutions and optics and optics-related companies will be strengthened to promote ongoing joint action in informal optics science education.

If you are interested in learning more about the HOO program, the Web site (www.Hands-On-Optics.org) affiliated with the program is due to launch by the end of August 2004. Please also feel free to contact Jason Briggs (OSA Education Program Manager) at jbrigg@osa.org.

Note

1. This material is based upon work supported by The National Science Foundation under Grant No. ESI-0307949

Students assembling a Newtonian reflecting telescope as part of a MESA science competition

Education Activities of the American Astronomical Society

Susana E. Deustua

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The primary education mission of the American Astronomical Society (AAS) is to optimize the contributions of the AAS and its members to ensure that undergraduate and graduate programs in astronomy and astrophysics prepare not only the next generation of professional astronomers but also broadly trained individuals with strong technical and scientific backgrounds; to provide encouragement and to broaden educational opportunities and enhance science literacy for all with particular attention to underserved groups in the physical sciences

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Within the Society, and more widely in the astronomical community, the AAS advocates greater attention to, encouragement of and rewards for excellence in research on teaching and learning in astronomy and in astronomy education. Additionally, the AAS is an advocate for astronomy and astronomy education in national and state education forums, to funding agencies, and to the scientific and education communities.

The education activities of the AAS are thus geared toward meeting these goals – from the Bok Awards, which aim to encourage young scholars in the pursuit of a science career, to sponsoring workshops that enable new faculty to hone their teaching skills. Following is a description of some of the education programs of the Society.

The Priscilla and Bart Bok Awards and the Richard D. Lines Special Award

The Priscilla and Bart Bok Awards (First and Second Awards) are presented annually by the AAS and the Astronomical Society of the Pacific (ASP) for outstanding astronomical research projects at the annual Intel International Science and Engineering Fair (ISEF) for high school students. The Richard D. Lines Special Award is presented annually by the International Amateur-Professional Photoelectric Photometry (IAPPP) at the ISEF. These awards are administered by the AAS on behalf of the AAS, the ASP and the IAPPP, and are funded by the National Science Foundation's Astronomy Division Special Programs. The main criterion for selecting the two Bok Awards is scientific merit. Observational, instrumental or theoretical projects are all eligible, as are interdisciplinary projects involving Physics, Math, Computer Sciences, Engineering, etc. Although scientific merit is the primary criterion for the Lines Award, a project is sought which best reflects both the mission of the IAPPP (collaboration between amateurs, students, and/or professionals) as well as excellence in observational and/or instrumental astronomy. Most of the young recipients of these awards go on to major in Science, Technology, Engineering or Mathematics, and often obtain graduate degrees.

The Harlow Shapley Visiting Lectureships in Astronomy

The Harlow Shapley Visiting Lectureships provide any host undergraduate institution: community colleges, teacher colleges, liberal arts colleges and non-research universities, and institutions not offering an astronomical degree with a program of two day visits by professional astronomers. Visiting professors can contribute to the host institution's academic program and intellectual environment in many different ways from teaching a variety of classes in physical, mathematical and general sciences, as well as astronomy to giving popular public addresses. The level of these presentations range from the elementary and non-mathematical to the advanced and technical. In informal discussions, the visitors can advise students on possible future scientific careers and can discuss teaching and curriculum problems with faculty members, deans and administrators. Talks at local secondary schools are also encouraged as part of the visit.

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Workshop for New Faculty in Physics and Astronomy

The American Association of Physics Teachers (AAPT), in conjunction with the American Astronomical Society (AAS) and the American Physical Society (APS), hold a workshop for new physics and astronomy faculty members in November each year at the American Center for Physics. Now in its eighth year, this annual conference helps new faculty understand how students learn physics and astronomy and suggests how this information can impact a new professor's teaching methods. The workshop is funded by the National Science Foundation's Division of Undergraduate Education. Department chairs submit nominations of faculty to attend the workshop.

ComPADRE (Communities for Physics and Astronomy Digital Resources in Education)

ComPADRE is a network of well-organized digital collections of high-quality educational materials in physics and astronomy. This project is the cooperative effort of the American Association of Physics Teachers, the American Astronomical Society, the American Institute of Physics and the American Physical Society. Funding is provided by the National Science Foundation as a part of the National Science Digital Library project.

