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April 2008

Global Perspectives on Physics Education

AAPT National Meeting

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AAPT PHYSICS EDUCATION

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InterActions
across physics and education

About INTERACTIONS

Interactions is a general-interest magazine about physics education. Our mission is to inform and stimulate diverse conversations on teaching and learning by publishing thought-provoking news, analysis, and commentary on the people, programs, and policies that interact to influence scientific practices and knowledge—and, ultimately, human destiny.

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The editors welcome your response. Send comments, questions or suggestions to interactions@aapt.org or mail letters to Interactions Forum, One Physics Ellipse, 5th Floor, College Park, MD 20740. Please include your full name, mailing address, and daytime contact information. Space is limited and all published comments are subject to editing.

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AAPT | PHYSICS FROM THE GROUND UP

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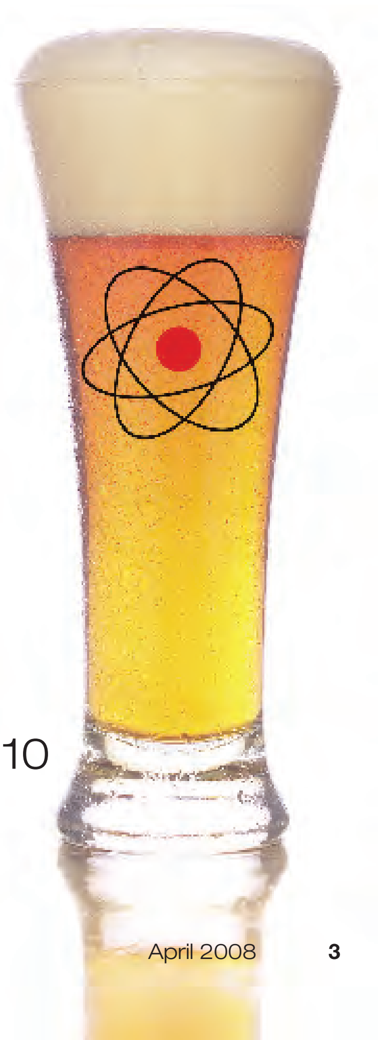

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Gravity of It All

Teachers should not confuse weightlessness with zero- or microgravity ("Teachers' Zero-Gravity Flights Give Lessons a Lift," IAmonitor, September/October 2007). The airplane flies a parabolic path that does not resist the force of gravity on the passengers and they are weightless but accelerating toward the earth due to gravity. The space station is in a circular path around the earth and centrifugal force, due to inertia, equal and opposite gravity makes people and things in orbit weightless.

The teacher made a mistake to say, "it wasn't hard to show why the occupants of the space station felt weightless in a vehicle that is doing the exact same thing at a higher altitude." Centrifugal force!

Physicists have caused much confusion about the forces in rotating bodies by taking inertial and non-inertial frames of reference. They would understand the forces in seed or fertilizer spreaders; with rotating impellers, centrifuges, centrifugal pumps and roller coasters if they use the radius of rotation as the frame of reference. Δ

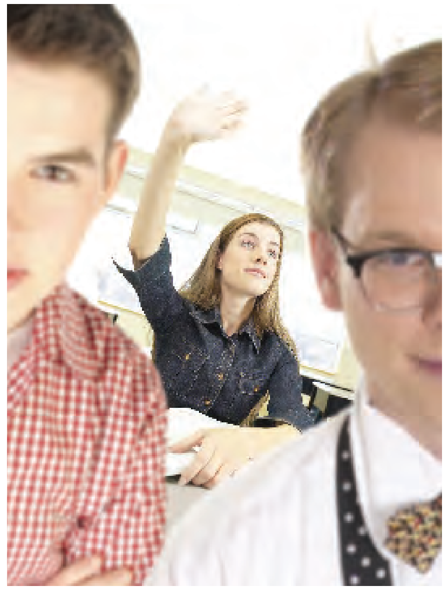
James F. Jackson
Carlisle, Indiana

Women and Physics Redux

The several articles in *Interactions* (June/July 2007) discussed the student and faculty population statistics and made several suggestions of improving the participation of women. If you Google "Nancy Lorraine Jensen," you will see how, by endowing a scholarship for women majoring in physics; chemistry; chemical, electrical or mechanical engineering, my late wife and I have encouraged women to start careers in these fields.

one makes a significant difference for the good in the world by invention and development of new products that can change for the better the way we live

I have encouraged our scholars not to consider careers in academia, but rather consider industry or perhaps government since these organizations are so much more friendly to women's problems and aspirations. Every woman should expect to be married and start a family. Industry expects this and encourages a woman engineer/scientist to return to work as soon as possible and at least at the same level and seniority. I believe the government does likewise. Industry also often provides further study in the woman's field



so she can be more productive and advance in rank. I have known several women engineers who have advanced to management positions (This was about 1975, not only just recently, and there are today several [technology] companies with women CEOs.)

Of course, very few in industry earn Nobel prizes, but one makes a significant difference for the good in the world by invention and development of new products that can change for the better the way we live. Δ

Arthur S. Jensen
Parkville, Maryland

We welcome your feedback.

Comments should include the writer's name, address and daytime telephone number.
Letters may be edited for length and clarity.
Email address is interactions@aapt.org.

Global Scope

By Charles Holbrow

Some 2200 years ago Eratosthenes had a global view. He knew the world was round and determined its circumference quite accurately. He also lived a life of far-reaching interactions with people and ideas. Born in Libya, North Africa, he studied in Athens, Greece, and worked in Alexandria, Egypt. In a world without nations he was a man with a global scope of mind.

Today we know Earth's shape more precisely than Eratosthenes did, and we know its place in the Universe in more breadth and detail. But our wired world is producing a revolutionary new "global scope of mind." Electronic links between peoples and their ideas are creating an intensively connected world. This issue of *Interactions* presents interesting examples of the effects of globalization on physics education. The belief that rote learning is not enough is gaining acceptance in quite different national cultures; efforts to assure that all children learn science are spreading widely.

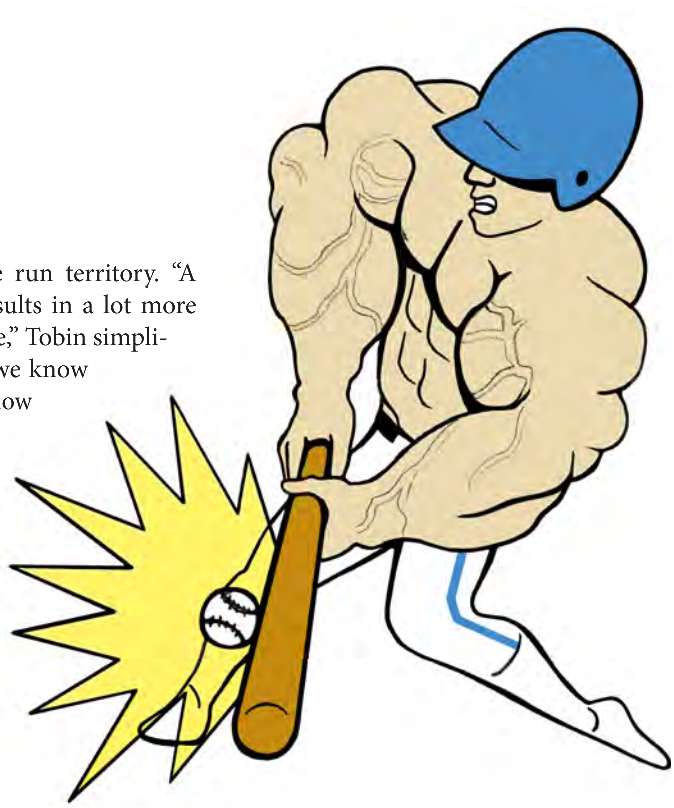
- Carun Anand (p. 14) grew up in Delhi and got his start in computer science at the Indian Institute of Technology (IIT) in Kanpur. After further study and work in the U.S., he set up a company—Perfect Future—whose School in a Box project brings basic Internet-age tools to impoverished schools in India. His project also introduces students to a historical mathematics system associated with Hindu tradition.
- Priscilla Laws (p. 20) tells about Active Learning in Optics and Photonics (ALOP), a workshop/curriculum project supported by the United Nations Educational Scientific and Cultural Organization (UNESCO), and by other organizations including AAPT. ALOP helps students in developing countries prepare for careers in science. It's based in Paris, with faculty from the U.S., Tunisia, Canada, Australia and the Philippines.
- Eugenia Etkina and Katya Denisova (pp. 26 and 28) both studied physics in Russia. Now they work in the U.S., in ways that differ dramatically. Etkina is a faculty member at the Rutgers Graduate School of Education in New Jersey. Denisova teaches in a troubled high school in Baltimore, Maryland.
- Lei Bao and Zuren Wu (p. 24) discuss large-scale educational reforms over the past century in China, where physics has long been emphasized in the curriculum. The nationally standardized approach of the 1950s, with its rote learning and problem-solving orientation, is being phased out under a massive restructuring implemented in 2001.
- William R. Brody (p. 32) considers implications of the emerging global demand for advanced professional degrees and expertise. New capabilities for rapid travel and instantaneous communication can melt physical and intellectual boundaries and decouple academics from their home institutions.
- Ben Stein's article, "Prevailing Wisdom", (p. 16), may seem outside our international theme. Stein reports on efforts to persuade American voters to keep creationism or other religious views out of science classes. But as you read, notice that the problem faced by American physics educators—that of communicating across a wide cultural divide in their own country—is a problem shared with everyone who seeks to communicate across national boundaries, national languages, and national outlooks.

On p. 12, you can read about AAPT President Lila Adair's hopes for AAPT, and, in "Homer Dodge's Notebook", you'll find a report on the 12th Annual New Physics and Astronomy Faculty Workshop with featured presentations by Eric Mazur (see below) and by Mario Belloni and Wolfgang Christian.

Our international theme is especially apt as you prepare to attend AAPT's Summer Meeting in Canada. The preliminary program appears in this issue. Note that there will be talks by two outstanding physicists. Harvard professor Eric Mazur is the 2008 Millikan Award winner and lecturer. Michio Kaku, television celebrity, author, and CUNY professor of theoretical physics, is this year's Klopsteg Memorial lecturer.

Join us in Edmonton and in future AAPT publications—in print and on the web—for more views of the world of physics and physics teaching. ∆

Charles Holbrow is executive officer of AAPT.


Matt Payne

People

Physicist Strikes Out Home Run Hitters

A few years have passed since former Oakland A's slugger Jose Canseco exposed steroid use in major league baseball with his tell-all book, *Juiced: Wild Times, Rampant 'Roids, Smash Hits, and How Baseball Got Big*, but a physicist is now throwing strikes against America's favorite pastime.

Roger Tobin, a physics professor at Tufts University, claims that the increase in the number of home runs hit in a season during the past decade is consistent with the gains in the muscle mass of the players suspected of steroid use.

Applying the laws of mechanics, Tobin studied the effect of body weight and swing speed on the force of the collision between bat and ball. Assuming that steroid use gives a batter a more powerful swing, and holding all other variables constant, Tobin found that a 10 percent strength gain can result in a 4 percent increase in bat speed, which, in turn, results in a 3 percent increase in the velocity of the ball off the bat.

"In other sports, you don't see athletes breaking records by 20 percent—you don't have people running 8 second hundred meter dashes or jumping one meter farther in the long jump," Tobin says.

According to Tobin, professional baseball has a "discreet threshold," where a substantial number of players are hitting balls near home run territory. "A little extra muscle results in a lot more balls hit over the fence," Tobin simplifies. "And one thing we know that steroids do is to allow people to gain muscle mass."

It started with the Sammy Sosa–Mark McGwire duel during the summer of 1998, which resulted in 70 homers for McGwire and 66 for Sosa. Barry Bonds has since set the records for the most single-season and career home runs, 73 and 762, respectively. Prior to that, Roger Maris's record of 61 single-season home runs had stood for 37 years. Before that, Babe Ruth's home run reign of 60 had lasted 34 years.

Tobin became suspicious. Was this recent spike in record breaking home run seasons the result of technological advances in the equipment, the players' skill or something else?

Tobin, a lifelong New Englander and ardent Boston Red Sox fan, has taught courses on the physics of sports; so, it is no surprise that he believes physics can determine what investigative journalism, grand juries, and congressional hearings have not.

In fact, Tobin's research has caught the attention of both the scientific and sports communities. His paper, "On the potential of a chemical Bonds: Possible effects of steroids on home run production in baseball," was published in the January 2008 issue of *American Journal of Physics*. The Mitchell Commission, which investigated steroid use in major league baseball, has even talked to Tobin about his findings.

However, Professor Tobin has been quick to point out that his research does not suggest that steroids alone can create a home-run king—lest aspiring sluggers be tempted to mimic the feats of baseball's substance abusers. "I looked specifically at people who were already extraordinary athletes. The increase in home run production goes up so dramatically because they are already hitting a lot of balls that are almost home runs."

—Steve Davolt

Surfing Physicist's Totally "Rad" Theory

Theoretical physicist Garret Lisi spends a lot of his time unlocking the secrets of the universe, so why wouldn't he devote his leisure to an equally quixotic quest—searching for the perfect wave.

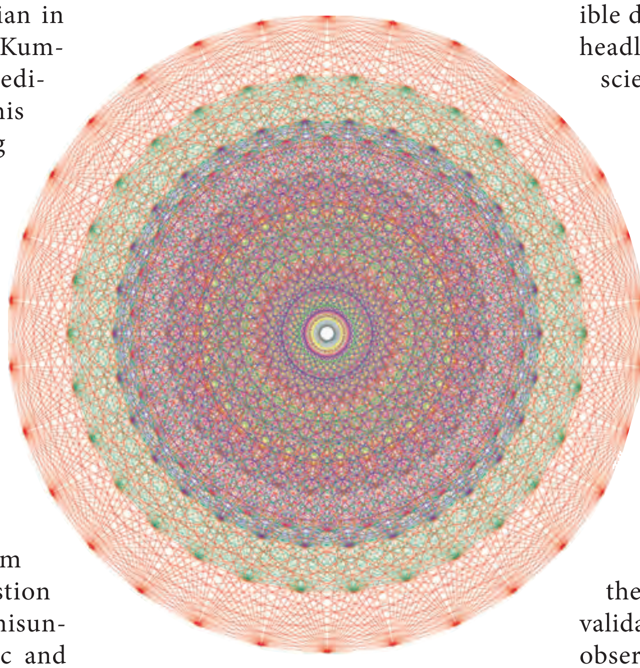
A native San Diegan, Lisi earned his undergraduate and doctorate degrees in physics in California, where he was never more than a stone's throw away from some of the world's premier surfing. The consummate Californian in his love of outdoor sports and Kumbaya culture, the 39-year-old dedicates almost as much space on his personal homepage to surfing and the Burning Man festival as he does to physics.

Enamored, perhaps, by this casual, "beach boy" demeanor, a few journalists sparked a minor media frenzy after they heralded a paper published by Lisi as the possible missing link in unified field theory. Many of Lisi's peers, however, were underwhelmed.

"I believe the hyperbolism surrounding Dr. Lisi's suggestion is symptomatic of a serious misunderstanding between the public and popular media on one side, and the scientific community on the other," said Sylvester James Gates Jr., the John S. Toll Professor of Physics at the University of Maryland.

In November 2007, Lisi posted online "An Exceptionally Simple Theory of Everything." In the 31-page paper Lisi claims "E8"—a complex, 8-dimensional mathematical pattern first introduced in 1890, and solved only last year—explains the behavior of all matter and energy, from subatomic particles to the formation of galaxies.

Much of the scientific community, however, is largely skeptical, if not outright dismissive, of Lisi's latest theory. On a blog, Czech physicist Lubos Motl went so far as to call Lisi's theory of everything "a huge joke" and blasted the U.K. newspaper *The Telegraph* for fanning the flames of sensationalism by making exaggerated claims on the impact of the theory. "I am quite sure that his proposal is fatally flawed," said Caltech theoretical physicist John Schwartz, pointing out that the hullabaloo raised in the popular press was not reflected among Lisi's physicist peers. For one thing,



Schwartz and others had postulated decades ago that the Lie geometries from which E8 derives may eventually help to mathematically explain a universal string theory.

Things started spiraling out of control after Lisi posted his paper, made some speeches, and gave a few interviews. Soon, a spate of articles in such publications as *New Scientist*, *The Telegraph*, and the *Economist* suggested Lisi had discovered what has been a Holy Grail of theoretical physicists. A few reporters even compared Lisi to Einstein—a comparison Lisi calls "unjustified for many reasons."

"When Einstein proposed his theory of general relativity, he revolutionized physics by introducing a geometric description of the universe," Lisi explained. "Even if this theory I've proposed turns out to work—a big if—it will not be nearly as significant as what he did for physics. At best, I am only advancing physics a little."

Lisi attributes the Einsteinian praise to the insatiable appetite of the popular press, and presumably, the public at large, for the little-person-does-big-thing storyline. But in reporting Lisi's theory, the irresistible demands of story-telling collided headlong with the immovability of the scientific method.

"Journalists jumped on the fact that someone without an academic position—and a surfer no less—was coming up with a significant new theory, and used this to justify the comparison," Lisi explained. "This resulted in a lot of hype, and physicists hate hype."

"The good journalists made it clear that this new theory was untested and might be wrong, and that it was part of a larger research program."

Unlike Einstein's relativity theory, which was momentously validated in 1919 when astronomical observation teams viewed sunlight bent by the gravitational pull of the moon during a total solar eclipse, Lisi's hypotheses remain untested. For his theory to work, Lisi posits the existence of 20 more subatomic particles and hopes these will be discovered using the Large Hadron Collider, currently under construction near Geneva, Switzerland.

Nonetheless, Lisi's work is not without its share of advocates. "It is one of the most compelling unification models I've seen in many, many years," said Lee Smolin at Canada's Perimeter Institute for Theoretical Physics. The institute has supported Lisi's work with small grants.

Lisi concedes he's enjoyed the attention he has gotten, "I am trying to use the attention to promote the idea that physics is beautiful, and worth time and effort to understand, even by people who aren't, or aren't yet, physicists," Lisi said, then noted: "That seems to be going well, and it's good for the field."

—S.D.

Programs

Europe's Prodigal Scientists

If you're a promising young European scientist, what will it take to keep you from leaving your native country? The European Science Foundation and the European Heads of Research Council believe the answer is international recognition and research funding and to prove it the organizations teamed up to found the European Young Investigators Award (EURYI).

Established in 2003, the award was created to encourage scientific research in Europe and stanch the "brain drain" of the continent's best and brightest. "The idea came up when the sponsors realized that many leading young researchers were leaving Europe to work, said Isabelle May, the program secretariat in Strasbourg, France.

EURYI doles out grants of approximately one million or more euros to scientists performing "groundbreaking research" within two to eight years after earning their doctorate. Winners are chosen via a two-step selection process—first at the national level and then by a series of international panels.

Although researchers working in diverse scientific disciplines ranging from chemistry to economics to psychology are eligible to participate, physicists are well represented among past EURYI winners. In fact, of the 95 EURYI award recipients from 2004–07 about 24 are either physicists or scientists conducting physics-related, interdisciplinary research.

EURYI winners confirm that the award is realizing its intended goal. A EURYI winner name Martin Schnabl, a Czech theoretical physicist at Princeton's Institute for Advanced Study, received 755,000 euros this year to pursue his work in string theory. He could have sought up to 1.25 million, "If I knew what to do with that much money," Schnabl confessed. Although Princeton is world renowned for work in his field, Schnabl plans to take the money and return home. The main reason, according to Schnabl, is he won't have to worry about funding for the next five years. "I am given an excellent opportunity to build up my own program in Prague, my home town."

For Finnish physicist Pavia Torma, money means more time, which she presently splits between two major research activities: studying the behavior of ultra-cold gases and exploring ways to further miniaturize circuitry using molecular electronics. Her 2005 EURYI award of 1.2 million euros (roughly \$1.8 million given the exchange rate as of this writing) gave her a lot more time to devote to her divided interests. "It helped me hire researchers, buy the necessary equipment, and importantly, gives me more time to concentrate on research," Torma said.

The latest round of EURYI winners, announced in September 2007, is also the last. As the European Science Foundation relinquishes the program, the European Research Council, a nonprofit based in Brussels, launches a nearly identical award called the Starting Investigator Research Grant. According to the organization's website, grants will pay 400,000 euros a year over five years. Perhaps, even more promising young scientists in Europe will soon discover there's no place like home.

—S.D.

Places

Space Camp Goes Global

The popular experiential program Space Camp is extending its frontiers to the Middle East. The U.S. Space and Rocket Center, the camp's operator, has signed off on a licensing agreement that allows the Dubai-based Space Investment Company to build up to three Space Camp and Aviation Challenge facilities. The first, part of a Dubai entertainment and retail complex called Space World Arabia, is slated to open in 2010.

"This is an effort to keep our people and our region at the forefront of space technology," said Ghazi Al Ibrahim, executive chair of Space Investment. "Our mission is to use U.S. space and aviation technology to stimulate regional interest in the study of aerospace sciences."

Ibrahim and U.S. Space and Rocket Center CEO Larry Capps expressed hope that the deal will inaugurate a long, fruitful relationship. The Space Investment Company pays licensing fees to use Space Camp's intellectual property, and Space Camp does not incur responsibility for direct oversight of the Middle Eastern facilities, according to Al Whitaker, a U.S. Space and Rocket Center spokesman. Space

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Investment Co. is expected to open the other two locations within five years.

"The agreement contains provisions that protect the name, image, and reputation of Space Camp," Whitaker said. Under the agreement, the Center will provide curriculum, simulators, training apparatus, and environmental layouts to the Middle East sites. The Center will receive $1.75 million in licensing fees associated with all three locations, according to the *Birmingham News*.

"What drew the foreign interests," Whitaker noted, "was the type of experience Space Camp provides, what kids say about it afterward, the emphasis on teamwork, the science and math education kids get during camp, and the success rate in inspiring kids to go on to train for high-tech jobs."

The space-themed residential camp, which launched in 1982, simulates missions aboard the Space Shuttle, the International Space Station, and FA-18 Hornet jet fighters, and has hosted more than 500,000 campers. Other countries that either have already completed a Space Camp or have one in the works include Canada, Belgium, Turkey, Italy, Japan, and South Korea.

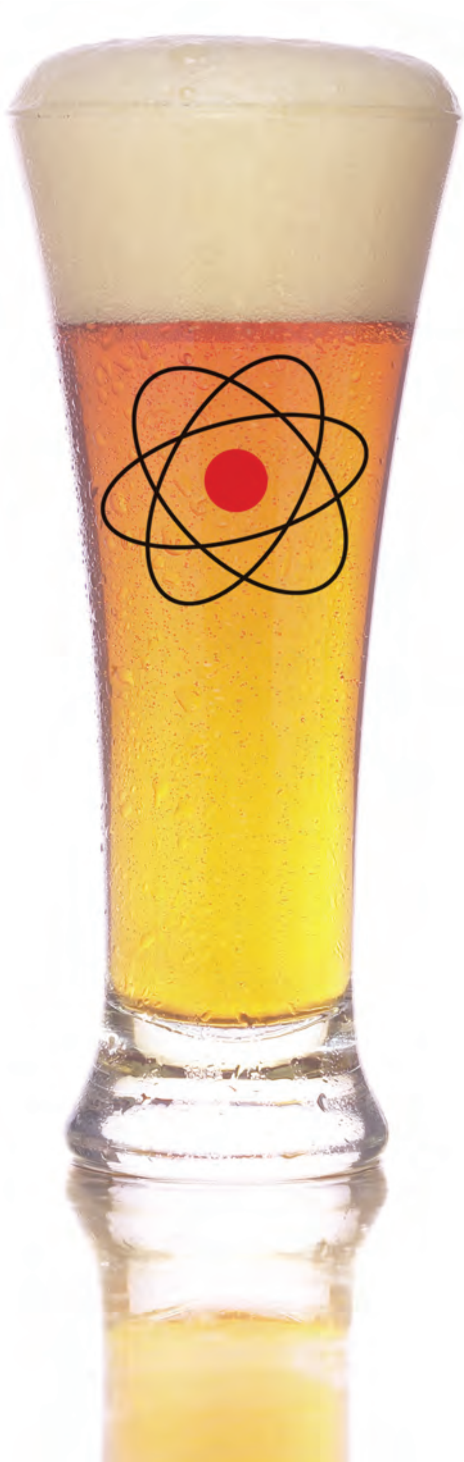
"[The mission of the Middle East Space Camps] seems very much like ours," Whitaker said. "They see it as a vehicle to get kids excited about math and science education. We frequently find that Space Camp is the first real-world application that kids use for science they've already studied."

—S.D.

Physics Demos on Tap

A small crowd of New Yorkers probably thought they had one too many when they watched a man on stage take a hammer and shatter a liquid nitrogen-dipped red carnation into hundreds of tinkling, glassy shards. That was just the opener in a string of Gallagheresque antics that Dave Maiullo, a demonstration specialist in Rutgers University's physics department, regaled onlookers with one Wednesday night last November. Maiullo built up to a finale in which he lay between two beds of nails as an assistant smashed a brick on the top plank.

It was the kind of exhibition Maiullo has performed hundred of times at AAPT National Meetings, as well as at schools, libraries, museums, county fairs, and senior centers across the country. But this show was taking place in the Union Hall bar, in the fashionable Park Slope neighborhood of Brooklyn. Maiullo was the opening act for the Union Hall Secret Science Club, a group that hosts a monthly event featuring discussions led by working scientists, accompanied by demonstrations, films, and music.



The bar crowd was a decided departure from the students Maiullo generally performs for. "In many ways, by being older and interested in science, they knew a lot of physics," he said. "But they've forgotten the particulars. A high school class is 'immersed' in the details, so they remember the vocabulary of physics a bit better. When I do a show at a school, you know what level of physics they have, right to the last concept. Here, it was much more open. The only common denominator was a collective love of science."

More surprising, the Secret Science Club meeting was the topic of a *New York Times* piece, which in turn caused the story to be picked up and circulated as far afield as Italy's *La Repubblica* newspaper.

The scientific variety show, already a familiar attraction in college lecture halls and student assemblies, is part of a nascent trend popping up across the country. Partly inspired by the Café Scientifique movement in the United Kingdom, a growing number of coffee shops, restaurants, and even bars and brew pubs are hosting "science cafes." A stated goal of these demonstrations is to stimulate discussion of and interest in science. The cafes represent a rare opportunity for physicists to present their discipline to the general public.

Ben Weihe, an outreach coordinator for NOVA's *ScienceNOW*, a newsmagazine produced by Boston's WGBH, a flagship PBS television station, estimates there are as many as 60 science cafes underway in the United States at present. The WGBH Educational Foundation provides a small amount of material support and seed money for budding science cafes. In 2006, *ScienceNOW* and Sigma Xi hosted the first national conference of science café organizers in Research Triangle Park, NC, in which approximately 40 people attended. The purpose of the conference was to foster a conversation on current science issues. "It's not a lecture," Weihe pointed out, "but a conversation."

The barroom dynamic strikes a refreshing contrast to the lecture hall. "The difference between science cafes and other educational formats is that everyone has a voice," Weihe said. "People are free to disagree." Establishment patrons are free to do their own thing too, so their attention must be grabbed in the first three to four minutes

Maiullo attests to the opportunity presented by the science cafes for science educators: "Any amount of public interest in physics, or science in general, should be encouraged. It's important to connect the public to physics in a way which brings down the ivory tower. Show them it's not just for the dusty halls of a university, but it's real."

—S.D.

Policy

The Word Is…

At first thought Charles Tahan's proposal would seem simple enough: He wants the term "spookytechnology" listed in the dictionary. Tahan even wrote a paper defending his reasoning and posted it on arXiv.org, an open source e-journal on physics and other science and technology fields operated by Cornell University.