ComPADRE currently houses six collections of materials, connecting a wide range of digital resources including curricular materials, digital libraries and online journals. These initial collections are the 1) PSRC (Physical Science Resource Center) which is the general or central collection for ComPADRE, 2) The Nucleus, a collection by and for the AIP/Society of Physics Students which provides physics and astronomy resources for undergraduates; 3) Physics to Go a library of informal science websites, 4) Quantum Exchange, a web-based repository of resources for teachers of quantum and modern physics, 5) Astronomy Center, a web-based repository of resources compiled to assist in the teaching of a collegiate level Introductory Astronomy course. The materials on this site are selected by the Editor and the Astronomy Center Editorial Board for being high quality educational resources and are peer reviewed for content, usability and quality, and 6) The Physics Front, a digital library for all secondary school physics teachers. ComPADRE collaborates with projects like MERLOT and groups like the Physics Education Research community to help create digital resources for those communities. See the article by Bruce Mason and Warren Hein in this issue.

Education Prize

The AAS Education Prize recognizes outstanding contributions to the education of the public, students and/or the next generation of professional astronomers. This prize superseded the Annenberg Prize in 2001 and is awarded annually. Recipients have been Frank D. Drake (2001), Michael Zeilik (2002), Jay M. Pasachoff (2003), and the most recent is Owen Gingerich (2004).

Publications

Additionally, the Society has several publications, all available on line. These include *A New Universe to Explore: Careers in Astronomy,* for high school students and undergraduates, *An Ancient Universe: How Astronomers Know the Vast Scale of Cosmic Time,* a primer on cosmic evolution for pre-college science teachers and co-published with the Astronomical Society of the Pacific and *Goals For "Astro 101: Report On A Workshop For Astronomy Department Leaders,* now published in the Astronomy Education Review at http://aer.noao.edu.

Further information about the AAS education projects can be found at http://education.aas.org, or contact Dr. Susana E. Deustua, Director of Educational Activities at deustua@aas.org.

Education and Outreach Programs at the American Geophysical Union: Strategic Investment for Maximum Impact!

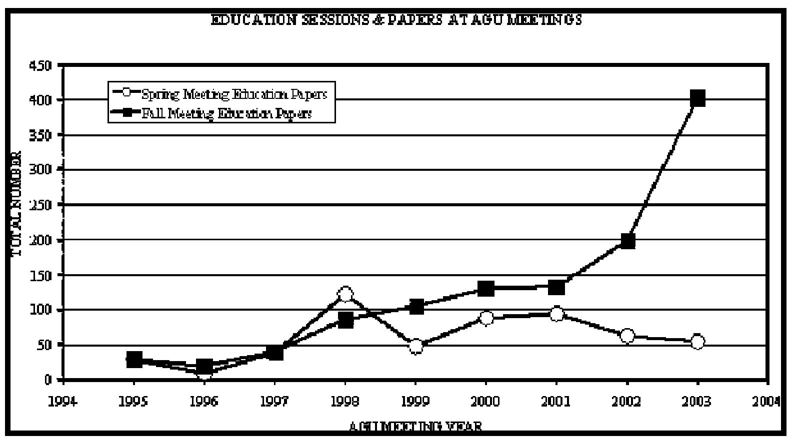
Jill Karsten

The AGU is a global network of nearly 40,000 Earth and space scientists from 130 countries. Our membership is dominated by scientists in the academic and government sectors and almost one-third of them work outside of the United States. Not surprisingly, “job one” at AGU is the business of supporting scientific research, through peer-reviewed publications and annual meetings for the scientific community to gather and share their results and ideas. Although education and outreach programs at AGU are relatively small in comparison, they play a vital role in helping to: strengthen undergraduate and graduate geoscience departments; improve pre-college Earth science teaching; facilitate communication of research in the Earth and space sciences to the public; and recruit a strong and diverse next generation of geoscientists. The Committee on Education and Human Resources (CEHR) has helped AGU build a strategic portfolio of education and outreach programs that capitalize on our main resources—our global network of scientists and access to cutting-edge research. These efforts have been greatly enhanced through leveraging of resources in partnership with other organizations serving the physical sciences community.

AGU offers several programs aimed at strengthening teaching and research in geoscience departments. Chief among these has been dissemination of “best practices” and new strategies through special conferences, workshops, and **education-themed (ED) sessions** at our annual meetings. In the past decade, the number of ED session papers submitted to the Fall AGU Meeting (which now attracts 10,000 scientists) has grown from under 30 in 1995 to 396 in 2003. A large part of this growth is likely due to the increasing pressure applied by federal funding agencies for the research community to consider the broader impacts of their research projects; ED sessions provide a great venue for showcasing these activities.

AGU has also made ED session papers exempt from its rule limiting abstract authors to one first-author contribution, thus enabling scientists to display the products of both their technical and education/outreach efforts at the same meeting.