Tahan, who is a physicist, defines spookytechnology as "all functional devices, systems, and materials whose utility relies in whole or in part on higher order quantum properties of matter and energy that have no counterpart in the classical world." He coined the word when he was a postdoc at Cambridge University.

Surprisingly, etymology supports Tahan's argument. Einstein himself dubbed certain aspects of quantum theory "spooky." And, in the "spooky" world of espionage, advances in cryptology are partly attributed to NSF-funded research in quantum physics. That said, however, can any word containing "spooky" really catch on with the physics community?

"I suppose it is the 'catching on' that is the key to words entering general use," said John Daintith, editor of the *Oxford Dictionary of Physics*. According to Merriam-Webster's website, "To be included in a Merriam-Webster dictionary, a word must be used in a substantial number of citations that come from a wide range of publications over a considerable period of time. Specifically, the word must have enough citations to allow accurate judgments about its establishment, currency, and meaning."

Spookytechnology notwithstanding, most scientific terms have rather dull etymological roots—often formed from either acronyms or existing root words. There are some colorful exceptions, such as the word "quark," which was cribbed by physicist Murray Gell-Mann from James Joyce's *Finnegan's Wake*. Then there are eponymous terms, such as "fermions," named for the Nobel Laureate Enrico Fermi, and "buckminsterfullerenes," in honor of the polymath father of the geodesic dome.

Unfortunately, the odds are against Tahan. In physics, as in other sciences, new terms run a more rigorous gauntlet of approval before they enter their specialized lexicon, according to the editor Daintith. Scientific committees must approve many terms, such as the names of elements in the Periodic Table. Along the way, strict teachers and journal editors act as linguistic gatekeepers.

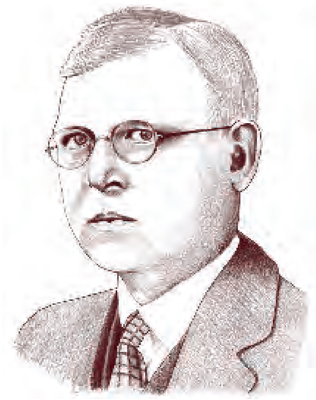
"In updating our dictionary, we do keep a check on general-language sources," Daintith said. "Any references to physics terms in newspapers are noted. But our main sources are university and school syllabuses, textbooks at all levels—and, in particular, general science publications such as *Scientific American*, *Science*, *Nature*, and *New Scientist*."

In the end, the physics lexicon is subject to the same linguistic force as any other. If people use it, it goes in. Perhaps Tahan should start a blog, which he would no doubt name "Spookytechnology." Δ

—S.D.

"What we need at this point is more action and less talk. Let us experiment with our ideas rather than simply discuss them."

— Homer Dodge, AAPT founding member (1930)



New Faculty Return to Class in 12th Annual Workshop

Class was in last fall as 83 new physics and astronomy faculty members from 70 colleges and universities across the country gathered at the American Center for Physics for the 12th annual New Physics and Astronomy Faculty Workshop. Over November 8–11, participants chose from a curriculum chock full of sessions on interactive pedagogy, problem solving, just-in-time teaching, information technology, and teaching for retention. This year's New Faculty Workshop included sessions on tenure matters and time management, tutorials for upper-level quantum mechanics courses, and assessment and evaluation of effective pedagogy.

Eric Mazur, Balkanski Professor of Physics and Applied Physics at Harvard University, led two general sessions introducing faculty to peer instruction, a subject he literally wrote the book on (*Peer Instruction: A User's Manual*, 1997). Mazur recalled with some discomfort the circumstances that led him to adopt the interactive teaching method, in which students prepare for each class with outside reading, then help each other work through concepts and problems in the classroom.

"I made the agonizing discovery that students were passing tests only by rote memorization," Mazur said. "A student asked me, 'Do you want me to answer this on my own or how you taught me to answer?' " The shock was enough to inspire him to go from being "a sage on the stage" to "a guide on the side."

Computer modeling continues to gain currency as an interactive teaching technique for teaching everything from introductory physics to advanced quantum mechanics. Mario Belloni and Wolfgang Christian led a series of small sessions on Physlets, open source Java applets that have become building blocks in much simulation exercises.

The success of the New Faculty Workshop is spreading. To provide continuing interaction among the participants and presenters, AAPT has established a listserv so the participants can trade teaching questions and ideas. Interest in the workshop isn't confined to our discipline: Chemistry faculty members and a staff member from the American Chemical Society attended the workshop to develop plans for an analogous series of workshops.

AAPT President: The Adair Era Begins

America may have yet to elect a woman president, but the American Association of Physics Teachers will soon welcome its fifth. In an annual tradition, President Lila Adair assumed official responsibilities from Past-President Harvey Leff on January 19, at the AAPT Winter Meeting in Baltimore.

In retrospect, many years of dedication to physics education and to AAPT make Adair's ascent through the association's governing body appear inevitable. Possessed from an early age by the desire to lead, the diminutive Southerner was abetted by a loquacity that lends itself to public speaking. Her first appearance in front of a large crowd came when she was 12 years old. Addressing a statewide Girl Scouts rally in an Atlanta amphitheater, she snagged one of her white gloves on the microphone, but she calmly walked away leaving the glove dangling in her wake.

Adair's grounding as a physics educator is founded on 35 years of teaching in Georgia high schools. Her long secondary education career went hand-in-hand with membership in AAPT, which she joined in 1974. She has also held offices in the Georgia Science Teachers Association and the Georgia Junior Academy of Science. Currently, she teaches a science methods course and oversees teacher training at Piedmont College in Demorest, GA.

Interactions found her taking the last weeks before the Baltimore meeting to hammer out details of her presidential agenda, and during one of her many working visits to the American Center for Physics in College Park, MD, she gave a preview of things to come.

Matt Payne

“My idea of being a good president is to make this organization the best it can be for its members,” Adair said. “I want to be successful in bringing new members in, and I want to succeed in providing services to nonmembers.”

Adair outlined the priorities she intends to pursue in her term as AAPT president:

- Increasing the visibility of AAPT through meetings, publications, marketing, and an improved web presence;
- Improving teacher training and staff development through PhysTEC, PTRA, and topical conferences;
- Increasing outreach to K-8 teachers and research university professors;
- Creating new programs that bring different constituencies of AAPT together to collaboratively solve problems and provide service; and
- Renewing a sense of pride in being a teacher, at all levels, K-20.

Adair is unreservedly optimistic on the current state of physics education and the opportunity for AAPT to exercise its leadership role. “Physics education is very ‘hot’ right now,” Adair said. “Physics has become popular through movies, books, and star-quality physicists such as Neil deGrasse Tyson, Stephen Hawking, and Lisa Randall. Currently, there is money available to train teachers and to provide enrichment programs. PER and AER groups are growing and drawing national attention. Small conferences are being held to share research and best practices. Evaluation and assessment of college programs and quality of teaching have become common practice. The high school AP Physics test is being redesigned to provide a better learning opportunity prior to college.”

“All of this attention has opened the door for AAPT to step in and take the lead in shaping physics education for the future,” she said.

Adair spoke highly of outgoing President Leff, who teaches physics at California Polytechnic State University-Pomona, a “friend” and a “mentor” with whom she has collaborated for years. Adair will be succeeded in 2009 by President-Elect Alexander Dickison, a physics professor at Seminole College in Sanford, FL.

“I’ve been totally absorbed in AAPT for 30 years, so I know a lot about the organization, the people, and what the members want,” Adair said. “The purpose of the organization is to, number one, serve the members. If we don’t serve the members, we’re not doing our job. Beyond that, we want to reach out to people who are not members and make them understand that we are an organization worth participating in.”

One way of reaching nonmembers is via the Physics Teaching Resource Agent program (PTRA), an initiative Adair has been involved with since its inception more than 20 years ago. The program, in which master physics teachers who are AAPT members train less experienced counterparts, reaches thousands of teachers a year. In one 10-year period, Adair recalled, she led more than 300 workshops.

“The PTRA program reaches a lot of people who are not members,” she said. “When I was leading PTRA workshops, I encouraged every participant to join. If they said, ‘I can’t go to national,’ I said, ‘Then go to the section meetings.’ ”

And when it comes to being a female president, that’s not really a factor. “Women in physics are accustomed to the majority of people working around them being men, so it’s really nothing new,” she said. “The people who voted for me, voted for me based on my qualifications, my experience, my ability to lead, as opposed to the fact that I was a woman. At this level, all the men and women who ever won, won because of their abilities.”

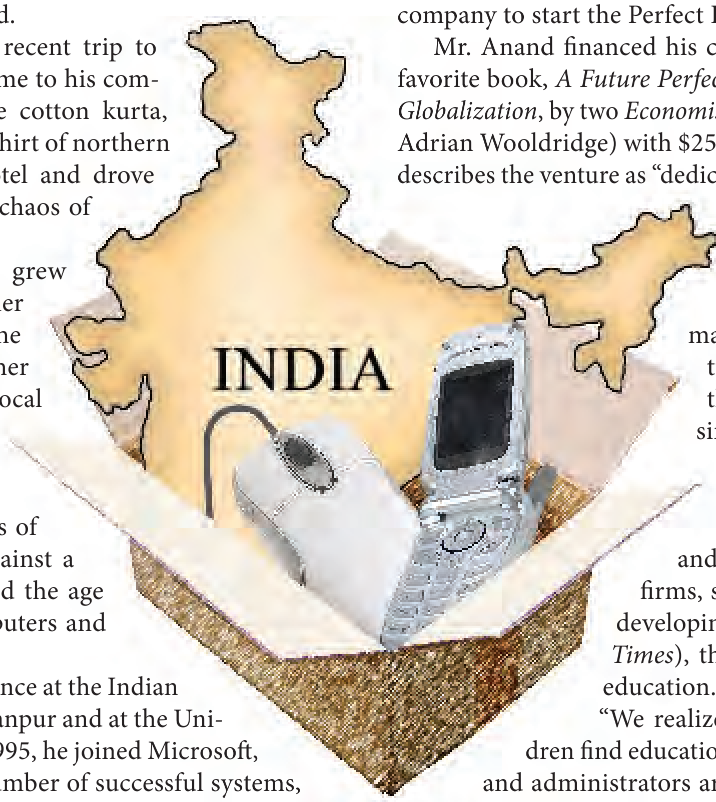
“We often say that we want to be the ‘voice’ of physics education,” Adair said. “I think AAPT needs to be the ‘home’ of physics education. AAPT should be the first choice of anyone wanting to learn about the teaching of physics, the best physics education resource on the Internet, and the initiator of all new programs for physics education—not the partner or follow-up group.” Δ

A Microsoft Alumnus Shares His Good Fortune

With "School in a Box" Carun Anand hopes to provide India's educational system with a Perfect Future.

By Jason Pontin

Carun Anand, the co-founder and chief executive of the Perfect Future, a start-up near Delhi, made his fortune in the United States, but returned to India to become an entrepreneur. He wants to use Web and mobile telephone technology to reform, or at least begin to improve, the uneven condition of education in his homeland.



Matt Payne

I met Mr. Anand on a recent trip to India, where he introduced me to his company. Wearing a chartreuse cotton kurta, the traditional knee-length shirt of northern India, he arrived at my hotel and drove me through the squawking chaos of Delhi's industrial suburbs.

Mr. Anand, who is 34, grew up in Delhi, where his father taught political science at the University of Delhi (his mother was a chemistry teacher at a local school). He was always a tinkerer and engineer. "At the age of 10, I built a film projector and watched strips of Indian cinema projected against a white wall," he said. "Around the age of 14 I got hooked on computers and started programming."

He learned computer science at the Indian Institute of Technology in Kanpur and at the University of Texas, Austin. In 1995, he joined Microsoft, where he helped design a number of successful systems, including Windows NT and 2000, as well as Microsoft's most important software development tools.

In 2001, Mr. Anand returned to India to work for Microsoft as a "technical evangelist," with the unenviable job of persuading other software developers to embrace Microsoft's technical standards, products, and services. Even then, he said, he knew that he would eventually leave Microsoft to start his own business in India.

"I was honest with my boss, but I was building contacts and a network," he told me.

He achieved limited institutional fame when he was named Microsoft's Worldwide Software Architect of the Year in 2003. But the next year, when his stock options vested, he quit the company to start the Perfect Future.

Mr. Anand financed his company (which is named for a favorite book, *A Future Perfect: The Challenge and Promise of Globalization*, by two *Economist* editors, John Micklethwait and Adrian Wooldridge) with $25,000 of his Microsoft money. He describes the venture as "dedicated to bringing innovative solutions to emerging markets."

"That's where the most demanding customers exist today," he said. "Emerging markets also offer you the opportunity to experiment on both the mobile and Web platforms since the largest number of Web and mobile users exist in those markets."

After a number of false starts, and, like so many Indian software firms, some service work (in this case, developing the Web site of *The Hindustan Times*), the start-up decided to focus on education.

"We realized that in Indian schools, children find education boring and static, and teachers and administrators are overburdened," he said. "Parents are also out of touch with what's happening. But most importantly, children are unprepared for real life."

India's international reputation for educating so many to high standards is deserved, and is the more remarkable in a nation whose per-capita income was $3,700 in 2006.

But that reputation disguises significant disparities.

According to India's Department of School Education and Literacy, 90 percent of the country's children enroll in school, but after five years in class around 50 percent of the students fail basic reading tests and are unable to perform single-digit subtraction. Ninety percent of Indian children drop out before they reach high school.

When I visited with Mr. Anand, his company had just moved out of a garage into its new offices (an undistinguished low-rise office block in a dry, sun-blasted field in an industrial park) and was weeks away from shipping its first branded product, called "School in a Box." In the 115-degree heat of a Delhi afternoon (the air-conditioning in his company's new offices had failed), Mr. Anand's small team of programmers and educational advisers proudly showed me their answer to the problems of Indian education.

School in a Box offers Indian primary and upper primary schools (that is, for children from 5 to 14) an array of services which the Perfect Future hosts and manages. Teachers and others can use the services either on the Web, on mobile phones or even, in many cases, print them out at an Internet cafe and take them to school.

Among the tools that School in a Box users can deploy are simple text messages to notify school administrators, teachers, parents, and children of important events; online student assessment tools; interactive question-and-answer examinations; and something called "activity-based learning," or 25 games (most of them traditional and Indian) that teach children chemistry, physics, and vocabulary.

By far the most interesting and radical element of School in a Box is how it attempts to promote Vedic mathematics, a system that Bharati Krsna Tirthaji Maharaja, a Hindu mathematician and scholar of the last century, claimed to have rediscovered in the Vedas, or Hindu sacred literature.

Vedic mathematics is controversial. It is associated with Hindu nationalism. The section of the Vedas where Mr. Tirthaji unearthed them is notoriously obscure, and some mathematicians believe that Mr. Tirthaji was a fabulist whose inventions distracted from the genuine achievements of ancient Indian mathematics.

While I am no great mathematician, Mr. Anand's short tutorial revealed to me a system of remarkable power and elegance, ideally suited to calculations that must be performed without pen or paper.

Mr. Anand believes that traditional Indian learning, of which he thinks Vedic mathematics is an example, was suppressed by the British during their administration. "Most Indian children are unaware of the rich traditional knowledge and educational system of a great civilization," he said.

The Perfect Future will earn money from School in a Box by charging schools about 15 Indian rupees, or around 40 cents, a month for each child, according to Mr. Anand. But he says the company will give away the service to the poorest schools or schools in rural areas.

> we realized that in Indian schools, children find education boring and static, and teachers and administrators are overburdened

Still, School in a Box, for all its high-minded promise, faces real challenges. To flourish, it would have to be purchased by Indian school administrators, who are typically conservative, and who have limited resources.

For his part, Mr. Anand believes that his service will succeed because it doesn't threaten administrators, but will help them to do their jobs better. In the meantime, he is seeking the patronage of the minister of education for Delhi State, Arvinder Singh Lovely, whom he hopes will recommend School in the Box to administrators, and he is pursuing partnerships with other companies with interests in Indian education.

More tellingly, it's not clear how much the new service can help Indian education. But for Mr. Anand, at least, it's a start. "It's not an easy task to uproot an existing system, no matter how bad, with a new one," he argued. School in a Box, he said, won't foment any revolution. "It was designed to bring an effective, affordable and user-friendly interface between technology and education."

Tarun Anand is one member of an intriguing and growing group: Indians who have done well in the United States, and who, in preference to becoming even richer in their adopted country, have come home to see what commercial technology can do to improve the intractable problems of the subcontinent. Δ

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Prevailing Wisdom

A nationwide study of 1,000 likely U.S. voters has revealed new information about public perceptions and attitudes toward evolution and creationism.

By Ben Stein

Teaching evolution is the most favored public science school curriculum, with 54 percent of those surveyed strongly or somewhat favoring it, compared to 28 percent for intelligent design, which was declared “a religious view, a mere re-labeling of creationism” by a U.S. Federal judge in a landmark December 2005 decision. The survey revealed that only 22 percent of the U.S. voting public was not sure whether evolution should be taught in public schools.

The respondents found both privacy and taxpayer-spending issues to be persuasive reasons for keeping religion out of public-school science classrooms: public schools should not impose one religious viewpoint on students (56 percent of respondents) and tax dollars should not support religion in science class (54 percent).

Figure 1: Religion in Public Institutions (Percent responding)

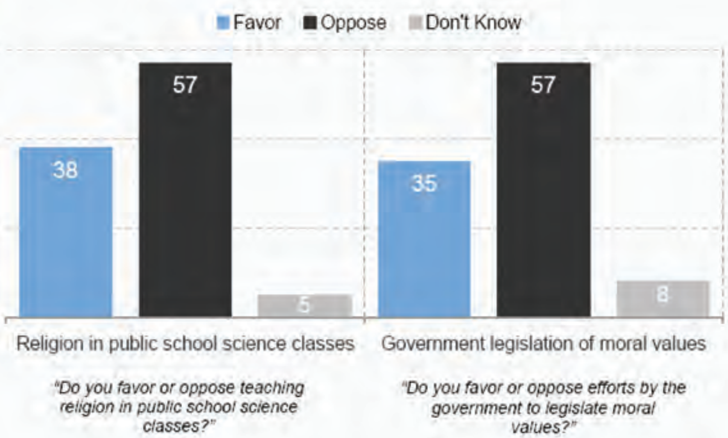
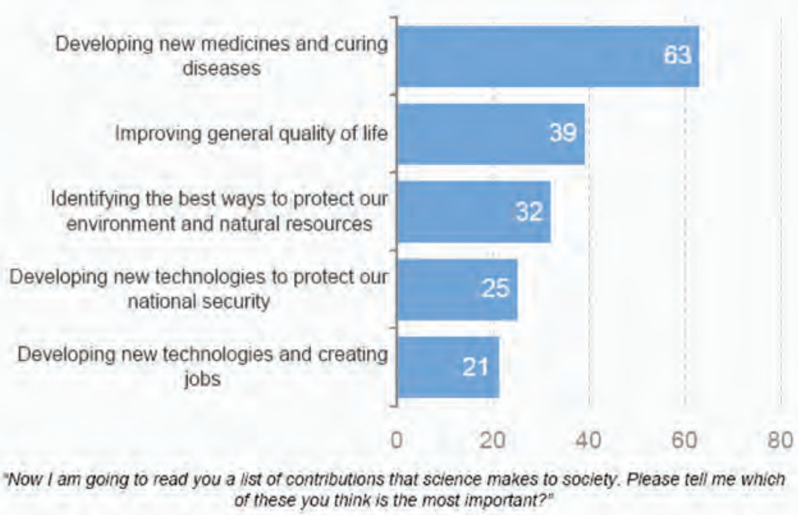


Figure 2: Contributions of Science to Society (Percent responding “important;” multiple responses allowed)



The study also explored how the public perceives science’s contribution to society (Figure 2). Developing new medicines and curing diseases was the contribution that most respondents said was important, 63 percent.

Other contributions to society that were thought of as important are improving the general quality of life (39 percent), identifying the best ways to protect our environment and natural resources (32 percent), and developing new technologies to protect our national security (25 percent).

Many respondents viewed science education as an important component of a larger, general education (Figure 3). According to an overwhelming majority of respondents, science education should promote how to draw conclusions from evidence (80 percent) and to learn how to think critically (78 percent). According to the survey, more people can agree that critical thought and college preparation are the purpose of science education rather than scientific literacy or practical applications of science to the real world.

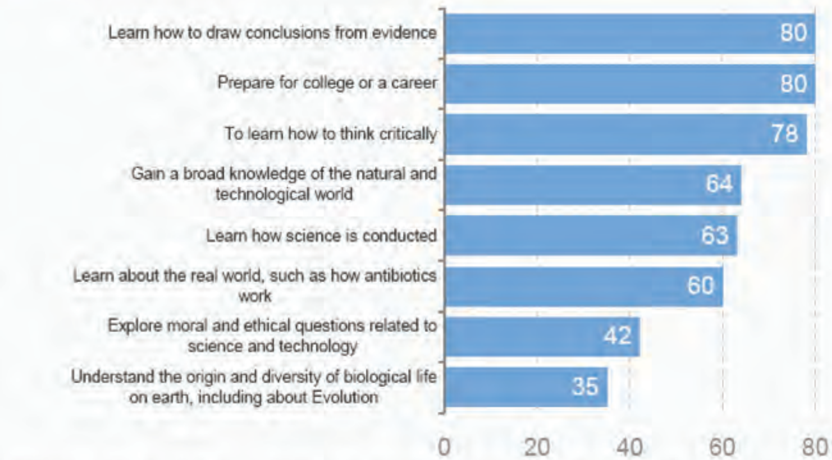
The study also shows the voting population has distinct ideas about religion in public life. A majority said they go to church at least once a month, and most respondents agree there should be a "high wall of separation" between church and state, with 59 percent agreeing and 43 percent strongly agreeing. Nearly all respondents, 89 percent, agree that parents today are not taking enough responsibility for teaching their children moral values. And the majority of respondents, 57 percent, oppose efforts by the government to legislate moral values, while only 35 percent favor it.

Another goal of the study was to take a brief inventory of U.S. voters' knowledge of basic science information (Figure 4). It was found to be spotty, at best.

Respondents were given three statements. They had to answer whether they agree with, disagree with or were unsure about each of them: The continents or the land masses on which we live have been moving for millions of years and will continue to move in the future; The earliest humans lived at the same time as the dinosaurs; Antibiotics kill viruses as well as bacteria. Seventy-nine percent correctly agreed with the first statement, 53 percent correctly disagreed with the second statement, and 43 percent correctly disagreed with the third statement. As illustrated in Figure 5, 39 percent of respondents gave less than two correct answers, 38 percent gave two correct answers and only 23 percent gave correct answers to all three.

Which authorities should inform the voting public about evolution and creationism? The respondents said they'd be most interested in hearing from scientists (77 percent somewhat or very interested) and science teachers (76 percent somewhat or very interested), with members of the clergy a strong third (62 percent somewhat or very interested).

Figure 3: Science Education Goals – (Percent responding "very important;" multiple responses allowed)



"Now I am going to read you a list of contributions that science makes to society. Please tell me which of these you think is the most important?"

Figure 4: Scientific Knowledge (Percent responding accurately)

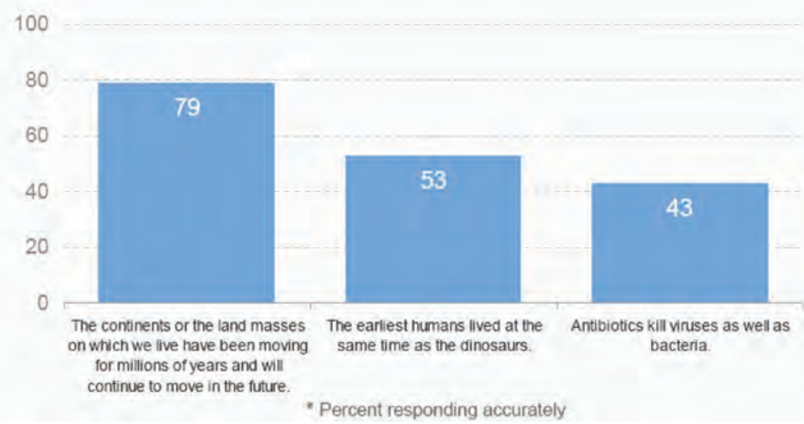
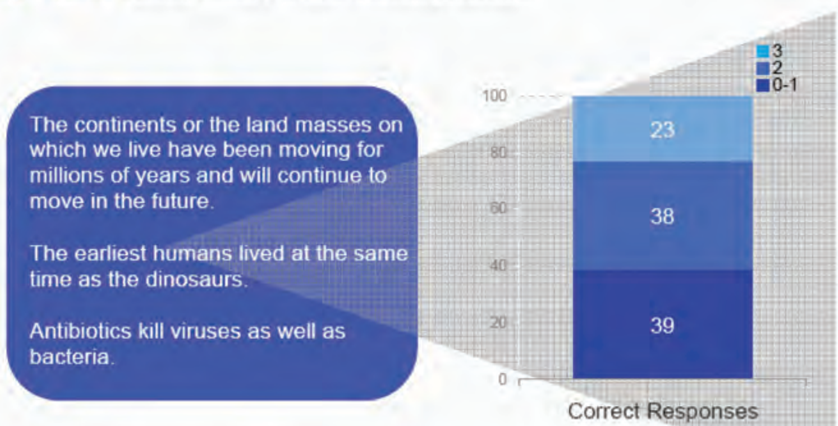


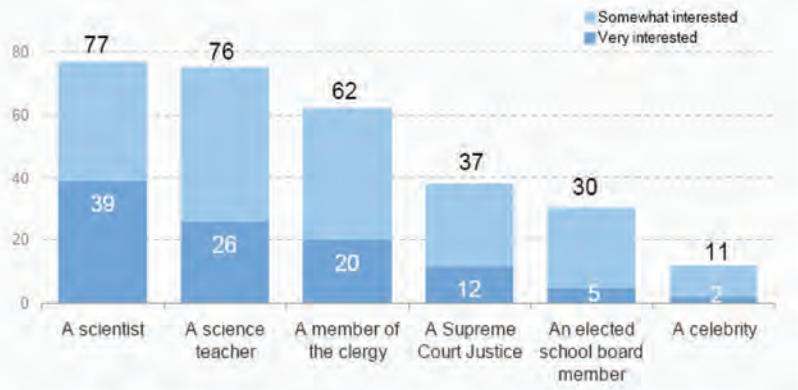
Figure 5: Scientific Knowledge (Percent responding accurately)



"Now, I am going to read to you a list of statements. For each of the following please tell me if you agree or disagree with the statement. If you neither agree nor disagree with the statement, or don't know, please say so."

The study was performed by Greenberg Quinlan Rosner Research and Mercury Public Affairs in August 2006 and surveyed 1,000 U.S. citizens likely to vote. It was commissioned by more than 30 scientific organizations, including the American Institute of Physics, American Physical Society, the Federation of Associated Societies for Experimental Biology, American Chemical Society, American Institute of Biological Sciences, Consortium of Social Science Associations, and the Society for Developmental Biology. Δ

Ben Stein works in public affairs at the National Institute of Standards and Technology.



"Now I'm going to read you a list of people who might get involved in explaining science to the public. Please tell me how interested you would be in hearing from each person about Evolution, Creationism, and Intelligent Design."

NIST Student Tours

www.nist.gov/public_affairs/edguide.htm

College Tours

These guided class tours consist of visits to three NIST labs. The tours are geared toward the students' area of study, such as engineering, physical science, mathematics, and computer science. Each tour can accommodate up to 24 students.

9th-12th Grade Tours

These guided two-hour tours of NIST consist of visits to three labs. The tours are geared toward the students' area of study or interest. Each tour can accommodate up to 24 students.