Recent ED sessions have covered a wide range of topics, from enhancing K-12 education through partnerships with universities to identifying best practices for integrating research and education at the undergraduate level; from exploring the use of innovative technology in teaching geosciences to using the insights from cognitive research on how people learn science in developing effective science courses.



Recent studies (e.g., Weiss et al., 2002) have demonstrated that secondary Earth science teachers have the weakest training in their subject, when compared with teachers from the other natural sciences. This reality has prompted AGU to offer **Geophysical Information for Teachers (GIFT) Workshops** that help to strengthen the content knowledge of Earth science teachers and provide them with resources which facilitate teaching

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Bright STaRS students from the SF ROCKS! program at San Francisco State University presenting their results at the 2003 Fall AGU Meeting

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these concepts in the classroom. GIFT Workshops, which are held in conjunction with annual AGU meetings, bring scientists attending the meeting together with teachers from local schools for a day-and-a-half program of scientific presentations and related hands-on activities. The teachers are also given complimentary meeting badges that allow them to attend technical sessions and the exhibit hall on the second afternoon of the workshop. Recent GIFT Workshops have focused on climate change research in the sensitive polar regions and mid-ocean ridge research; this latter workshop included an exercise to build your own remotely-operated vehicle which the teachers tested in the hotel swimming pool!

Although AGU has a significant student membership (~17% are undergraduates or graduate students), the median age of the AGU membership has increased over the past decade and is now 45 years old. Fostering the next generation of geoscientists and recruiting the "best and brightest" of the entire talent pool available has become an increasingly important focus for AGU's education and outreach programs. With the completion of a comprehensive Diversity Plan for AGU in May 2002, CEHR has identified several new initiatives for increasing the participation of underrepresented groups in the Earth and space sciences. [see http://www.agu.org/sci_soc/education/diversity.html]. Two programs are particularly noteworthy.

In June 2003, AGU co-sponsored a ***Joint Society Conference on Increasing Diversity in the Earth and Space Sciences (IDEaSS Conference)***, which

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brought together representatives from 26 different societies and organizations to discuss the community-wide problem of increasing diversity. [see http://www.agu.org/sci_soc/education/jsc/]. One outcome of the IDEaSS Conference was a Resolution to collaborate which has to date been endorsed by several leading organizations in addition to AGU, including the American Meteorological Society, Association of Women Geoscientists, National Association of Geoscience Teachers, and Houston Geological Society.

The second main diversity program, **Bright STaRS (Students Training as Research Scientists)**, is a day-long program for high school students involved with after-school and summer geosciences-related research experiences in their local communities. About 45 students, mainly from underrepresented communities, are invited to submit abstracts on their research and attend the meeting. The students present their results during a special afternoon poster session and the abstracts are published in the meeting abstract volume. In a dedicated morning symposium, the students learn about the breadth and excitement of research in the Earth and space sciences from prominent scientists attending the meeting.

Future directions for AGU and CEHR will include a new outreach web site that will provide less technical synopses of current AGU publications, thereby making some of the most recent research in the Earth and space sciences more immediately accessible to the general public. CEHR also hopes to expand its education and outreach offerings in ways that better serve the diverse needs of its international membership. This will not be an easy task, given that most educational decisions are developed locally, thus making it hard to utilize "one size fits all" strategies. We look forward to continuing our tradition of partnering with other scientific societies in identifying practical and effective solutions for achieving that goal.

Reference:

Weiss, I.R., "2000 National Survey of Science and Mathematics Education: Status of Secondary School Earth Science Teaching," Horizon Research, 2002.

Jill Karsten is the Manager of Education and Career Services at the American Geophysical Union. Prior to joining AGU staff in the Fall of 2001, She was a member of the research faculty in the Department of Geology and Geophysics at the University of Hawaii at Manoa for twelve years, and served as a Program Officer in the Marine Geology and Geophysics program at the Office of Naval Research for one year. Her research interests are focused on tectonic and volcanic processes of mid-ocean ridge systems. She is currently a member of the National Advisory Board for the Centers for Ocean Science Education Excellence (COSEE) and the American Geological Institute's Education Advisory Committee. She can be reached at jkarsten@agu.org.

Browsing the Journals

Thomas D. Rossing

- The April issue of *American Journal of Physics* is a "theme issue" devoted to Classical Mechanics and Nonlinear Dynamics. The issue begins with a brief introduction by the editors, followed by a paper "Sea gulls, butterflies, and grasshoppers: A brief history of the butterfly effect in nonlinear dynamics." Two papers discuss conservation laws, and four papers discuss curriculum development and physics education research. Pendula and oscillators are discussed, along with chaotic electronic circuits.