Tour of NIST's Center for Neutron Research for High School Science Classes

NIST's Center for Neutron Research (NCNR) offers a special tour of its facilities specifically tailored for high school science classes. Groups of up to 40 can be accommodated for the introductory lecture and tour that take about two hours. The emphasis is on how neutrons are used to probe the sub-microscopic structures and molecular motions that determine the properties of materials ranging from concentrate to cell membranes.

A Lens into the World

Active Learning in Optics and Photonics: a model teacher workshop for both the developed and developing worlds.

By Priscilla W. Laws

Physics educators who have taught for more than a year or two realize how incredibly challenging teaching introductory physics is. It's no wonder we flock to conferences on Physics Education Research (PER) and sessions on using active learning methods.

Anyone who attends international conferences quickly discovers that physics educators from other countries share many of the same challenges and frustrations. But, in addition, educators throughout the developing world have to cope with severe resource limitations that limit their access to basic equipment, computer technology, and professional development opportunities.

Suppose physics educators who are up-to-date on the outcomes of physics education research were asked to design and teach an ideal professional development workshop for the world's pre-service and in-service introductory physics teachers as well as for those who help train them. What would characterize our ideal workshop?

Based on physics education goals set at the 2005 World Conference on Physics and Sustainable Development (WCPSD) in Durban, South Africa (www.wcpsd.org) and my own experiences with curriculum and professional development, I believe that an ideal workshop would:

1. Be designed by an international team that has broad experience with teaching environments, cultural differences and the educational needs of peoples from many nations;
2. Provide teachers with tools for motivating student learning both because the topics are introduced in a coherent and inherently fascinating way and because the applications of the physics are tied to employment and research opportunities in the global economy;
3. Replace lectures with sequenced activities based on direct engagement with physical phenomena and designed based on current understanding of learning difficulties informed by PER;
4. Use appropriate pedagogical techniques and apparatus that are low-cost and accessible;
5. Provide participants with a PER-based conceptual evaluation that allows teachers to measure student learning; and
6. Provide illustrated and guided inquiry materials for students, teacher guides, and apparatus plans that can be translated into local languages and adapted to meet local needs.

For the past few years, Dr. Minella Alarcon, program specialist for Physics and Mathematics at the United Nations Educational Scientific and Cultural Organization (UNESCO) in Paris has worked with an international team of physics educators to develop a five-day workshop on Active Learning in Optics and Photonics (ALOP). Although UNESCO coordinates and funds the project, additional support has come from the Abdus Salam International Center for Theoretical Physics (ICTP), the International Society for Optical Engineering (SPIE), the American Association of Physics Teachers (AAPT), the National Academy of Sciences, the Association Francaises de l'Optique et Photonique, and Essilor.

UNESCO chose to develop this workshop curriculum on optics and photonics because it is an emerging field in contemporary physics and is relevant and adaptable to research and educational conditions in many developing countries. Photonics is basically applied geometric and physical optics—topics that teachers in developing countries often shy away from due to lack of equipment or familiarity with the topics.

ALOP is the only professional development workshop I have encountered that is targeted specifically to opening up jobs and research opportunities in fields such as optometry, atmospheric physics research, and communications for students in the emerging global economy. In addition it has most of the six attributes outlined above.

Why is the ALOP Workshop a Model for Teacher Training and Professional Development?

1. The ALOP Development Team and Low Cost Equipment Skills
The ALOP team led by Dr. Alarcon includes David Sokoloff (University of Oregon), Zorha Ben Lakhdar (University of

anyone who attends international conferences quickly discovers that physics educators from other countries share many of the same challenges and frustrations

Tunis, Tunisia), Vasudevan "Vengu" Lakshminarayanan (University of Waterloo, Canada), Ivan B. Culaba and Joel Maquiling (Ateneo de Manila University, Philippines), and Alex Mazzolini (Swinburne University of Technology, Australia). Each member of the team brings a unique set of experiences and talents to ALOP.

Sokoloff has more than 20 years of experience with Physics Education Research and related curriculum development. He is co-author (with Ronald Thornton and me) of *RealTime Physics Active Learning Laboratories,* of which module four is on light and optics. Other members of the ALOP team were introduced to active learning in a series of workshops sponsored by UNESCO's Asian Physics Education Network (ASPEN) in Australia and Korea beginning in 1999.

Zohra Ben Lakhdar was awarded the prestigious 2005 L'Oreal-UNESCO Award for Africa, which honors exceptional women in science (www.sciencemag.org/sciext/globalvoices/). Although she won the award for her work on atomic spectroscopy, Zohra is also honored as an outstanding teacher.

Vasudevan "Vengu" Lakshminarayanan is the most "multicultural" member on the team. Although he is a U.S. citizen, he did his undergraduate work in India and is currently teaching in Canada. He is well-known for his research in optometry, optical fibers, and optical engineering.

Ivan Culaba and Joel Maquiling are well-known in physics education circles in the Philippines for their innovative work in developing low cost equipment such as "free" interference and diffraction gratings fabricated using razor blades, pocket mirrors, and discarded CDs. The He-Ne laser pointers that they bring to the workshops are available in Manila for less than 50 cents U.S. apiece. Culaba also has published on optical engineering and the optical properties of thin films.

Australia's Alex Mazzolini, the team's photonics expert, has developed unique hands-on photonics activities and a marvelous inexpensive demonstration of optical multiplexing—a technology that has revolutionized communications.

2. Introducing Basic Topics and Motivational Applications

ALOP's intensive workshop illustrates the pedagogy of active learning through carefully crafted learning sequences that integrate conceptual questions and hands-on activities like those found in the *RealTime Physics Laboratory* curriculum. Topics that require more expensive equipment or extra time on the part of students are presented as Interactive Lecture Demonstrations. Some ALOP curricular materials can be introduced in either interactive lecture or hands-on formats.

The ALOP Training Manual contains six modules, each of which has embedded applications that are designed to intrigue students and help them realize that basic physics has vital practical applications. The applications better help students understand their everyday world and become aware of career opportunities.

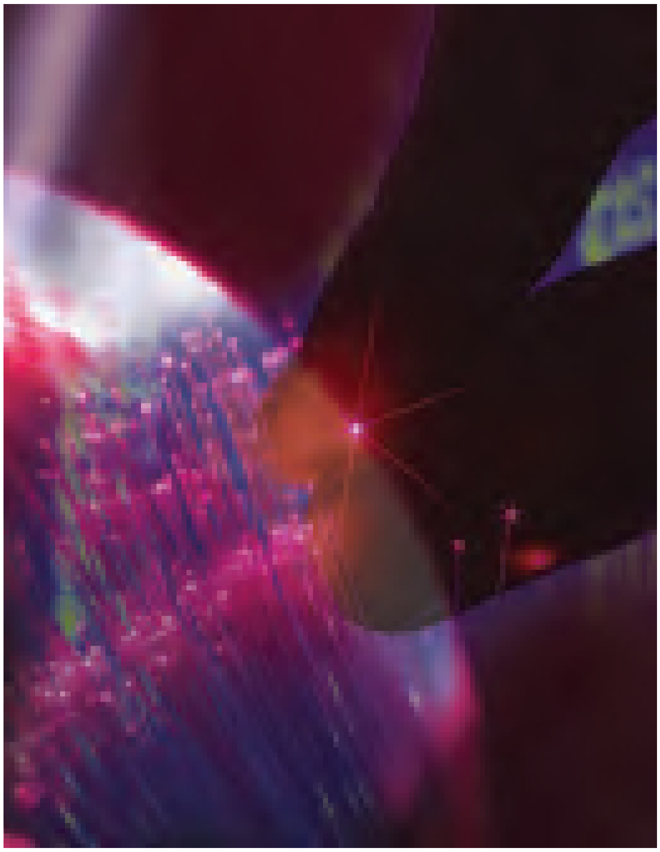
- **Introduction to Geometrical Optics:** How does an understanding of refraction explain how a broken test tube can be tossed in a container of "magic" fluid and brought out whole? How can the concept of critical angle be used to explain why a laser beam can be confined inside a stream of water that moves in a parabolic path? Why does covering half a lens result in a different image than covering half the object?
- **Lenses and Optics of the Eye:** How do spherical and cylindrical lenses focus light? How can spherical lenses be used to model a normal eye? How can external lenses correct near- and farsightedness. How do cylindrical properties of the lenses in the eye cause astigmatism?
- **Interference and Diffraction:** How do we infer that light can behave like waves? How can diffraction and interference be explored with equipment teachers and students can make for themselves at almost no cost?
- **Atmospheric Optics:** Why do clouds sometime appear white or grey or black? How can optical resonance be used to explain why skies are blue and sunsets red? How does scattered light become polarized?
- **Optical Data Transmission:** How can information be carried by light waves? How can light be recoded as an electrical signal? How does total internal reflection allow optical fibers to transmit information?

- **Wavelength Division Multiplexing:** What is optical multiplexing, and how has its use led to a dramatic increase in the information transferred by an optical fiber and decrease in the price of international phone calls and internet communications?

3. A Comprehensive Conceptual Evaluation

At the beginning to the workshop, participants are given a Light and Optics Conceptual Evaluation (LOCE), which contains 50 multiple-choice and one short-answer questions designed to test learning difficulties that have been identified through PER. The goal is to encourage participants to evaluate their own students before and after instruction. This allows instructors to gauge the effectiveness of their instructional strategies when they use the materials with students. [Author's note: The LOCE is under revision and not yet available. For details, contact David Sokoloff at sokoloff@uoregon.edu.]

By 2005 the first, full versions of ALOP had been offered in Ghana and Tunisia. When a group of physics educators who attended WCPSD in late 2005 learned about the virtues of ALOP they pledged to help UNESCO offer further workshops in three developing regions: Asia, Sub-Saharan Africa, and Latin America.



The Current Status of ALOP in the Developing World

Since late 2005, several WCPSD participants and I began working with Dr. Alarcon to raise funds and to provide administrative support for additional ALOP offerings in the three developing regions. These WCPSD participants include: Pratibha Jolly from India, Margaret Samiji from Tanzania, Zohra Ben Lakhdar from Tunisia, Mauricio Pietrocola from Brazil, Julio Benegas from Argentina, Cesar Mora Lay from Mexico, and David Sokoloff from the United States. As a consequence of this work, additional ALOP workshops were offered during 2006 and 2007 in Delhi, India; Dar es Salaam, Tanzania; São Paulo, Brazil; San Luis Potosi, Mexico; and Marrakech, Morocco. Each of the eight workshops given to date hosted between 30 and 60 teachers and teacher trainers.

In spring 2007, the American Association of Physics Teachers joined about a dozen other supporters by contributing a total of $9,000 to ALOP workshops given in Tanzania, Brazil, and Mexico.

UNESCO will focus on offering additional workshops in one of the world's least developed regions, sub-Saharan Africa. This does not mean that other regions cannot take advantage of ALOP through less costly regional adaptations. These "spin-off" workshops that are adapted to meet local needs are essential to the long-term viability of ALOP and similar high impact workshops.

There are efforts underway to augment official ALOP offerings by organizing regional workshops taught primarily by physics educators who have already participated in an official UNESCO sponsored workshop. Souad Lamar and Khalid Barrada are leading the way by translating the ALOP manual into French and by offering a version of ALOP (ALOP française) using regional instructors in Tunisia and Morocco. In addition, Julio Benegas and Cezar Mora Ley are spearheading the organization of ALOP español—a regional effort for teachers and teacher trainers in the southern cone region of South America and, eventually, Mexico. As well as fundraising, the ALOP español organizers (in collaboration with participants from the recent San Luis Potosi ALOP) are translating the manual into Spanish. ALOP español plans to offer the first Spanish language regional workshop in Cordoba, Argentina in 2008.

Over the long term, we need to be able to convene international teams to develop ALOP-like workshop curricula in other topic areas.

The existence of ALOP as a model workshop and its potential to enhance physics education throughout both developed and developing countries reminds us that international collaboration is an essential element of our efforts to improve physics education for all the world's peoples. Δ

Priscilla Laws is Research Professor of Physics at Dickinson College in Pennsylvania.

Well Done in Math, Physics, and Chemistry

Physics Education in China: From Past to Future

By Lei Bao and Zuren Wu

Education has always been the primary emphasis in Chinese culture since several millenniums ago. Popularized education became widely accessible following Confucius philosophy that "poor or rich has the right to be educated." To talk about physics education, which is an important element in China's modern-day education system, we have to look at it not only by itself but also how it is connected to the rest of the education system. We will start with a quick overview of how physics education has developed in the last century in the context of a rapidly changing China.

Physics, as a field of science, was introduced to China a little over a century ago. Beijing University and QingHua University are the early pioneers. During the first half of the 20th century, China experienced many political uncertainties and a lengthy and difficult period of war; however, several top universities were able to produce a generation of excellent physicists and physics educators. Motivated by the dream of using science and technology to develop China, learning science and mathematics became a national trend. A very popular slang is "Well done in Math, Physics, and Chemistry. Well off everywhere under the sky!" It is still a prime time belief today. During this period (1900-1950), physics education followed the same style in the west.

After the 1950s China enjoyed a peacful period of development, and education for all ages and regions became a national emphasis. Gradually, a Soviet-style format was adopted. All schools in China taught the same curriculum with the same textbooks. All middle schools, which begin at the seventh grade, offered physics as a mandatory course. To become eligible for high school and college, students need to pass the nationally administered exams. Physics is a core component (and one of the most valued) of the national exam. Consequently, physics teachers often enjoy highly motivated students in their classrooms.

Another significant development is most universities and colleges offer physics education courses to train future physics teachers. As a result, physics education became widely available in China's schools of education.

Beginning around the late 80s a new reform movement in education emerged. Throughout the nation, free compulsory education consisting of nine years for all school-age children was introduced. And though the government enforced a national education standard, local administrators decided which textbooks and other education resources to use.

Entering the 90s, the effects of the reform had already reached a majority of the school-age population, and each year 20 million new middle school kids were introduced to physics. On a typical school day, 50 million middle school and high school students nationwide were sitting in a physics classroom, which was a great achievement in popularizing physics education.

Although a large number of students continued to enjoy physics classes in grades 7-12, educators started to question the way physics was taught and the role physics study played in students' career choice. Toward the end of the 20th century, physics education in China primarily emphasized the transfer of physics knowledge from teacher to students. The role of the student as learner and the process of developing knowledge were of little relevance.

Further, all students take the national college entrance exam, and only the top 10 percent are selected by reputable universities. Not surprisingly, with the focus on high exam scores, physics education at the high school level involved highly specialized training in solving increasingly difficult physics problems. As a result, students became very skilled problem-solvers, but many also lost interest in physics. The role of physics as an ideal playground for training students to develop scientific thinking and strategies was lost.

As the world entered a new millennium, the Chinese government began a national initiative on education reform aimed at improving the basic intellectual and scientific capabilities of all citizens, including a comprehensive restructuring of the education system. A huge team of professors and school teachers developed a new "Nine-Year Compulsory Education Standard," which was enacted in 2001.

Under this new standard, "free-market competition" was introduced into textbook publishing and development. In the past, a limited number of standardized texts were written by a small group of experts chosen by the education department. Now many more qualified educators and researchers are allowed to submit proposals to develop particular textbooks, including multimedia formats.

The education department assembles a panel of experts to review all proposals, similar to a research proposal competition. When a proposal is selected the author prepares the material and conducts small- to medium-scale testing. The final version is submitted to the education department for evaluation. Upon approval, the texts can be officially distributed for course adoption.

This new process has significantly increased the availability, diversity, and quality of education materials. Today, teachers have the authority to select from the most appropriate materials from among a wider range of choices.

In 2003, additional and more specific standards were developed for each of the content areas in the middle- and high school curriculums. The physics curriculum became "modularized," with certain modules offered as electives.

The reform in the physics curriculum emphasizes the important role of students in the learning process. The goal of the physics curriculum is to encourage students to be active learners. The emphasis is not only on content knowledge but also on the process of learning as well as the development of correct intellectual values.

Within the new curriculum reform, formative assessment and student self-evaluation are highly valued. This is a major departure from the focus on content-oriented summative assessment of the last century. Currently, the new standard has been enforced only in grades 1-9 nationwide, and half of the provinces have implemented the reform in the high schools.

In China, college-level physics education is separated from the curriculum used in the school system. Also, national standards on physics education differ based on degree levels and major. Furthermore, these "standards" are merely guidelines, and university instructors have much more freedom than the school teachers in selecting textbooks and other teaching materials. They are even allowed to write their own texts to use for their course.

In most universities, physics is highly emphasized in nearly every major. In a top 50 university, it is quite normal for more than 80 percent of all undergraduates to have taken at least one physics course in their freshman year. There are currently more than 20 million college students in China, which makes physics education a popular subject in higher education. In recent years, physics education research (PER) has also started to gain momentum in Chinese universities. The current emphasis is still mostly on curriculum development; however, a new trend has started to position PER as a formal research field in physics.

Perhaps the strongest impression people may come away with after looking at China's education system is that physics is a crucial, highly valued, and widely popular area of study. Furthermore, physics education will continue to play a significant role as a fundamental element in China's new education reform that strives to build China into a modern nation. Δ

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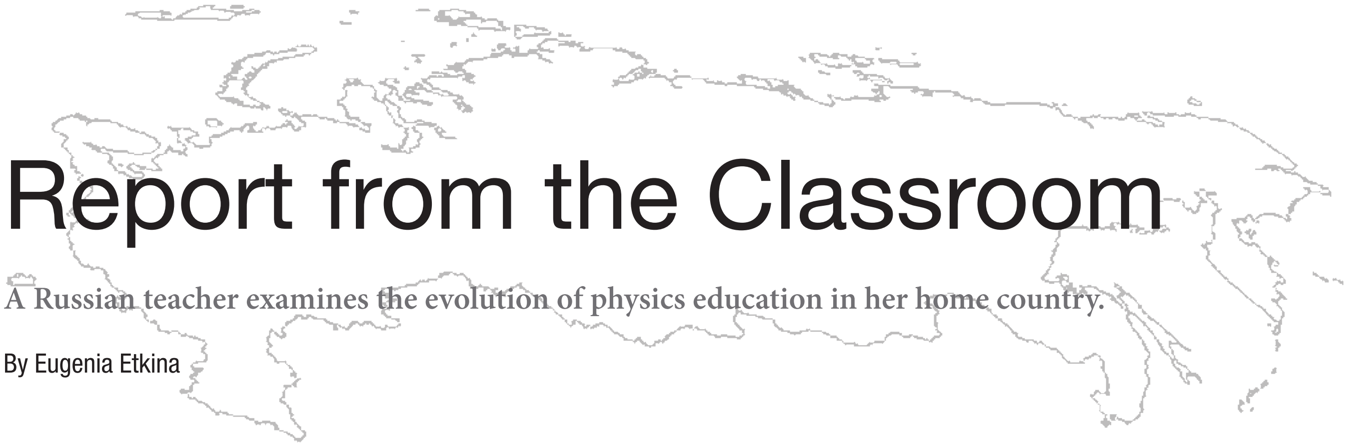

Report from the Classroom

A Russian teacher examines the evolution of physics education in her home country.

By Eugenia Etkina

I started teaching in Moscow in 1983. At that time the Soviet Union had a national physics curriculum, one set of textbooks, and the same graduation exam for all students. The national curriculum prescribed how much time a teacher could spend on a unit and the level of achievement (conceptual and procedural) that students should achieve at the end of each unit. In theory, a student moving from Moscow to Siberia would not notice any difference in the classroom—as all students were supposed to move at the same pace through the same topics. This, of course, was the intent. In practice, however, the timing and pace of the course sequence depended on teacher choices, preparation, and students' abilities. Still, the degree of variation within the same subject remained small.

Until 1989, a child entered the Soviet school system at age seven, and upon entering the first grade, would expect to have the same classmates when she/he graduated ten years later—all students took the same courses and stayed together in "classes."

Students began taking regular science subjects in fourth grade (the beginning of middle school), starting with general science. In fifth grade, biology and physical geography were introduced, with physics in sixth grade, chemistry in seventh, and astronomy in 10th grade. All students were required to take the same science subjects at more advanced levels until graduation (except for the geography sequence, which ended in ninth grade). Ideally, the same teacher—someone certified to teach the subject matter—taught the same science subject, to the same class, at every level. This was possible because elementary, middle, and high school students were not separated physically—all students stayed in the same building for 10 years.

In the early 90s, reflecting the political reforms happening at the time, the educational system changed. In 1989, 11 years of schooling instead of 10 was required; however, students still graduated at age 17, though they started school at age six. Also, more specialized schools appeared, where students could excel in a particular subject starting in grades eight or nine (a few specialized schools existed prior, but in the late 80s to early 90s their numbers increased dramatically).

Structure of the General Physics Curriculum

The Russian physics curriculum consists of two phases. During the first phase (i.e., grades seven and eight) students have two class periods per week. The course starts with the molecular nature of matter and density followed by kinematics of constant speed motion, qualitative Newtonian dynamics, fluid static and dynamics, and geometrical optics. Although the teacher ultimately determines the style of teaching, many schools encourage interactive engagement. The teaching approaches fall into one of two general categories: traditional or reformed.

Traditional teachers usually spend the first 15 to 20 minutes doing an oral assessment of the lesson. Several students are invited to the board to present the material from a prior lesson or the textbook. The teacher then asks students questions related to the presentation. The rest of the class observes passively or works on another problem-solving assignment. Each student has an opportunity at the board about once every two to three weeks. Afterwards the teacher explains the new material, shows demonstrations, and answers students' questions. If time permits there is a short practice based on the new material. Homework consists of reading the text and solving a few problems.

By comparison, reformed instruction involves much more student-teacher interaction, group work, explorations, learning games, student projects, and presentations. The new material is usually presented in the form of whole class discussion or small group investigations. Many teachers use the Socratic method as a way to engage students. Consequently, students are often graded on class participation. Assessment consists of quizzes, oral presentation grades, lab reports, and test scores. Rarely are tests multiple choice (in fact, before the 1990s there were nearly none).

The seventh grade physics course has about 15 prescribed labs that students perform usually at the end of the unit. Each classroom is equipped with a standard set of demonstration and lab equipment, and there are numerous books with lesson plans and suggestions on how to use the equipment productively. Before 1990 there was only a single textbook for each grade level; now there are a variety of textbooks and other classroom materials, similar to Active Learning problem sheets. There is also a wide range of "special problems books." The following is an example of one such problem used in the eighth-grade classroom:

> A piece of paraffin with a volume of 1 mm^3 was dropped in hot water. The paraffin melted and formed a thin film on the surface.
>
> a. What happened to the molecules of paraffin during this process?

b. What is the shape of the film on the surface of the water?
c. Why does at some point the area of the paraffin stop increasing?
d. Determine the diameter of one molecule of paraffin.

The eighth grade curriculum starts with basic thermodynamics, which includes calorimetry and phase changes. Students spend a significant amount of time studying energy transfer (e.g., conduction, convection, radiation, and evaporation) and transformations of gases into liquids, liquids into solids and vice versa. This is followed by static electricity (including the qualitative concept of electric field), then simple circuits (series and parallel resistors and Ohm's law, excluding the concept of emf), and magnetism. The course ends by introducing vibrations and waves. The material in both seventh and eighth grades involves simple algebra, and all problems require only one or two steps.

The "real" physics course begins in ninth grade, starting with a year of Newtonian mechanics. There are three to four periods per week. Kinematics features constant velocity and acceleration, projectile motion, including graphing, trigonometry, and multi-step problems. Students do several labs measuring speed and acceleration and predicting the location of a projectile. The level of difficulty is comparable to that of the college-based physics of the Cutnell and Johnson text; in fact, some problems are perhaps more difficult.

Because all students are required to take physics, some complete the course without achieving the necessary level of understanding. For those who struggle there is an after-school tutoring program. Teachers are paid extra to stay after-hours and help students with problems or answer questions. Many teachers also stay voluntarily for other physics-related activities such as challenge problem-solving contests, experimental contests, and "fun shows," where students demonstrate interesting physics experiments.

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Although teachers generally don't mind spending their own time working with students, it is important to note that the regular teaching load for Russian teachers is less than that for teachers in the United States—where a full-time workload is typically 18 periods per week. If a teacher takes on the extra load, he or she is paid separately for each additional period. Theoretically, a teacher could nearly double a full-time load; however, many principals cap the maximum number of periods at 24 to 26 per week with the assumption that more periods leads to lower quality teaching.

Tenth and 11th grade physics usually comprise four periods per week. The 10th grade course covers kinetic molecular theory, laws of thermodynamics, electricity, magnetism, and electromagnetic induction. Although the students already encountered most of these topics in the eighth grade, the material is now presented at a higher level of detail. For example, when first introduced to static electricity in eighth grade, they learn about two types of charges: conductors and dielectrics. Now they study Coulomb's law, expressions for a point charge and uniform electric fields, and solve complicated problems involving quadratic equations and trigonometry.

Eleventh grade physics starts with vibrations and waves (using pre-calculus and calculus) followed by electromagnetic waves. After a brief review of geometrical optics (first introduced in the seventh grade) students proceed to wave optics, photons, and atomic and nuclear physics. The course ends with elementary particles, with some teachers introducing the connection to astrophysics and cosmology.

Prior to 1990 all students had to take a compulsory oral physics exam upon completing the 11th grade. The content of the exam was the same countrywide, which included oral responses to two of 50 questions covering all five years of physics instruction, a problem-solving exercise or a lab that didn't require a lab write-up (e.g., determine the density of a rock). Students knew the questions in advance (but not the problems). After 1992, the oral exams became optional, and some schools later replaced it with an optional written exam.

Today, not every student takes the "general physics sequence" described above. Schools that offer specialized classes might reduce the number of hours of physics at the 9-10 grade level to 2 to 3 hours per week for those students in the humanities tracks and increase the number of periods (up to six hours per week) for students in the math and physics tracks.

To enroll in a specialized track students pass an entrance exam, and they usually have to work much harder than students taking the regular curriculum. The specialized track in physics includes a calculus-based curriculum starting at the ninth and 10th grade levels—similar to the curriculum introduced at the undergraduate level in the United States.

The substantial level of physics instruction described here might suggest that every Russian student who goes through this rigorous curriculum becomes a physics expert. Unfortunately, that is not the reality. Traditional teaching methods, for instance, tend to produce the same learning outcomes independent of geography. In addition, despite the huge amount of time devoted to physics instruction, FCI scores for Russian students not enrolled in the physics track do not differ significantly from the scores of U.S. students taking algebra-based physics. Δ

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Byron Rainey, left, and Larry Jackson wait as Katya checks their classwork.

Quantum Leap

In a random moment that a physicist might appreciate, a Russian Ph.D. named Katya Denisova suddenly found herself revealing the secrets of the universe to students at a troubled Baltimore high school.

By Sara Neufeld

Ninety minutes can be a long time to sit in physics class, but Katya Denisova's students don't stay in their seats for long.

They walk clockwise around the room, stopping at different stations to see what everyone else wrote about why humans can only see one side of the moon. They line up in front of motion detectors connected to computers to see how it looks on a graph when they walk at a steady pace, speeding up and slowing down.

Outside Room 350 at Baltimore's Homeland Security Academy, gang-related fights are so common that one student carries a mouthguard in his pocket, just in case he gets caught in the middle of something. The high school, part of the Walbrook complex, has made a name for itself as one of the most violent and lowest-performing in the state. Pass rates on the exams juniors may need to pass to graduate hover in the single digits.

Inside the room, a 32-year-old Russian immigrant with blond hair, a ponytail and a doctorate in physics education is opening students' eyes to a universe beyond West Baltimore. She loves surprising them with simple facts they should have learned years ago: The moon is a rock and doesn't emit light. The earth takes 24 hours to make one rotation.

"I get 12th-graders who need to get out of high school ASAP, and they know my class is going to be the hardest class they've ever taken," says Denisova, whose students call her "Dr. D."

In a school system with only 14 certified physics teachers, Denisova is a candidate for the nation's most prestigious teaching certification. She is qualified to teach anywhere. And yet she teaches here.