- "Scientific Teaching" is the title of a forum article in the 23 April issue of *Science*. The article traces some of the changes in science teaching that have occurred in recent years, especially since the publication of the AAAS 1989 report "Science for all Americans," along with recommendations for moving the so-called revolution forward. Active participation in lectures and discovery-based laboratories helps students develop the habits of

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mind that drive science. Even in large introductory classes, with enrollments approaching 1000 students, scientific teaching is possible, the paper argues; many courses have replaced lectures with other activities.

- The U.S. Department of Education recently released guidance on parental involvement to help states, school districts and schools ensure that parents have the information they need to help improve their child's academic achievement, according to the June issue of *The Achiever*, a publication of the DOE. An online copy of the guidance is available at www.ed.gov/programs/titleiparta/parentinvguid.doc.

- The United States faces a major shortage of scientists because too few Americans are entering technical fields, according to a story in the May 5 *New York Times*. Furthermore, international competition is heating up for bright foreigners who once filled the gap, according to the National Science Board. The Board issued a report "An Emerging and Critical Problem of the Science and Engineering Labor Force" as a companion to "Science and Engineering Indicators 2004." Both reports were released by the National Science Foundation. The United States ranks 17th among the nations surveyed in the share of its 18-to-24-year olds who earn natural science and engineering degrees, behind Taiwan, South Korea, Ireland, and Italy. In 1975, it was third. The report indicates that 38 percent of the nation's scientists and engineers with doctorates are now foreign born.

- "Teaching Special Relativity Using Wavelets" is the title of a paper by Wolfgang Christian and his colleagues in the May issue of *The Physics Teacher*. Because special relativity focuses on abstract concepts, the visualization that Physlet-based material provides is especially valuable. Earlier papers discussed the use of Physlet-based exercises to teach optics and quantum mechanics.

- A special section in the January issue of *Physics World* entitled "New Dimensions in Education" has several interesting articles such as "Should physics be more elitist?" "Challenging the next generation," Science education for the 21st century," "Back to the future," "A PhD is for life," and "Physics education research: the key to student learning.: Several well-known physics teachers, including Paul Hewitt (former boxer, uranium prospector, and cartoonist), include short essays on their own education.

- "Beyond PowerPoint," an article in the June issue of *Syllabus*, discusses some shortcomings of electronic slides that tend to prescript a lecture and make it difficult to adapt the presentation to the audience. An important part of lecturing is adjusting material in response to audience reactions and developing spontaneous examples and explanations to clarify and expand on topics. Systems have now been developed that allow writing on top of slides by using tablet PC as the instructor device. An interesting comment on PowerPoint teaching is given in an editorial in the March issue of *The Physics Teacher.*

- Some interesting observations on the physics of bicycles is discussed in a paper entitled "Wheelies and Headers, or How to Keep Both Bicycle Wheels on the Ground" in the January issue of *The Physics Teacher*.

- The novels of J.R.R.Tolkien, including the *Lord of the Rings* trilogy can help to make physics compelling for science-phobic students, according to a note in the May issue of *Physics World*. Tolkien, who has captured the attention of fantasy buffs and moviegoers, invented his own constellations, some of which correspond to actual star groupings.

- The March issue of *Physics Education* has a special feature on Physics and Archaeology. Included are articles on archaeomagnetic dat-

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ing, measuring radiocarbon from archaeological samples, the neutron as a tool in archaeology, the scanning electron microscope, free drying of wet materials, and modeling resistive surveys.

- "The nature and status of string theory" is the title of a Resource Letter in the June issue of *American Journal of Physics*. The letter recommends popular books, web sites, and popular articles, as well as advanced undergraduate material. There are sections on such subjects as branes (which the author calls the "most exciting development in string theory from the last decade), black holes, tachyon condensation, orbifolds, Calabi-Yau manifolds, and the holographic principle.

- The 2001 education reform bill, known as the No Child Left Behind Act, requires school districts to offer programs shown to be effective through "scientifically based research." However, no program has yet met that rigorous standard because none has been scientifically evaluated and shown to be effective, according to an editorial in 11 June issue of *Science*. Many programs may be doing a terrific job of helping children, but there's no way to tell, scientifically. Two recent reports, one by the National Research Council (NRC) and one by a public-private consortium known as Building Engineering and Science Talent (BEST) point out some of the difficulties in scientific evaluation of programs.

- Some interesting statistics from advertising are quoted on the "Feedback" page in the 12 June issue of *New Scientist*. One catalog offers low-energy light bulbs, which use "400 per cent less energy." Another advertises pepperami sausages with 108% pork among its ingredients. The column also tells us that one light year is $4.70279985 \times 10^{15}$ furlongs.

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