When Andres Alonso became chief executive officer of the struggling city school system this summer, he said he wanted to identify pockets of excellence, with an eye toward replicating them. Every school, he says, has at least one great teacher.

Denisova is one of the bright spots, her colleagues at Homeland Security say.

"When a teacher loves what they do, you can't hide it," says Arnetta Rudisill, who recently became the school's fourth principal in three years. "It spills over to the kids. If you're in love with it, they'll fall in love with it, too."

Like the troubled Homeland Security Academy, physics can be hard to love. The combination of the two seems almost impossible to contemplate. Yet here is Denisova offering energetic proof of the potential power of teaching to inspire even in the most unlikely settings. It's an encouraging lesson in a system fraught with failure.

Physics is not a priority for the school system's central office administrators. They are focused on biology, the subject of the state science exam used to assess student and school performance.

Students don't often enter Denisova's class caring much, either. Many are seniors who just need another credit to graduate.

But her enthusiasm is infectious. She wears T-shirts imprinted with formulas like $e=mc^2$. Next month, she'll participate in a "zero-gravity" flight simulating outer space, a mission for which her students are expected to help her prepare.

Denisova recently completed the requirements for the highest teaching credential, National Board Certification. Statewide, 822 teachers have the certification, but only 24 are in Baltimore.

Over the summer, Denisova led physics training for science teachers around the state through a program at Frostburg State University. She's working on her administrative credential.

She is a vocal proponent of Physics First, which calls for resequencing high school courses so that students can study basic physics before chemistry and biology.

Many now make it through high school with no physics. City ninth-graders take an overview science class, though they don't always have access to labs. They take chemistry as sophomores and biology as juniors, with the idea that by then, they're mature enough to pass the state's end-of-course biology exam.

Physics is optional, typically for seniors. The city has 35 physics teachers, compared with 89 in chemistry and 109 in biology. Some physics teachers are assigned to other subjects.

At Homeland Security, physics faces other distractions.

A few weeks into the new school year, moments after the bell rings, a woman's voice is on the loudspeaker: "At this time, please shut and lock your doors."

A boy dashes into Room 350 just as Denisova is closing the door. Counting him, there are 14 kids present in a class with 24 enrolled. A few minutes later, there are 16, plus an aide who's supposed to help a special-education student but mostly just sits there.

Already, some of the students have been won over. Denisova tries to hook them by making lessons relevant. To start a unit on global warming and fossil fuels, she'll have students study their family [electric] bills.

The one who carries the mouthguard, 19-year-old Eugene Thomas, appreciates Denisova's patience. He feels as though she really wants him to understand. "The teacher is in control," he says. "Other classes, students try to override the teacher."

Every year, Denisova discovers bright students who've made it to 12th grade without anyone telling them they're smart. Even if she can get their sights set on college, sometimes it's too late. By the end of the school year, they may be able to show her how not to overload an electrical circuit, but they still struggle to read.

Last year, one of her students who wanted to major in science got an athletic scholarship to a college out of state, and his grandmother wouldn't let him go.

Back in Russia, Denisova's grandfather was a dean of a university's theoretical mechanics department. Her mother is an astronomy professor, and her father has a doctorate in astronomy. "My first language was formulas and technical terms," she quips.

After studying physics education at Herzen State Pedagogical University, Denisova came to the United States to get a master's degree at University of Northern Iowa, which has an exchange program with Herzen. She then earned her doctorate through a joint program of the two universities, traveling between St. Petersburg and Cedar Falls.

In St. Petersburg, she taught science briefly at an English-speaking school in the U.S. Consulate. But the school

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had low enrollment, and Denisova decided to look to the United States for greater opportunities.

She had no choice about where she would be assigned to teach when she moved to Baltimore in 2002. Applying for jobs from overseas, she found no shortage of American school districts that wanted to hire her—until they found out they'd need to sponsor a visa for her. Then Baltimore's was the only offer still good.

The school system assigned her to what was then Walbrook High. She recalls how the principal—two-time mayoral candidate Andrey Bundley—told her she wouldn't last long.

"I remember I was scared to death to exit the building because I'd be the only white person in the street," she says. "I'm still the only white person in the street, but now people know who I am. ... I've been here in the same building in the same room for six years, and I actually like what I do immensely."

Walbrook has been through a lot during Denisova's time there. In 2004, officials discovered that students had been permitted to graduate without meeting all the requirements. That fall, the school was disrupted by dozens of arson fires. In 2005, Walbrook broke up into three smaller schools, one of which closed this summer after the state designated it "persistently dangerous." Homeland Security is one of the two that remain.

Denisova has been through a lot, too. She married and divorced, living now in Owings Mills, MD, with her 3-year-old son. In her spare time, she directs a Baltimore-based Russian folk dancing ensemble called Kalinka.

At work, she's often faced with bureaucratic barriers.

In the spring of 2004, with her Maryland teaching certification complete but her visa about to expire, the school system notified her she was being let go. For her visa to be renewed, system officials would have to place a classified advertisement for her job in a local newspaper to be sure that no qualified American citizens applied. They told her it wasn't worth their time.

"I was calling every number and I was knocking on every door," she says. "I was using all the network connections that I had. ... Eventually they let it happen. But they definitely did not welcome my intention to stay."

Since then, the system has hired hundreds of teachers from the Philippines. Nearly half the teachers at Homeland Security this year are Filipinos. It's more efficient to process paperwork for a group than an individual, school officials told her.

During a student weapons search at the Walbrook complex last month, school police confiscated 14 knives, a box cutter, a firecracker, three cans of mace and two bricks hidden inside socks.

For more than a year, Denisova has offered to lead training for city physics teachers on the school system's professional development days, when there's currently nothing for them to do.

The system's new head of secondary science says she'll work with Denisova to implement physics professional development by early 2008, pending a final proposal and budget approval.

At Homeland Security, Denisova is the science "instructional support teacher," a position similar to a department head. She teaches one 90-minute class and spends the rest of her day supporting other teachers.

Once a week, she's required to attend a central office meeting that conflicts with her class. So once a week, her class has a substitute.

One afternoon, Rudisill rushes up and asks Denisova to help a new chemistry teacher whose room looks uninviting and whose students are doing mindless work, copying the periodic table.

On top of the bureaucracy is the violence. During a student weapons search at the Walbrook complex last month, school police confiscated 14 knives, a box cutter, a firecracker, three cans of mace and two bricks hidden inside socks.

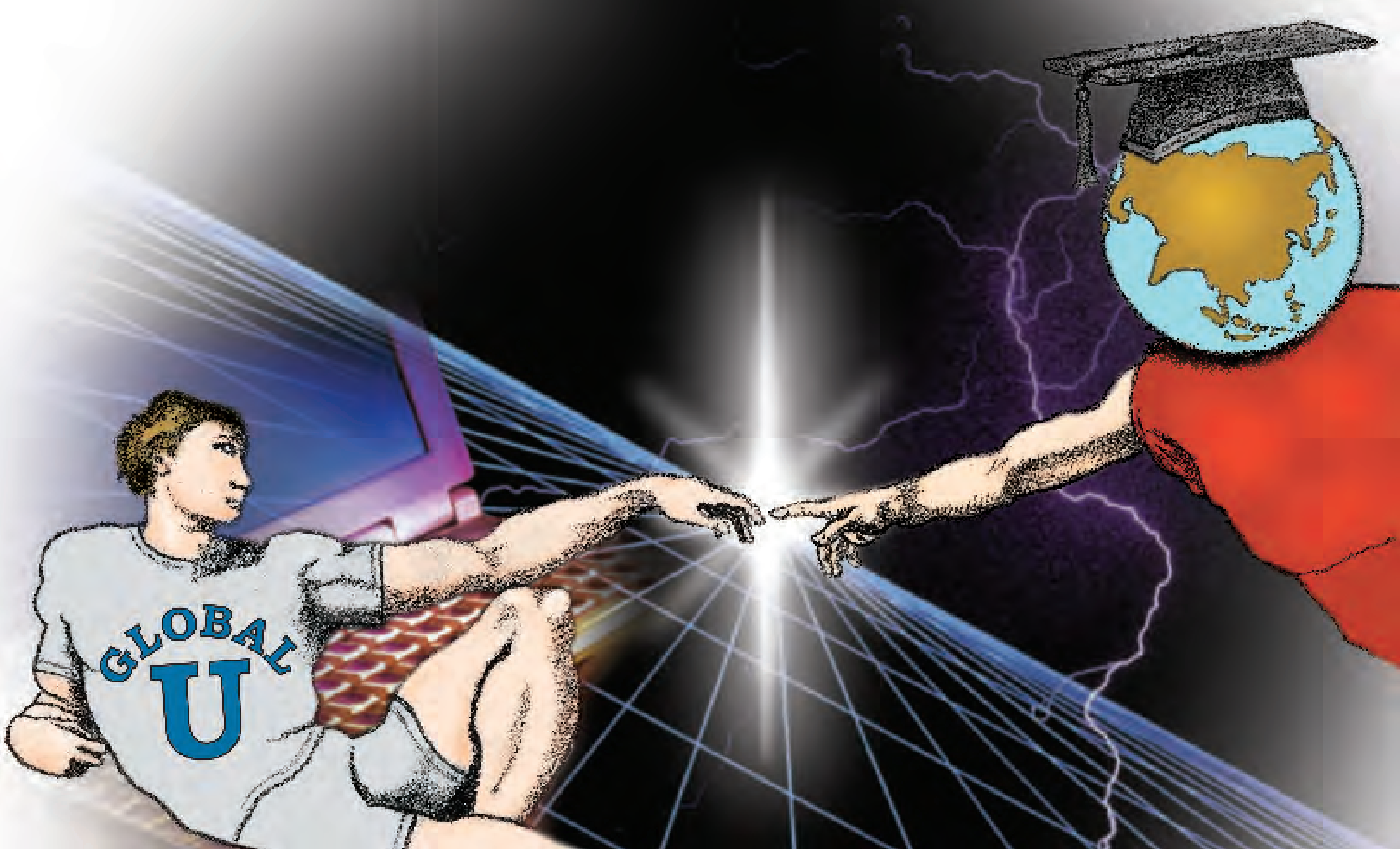
The day of the motion detector experiment, Denisova has her students on task for the full 90 minutes, moving between computer and word problem stations. At 1:15, the bell rings, and it's supposed to be lunchtime. But moments later, kids are streaming back into Room 350.

"Everybody out of the hall," an agitated female voice says on the loud speaker. "We've got a lockdown. Everybody get in a room, any room."

"Somebody got shot," a boy returning to Denisova's room says matter-of-factly.

As it turned out, a student on long-term suspension for bringing a knife to school entered the building, and there was a false rumor that he was armed. But for 10 minutes—until the lockdown is over—no one in the room knows what is happening.

"Everybody sit down and wait for announcements," Denisova says, her voice calm but firm. "You're completely safe in here." Δ



College Goes Global

The campus without borders? Maybe.

By William R. Brody

The Coming Test

In June, students of Shengda College, in Xinzheng, China, staged one of the most disruptive and violent protests since pro-democracy demonstrators took to Beijing's Tiananmen Square in 1989. Riot police were called in, the campus was locked down, and the college headmaster eventually resigned. The students rioted because they had received diplomas imprinted with the name of Shengda College rather than ones with the name of the more prestigious Zhengzhou University, the college's nominal mother school, which they claimed had been promised to them. They felt cheated after having paid five times the tuition that Zhengzhou University students pay, and they worried that getting the lesser degree would shut them out of China's economic future.

The unusual cause of this rampage reveals much about the role of higher education in today's global marketplace. Implicit in the incident is the recognition that a college degree is an indispensable passport to the globalized knowledge economy of the twenty-first century. Higher education, once the rarefied province of the elite, is now viewed by most nations as an indispensable strategic tool for shaping, directing, and promoting economic growth. There was, of course, an explicit message in the Shengda students' actions as well: a diploma from the "right" university is incomparably more valuable than just any old degree. Meritocracy be damned: pedigree counts.

Both of these messages would seem to bode well for U.S. universities. Since the end of World War II, the United States has been recognized as the world leader in higher education. It has more colleges and universities, enrolls and graduates more students, and spends more on advanced education and research than any other nation. Each year, more than half a million foreigners come to the United States to study. A widely cited article written by researchers at Shanghai Jiao Tong University that looked at the academic ranking of universities worldwide based on faculty quality and research output found that more than half of the top 100 universities in the world—and 17 of the top 20—were in the United States.

It would also seem that higher education is a market ripe for globalization and that U.S. universities—by right of their acknowledged achievements, outstanding reputations, and

Matt Payne

considerable advantages in size and wealth—are predestined to take on the world in the way that Boeing, IBM, Intel, and Microsoft have done within their respective industries. But as the president of a U.S. university that has operated one campus in China for two decades and another campus in Italy for more than half a century, I can say that consolidating U.S. dominance in international education will not be as easy or as likely as it seems.

The evolution of the global higher-education market, and the United States' predominant role in the field, is of great and increasing consequence both in the United States and abroad. How should U.S. institutions of higher learning—and, in particular, the United States' world-renowned system of private and public research universities—adapt to this changing environment? Is this field, like so many others in the past, destined to see the emergence of a handful of global players—educational powerhouses—that come to dominate and define it? Will the twenty-first century be the era of the "Global U"?

Trains, Planes, and Universities

When Johns Hopkins University was established in 1876, its founders hoped to depart from existing models. They took the highly unusual step of recruiting Daniel Coit Gilman, from the University of California, Berkeley, as the university's founding president. This choice was no small departure from established norms: to recruit in California from Maryland just seven years after the completion of the transcontinental railroad was an adventurous undertaking (at a time when trains averaged speeds between 25 and 35 miles per hour).

In those days, most scholars, and most people, were not freely mobile. This limitation had an important implication for faculty. If you were to become a scholar in Mesopotamian history at Johns Hopkins, for example, and you knew more than any other scholar between Washington, D.C., and New York City, you would have been in a good position to become a tenured professor. Even if you were not particularly accurate in your knowledge of the subject, your shortcomings would go undiscovered for months or even years. The diffusion of knowledge was slow, and, as a result, expertise was assessed within a local or regional context.

Today, knowledge is disseminated in seconds, and flawed information is quickly exposed. This is the effect of the "IT-IT phenomenon": cheap international travel and ubiquitous information technology combine to disassociate expertise from place. Speeches and papers appear on the Internet as soon as they are delivered or published. Theories are proved or disproved through an international network of scholars who have immediate access to the latest discoveries. Physicists in Ukraine, for example, debunked the "discovery" of cold fusion within days of the announcement in 1989. Since international air travel has become relatively affordable, the experts who generate such knowledge are also mobile.

As a result of this IT-IT phenomenon, expertise is now measured on a global rather than a local scale. It is no longer possible to depend solely on local experts for knowledge. Only if the local expert is also a globally recognized expert can you rely on your faculty colleague down the hall. On a trip to Singapore (where my university has partnered with the National University of Singapore to create a musical conservatory and where we also have a medical clinic and in-patient cancer facility), I found myself on the same plane as three Johns Hopkins faculty members: one teaches mathematics during the winter semester in Singapore, the other two were doing collaborative research with faculty at the National University. Their paychecks may state that they are employees of Johns Hopkins, but that is not what is important to their students and colleagues in Singapore—it is their world-class expertise that matters most.

Global expertise commands a premium—an academic version of the Michael Jordan phenomenon. Jordan was making $33 million a year when playing basketball for the Chicago Bulls, whereas the person sitting on the bench next to him, although a very good player in his own right, was making hundreds of thousands. Why? Because Jordan was truly the world authority of basketball and was able to command a global audience. The journeyman guard playing next to him may have been fine for the local crowds in Chicago, but he was not going to have the same drawing power on a worldwide espn broadcast.

This new emphasis on world-class expertise fuels a global search for talent that favors universities with access to the most resources. As in other spheres of life, in education, the rich will tend to get richer and the poor increasingly will struggle to catch up. As of June 30, 2005, Harvard's endowment was more than $25 billion; Yale, Stanford, Princeton, and the University of Texas system had each reported endowments over $10 billion; 24 U.S. colleges and universities had endowments of $2 billion or more; and nearly 60 had at least $1 billion in income-generating assets. By contrast, a 2003 British study on higher education noted that just five British universities had endowments worth at least $200 million, compared with 207 universities in the United States. Only Oxford and Cambridge—with more than $4 billion each—would come in the top 150 in the world (tied at number 15). Outside the United States, only countries with rapidly growing economies, such as China and Singapore, can afford to invest heavily in making their universities world-class research institutions. In countries with slower economic growth, universities increasingly depend on nongovernmental sources of revenue, chiefly endowment income.

Like faculty, students—particularly graduate students—are drawn from a global pool.The best professors need access to the best students, and so the talent search has moved to the international arena. This explains why in U.S. universities today, roughly a third of all graduate students in science and engineering and more than half of all postdoctoral students are foreign nationals.

School Daze

Just as geographic boundaries have become less distinct in higher education, the walls between academic disciplines within universities are being torn down as well. The frontiers of research, whether in the sciences, engineering, or the humanities, are increasingly those places where teams of experts from multiple disciplines work together. For decades, the life and physical sciences were separated by impermeable barriers. Today, if barriers exist at all, they are highly porous. Contemporary advances in medical science, for instance, often cannot proceed without significant contributions from robotics, information sciences, engineering, and the physical sciences. Even problems in biochemistry, a relatively narrow field, can no longer be dealt with by the biochemist alone: you also need a molecular biologist, a biophysicist, and a physiologist.

Universities must therefore develop the ability to assemble multidisciplinary expertise. As recently as 1985, most research grants in a Johns Hopkins academic department involved that department alone or a single faculty member. A decade later, grants were often going to groups of faculty members from multiple disciplines, but for the most part still within the university. Today, very few grants are given to just a single faculty member, and about a fifth of our grants involve one or more faculty investigators not at Hopkins. For example, we received a prestigious National Science Foundation grant for robotic surgery research that involved not just a number of divisions at Hopkins, including the Applied Physics Laboratory and the School of Engineering, but also faculty members from Carnegie Mellon, the Massachusetts Institute of Technology, and Harvard Medical School.

in the past six years the number of U.S. universities with campuses abroad has doubled to about 80, and new ventures continue to arise, especially in Asia, where the thirst for higher education seems unquenchable

The use of discipline-based departments has many advantages for teaching and quality assurance, but in many cases it also serves as an impediment to interdisciplinary research. Whether the barrier is geographic, financial, or bureaucratic, universities are being challenged by the need to quickly assemble interdisciplinary research teams to react to new frontiers.

The *New York Times* columnist Thomas Friedman might say that the academic world has gone flat. Hierarchical structures that contain expertise in divisions and departments and are under the supervision of a chair or dean apply less and less. This can perhaps be best understood through a "quantum physics model" of the university. In the classical model of the atom, a central sphere—the nucleus—has electrons circling around it in fixed orbits. In much the same way, in the classical model of the university, faculty and students orbit around the campus, held together by commitment and tenure. Although loyal to their discipline, professors have at least as great a commitment to their institutions. Students are present all the time and feel a strong sense of loyalty to the university.

But the classical model of the university has given way to a different reality, akin to the quantum model of the atom, which has electrons acting as waves as well as particles and consequently occupying positions that cannot be pinned down with absolute precision. Today, research universities have multiple campuses—in fact, more of a cloudlike collection of sites. Johns Hopkins, for instance, has more than a dozen sites in the United States, operates research projects in 80 countries, and will probably have even more campuses in the future. Nor is Johns Hopkins unusual in this regard. The University of Maryland has a business school with programs in nine locations on four continents, including campuses in Beijing and Shanghai. Yale University celebrated its tercentenary by declaring its intent to become, in the words of its president, Richard Levin, "a truly global university" and published a comprehensive plan to achieve that goal. Carnegie Mellon has a campus in Qatar. Temple University has a presence in Japan. MIT is one of several universities with programs in Singapore. According to *Newsweek International*, in the past six years the number of U.S. universities with campuses abroad has doubled to about 80, and new ventures continue to arise, especially in Asia, where the thirst for higher education seems unquenchable.

Faculty members are no longer in a tight orbit around a campus; they are loosely bound to their institutions. This is not without reason: the faculty has to be a collection of international experts. Professors are loyal not only to their disciplines but also to their research, and they need to work with others with the same focus. This association is natural and is now made possible through electronic connections and physical travel.

The loosening of the affiliation between faculty and universities is an inevitable consequence of the globalization of knowledge. In the quantum physics model, faculty obey a kind of uncertainty principle: you may know where a professor is at any given time or you may know his institutional affiliation. But the more you try to ascertain the former, the less sure you may be about the latter, and vice versa. This phenomenon prompted the former president of Boston University, John Silber, to actually propose taking roll call to see whether faculty members were on campus. But such a measure would go against the grain of how knowledge is generated and diffused in today's information-sharing environment, and Silber's proposal unsurprisingly has come to nothing.

> to be successful—and even to stay in business—a global university would somehow have to garner consistent and dependable financial support from many different nations simultaneously

One consequence of these changes is that the relationship between faculty and universities has become more and more one-sided. Tenure provides a lifetime, no-cut contract for faculty. But professors' and researchers' allegiance is linked to their research, and they have no requirement to stay until retirement with the university that granted them tenure. At the same time, faculty whose field of study becomes obsolete or is no longer within the primary purview of the university's mission cannot be removed. This is a potential Achilles' heel for worldclass universities bent on remaining relevant in an environment that places a premium on research and development and evolves at a rapid pace.

Already, increasing numbers of teaching slots at colleges and universities large and small are being filled with adjunct, part-time, and non-tenure-track faculty. But tenure remains a core value for professors, and the best and the brightest will continue to look for it. For the foreseeable future, it will remain up to universities themselves to award their lifetime contracts with great prudence and keep a watchful eye on future academic needs and evolving disciplines.

A Megaversity for the World?

All these forces at work in higher education today suggest the arrival of an entirely new institution: the "megaversity," a research and education dynamo electronically linking the best faculty and the most capable students in a worldwide academic community. Will a cartel of the richest and most aggressive schools come to embody and define the global university?

At the end of the twentieth century, the economist Peter Drucker told *Forbes* that the traditional university model was dead, predicting that big university campuses would be relics in 30 years. More recently, Princeton economics professor Alan Blinder predicted in these pages ("Offshoring: The Next Industrial Revolution?" March/April 2006) that any service capable of being transmitted through a wire—especially higher education—would eventually migrate from high-cost to low-cost regions: "As college tuition grows ever more expensive, cheap electronic delivery will start looking more and more sensible, if not imperative." Drucker's and Blinder's ideas suggest that the coming changes in higher education will resemble the experience of the manufacturing sector in the first half of the twentieth century. The Ford Motor Company's state-of-the-art River Rouge Plant, for instance, employed over 100,000 workers in the 1930s, making it the world's largest integrated manufacturing facility at the time. But it has since given way to a constellation of manufacturing facilities and independent suppliers scattered around the globe. A similar development in higher education would result in radically decentralized teaching institutions consisting of loose confederations of campuses (and electronic "virtual campuses") located in different regions and countries.

In spite of these forecasts, however, the era of the global megaversity may not be at hand. Three factors, in particular, suggest a somewhat different future. First, there is the weight of tradition, and the important but hard-to-quantify value that matriculating at prestigious schools brings. Going to college or university is a means of advancing one's education through the attainment of specialized knowledge, culminating in the bestowing of a formal credential. But more than that, it is an important rite of passage as well. College students traditionally inhabit a fuzzy time between youth and adulthood; there is an enormous appeal to—and probably some good social reasons for—spending this time of discovery, of choices, and of meeting future associates and lifelong partners in such a setting. Connecting all these young men and women through a wire would not be the same thing.

This environment is important to faculty as well. Colleges around the world may vary considerably in their layout and architecture, but almost every campus is a place apart. The term "ivory tower"—now largely understood in a pejorative sense—was originally meant to recognize and celebrate the essential separateness of the life of the mind. An ivory tower was a place of noble purity. Plato's champions reportedly raised 3,000 drachmas to buy a sacred olive grove outside the walls of Athens as the site of the Academy, home to many of the great thinkers of the Hellenic world. An essential feature of the university since its inception has been this sense of its being an exclusive and selective place apart. Pity the modern megaversity president who, to improve economic efficiency, has to inform her Nobel Prize–winning faculty member that the campus is being broken up and dispersed to countries with lower labor costs—or, worse yet, disbanded entirely.

The second issue that will ultimately prevent the creation of the Global U is the problem of national boundaries.Drucker, Friedman, and others may have observed that the power of the nation-state has withered, but by no means has it disappeared. Universities and the nations they call home exist in an extremely close and elaborately constructed symbiosis. Every nation in one way or another makes significant financial contributions to its resident universities and demands considerable returns in exchange—both in numbers of qualified graduates and in terms of the economic benefits that the education and research carried out by the universities provide. Also, credentialing—always a vitally important part of the educational process—is exclusively defined and controlled by the host nation, and it would behoove the soothsayers to remember that few nations are willing to adopt a laissez-faire attitude toward the teaching, beliefs, and activities on their campuses.

Finally, as is so often the case, the advent of the Global U really comes down to a question of money. Plato would not have had his Academy but for the generosity of friends who helped him buy the land it was built on. It was supported, according to a medieval account, by rich men who "from time to time bequeathed in their wills, to the members of the school, the means of living a life of philosophic leisure." That model of the university survives to this day. The only thing that may have changed is the question of degree. Ancient and medieval universities were expensive hobbies of the rich and the royal; today's modern research universities are several orders of magnitude more costly to run and sustain. Virtually every great university today depends on government funding, student tuitions (each of which covers only a portion of the cost of an education), alumni support, and the outstanding generosity of philanthropists to make ends meet. Even so, financing is always a struggle, and the price of a university education in the United States has marched determinedly ahead of the rate of inflation for decades now. To be successful—and even to stay in business—a global university would somehow have to garner consistent and dependable financial support from many different nations simultaneously.

So far, it has been those countries with especially deep pockets (some of the smaller Persian Gulf states), an especially profound commitment to higher education (Singapore), or unusually high growth potential (China and India) that have successfully marketed a combination of available land, government accreditation, and financial incentives to lure foreign universities to their shores. But most of this activity is brand new—especially when considered in light of the thousand-year tradition of higher education in Western civilization—and it remains to be seen whether these ventures will be viable long-term relationships or temporary accommodations born of an era of good feeling.

Think Global

Universities, like houses of worship, are among the few institutions that have survived fundamentally unchanged for centuries. Empires will rise and fall, and countless other social arrangements have, over the years, given way to political, geographic, and environmental forces. By their design, however, universities are slow, if not sometimes unable, to change. This inertia has been their intrinsic advantage. Yet today they are subject to the same forces and stresses created by globalization that confront all other aspects of society.

Increasingly, there are serious disputes revolving around who should own the rights to the intellectual property generated by faculty, the increasing mobility of professors and researchers, and the responsibilities of universities to their tenured staff. The productive faculty of today may be rendered less relevant to the research agendas of tomorrow as the pace of discovery quickens. Ultimately, the ability of universities to reconfigure their educational and research efforts will depend on the agility of their faculty and the porousness of their traditional boundaries.

For nearly three-quarters of a century, scientific research was largely the province of the United States and Europe. Now, emerging countries—especially in Asia—increasingly are significant contributors to science and technology, and this trend is likely to continue for the next half century or more. Existing research universities are liable to lose their leading role unless they are able to form, or join, worldwide networks of researchers working at the frontiers of knowledge.

The United States' oft-cited head start in universalizing higher education is also dwindling. Whereas Americans used to clearly lead the world in areas such as college participation rates and the breadth and diversity of higher education, the rest of the world has been catching up. Higher-education enrollment has increased by more than 30 percent in the United Kingdom in the last two decades and in France by an astounding 72 percent. China quintupled its number of college graduates in the past seven years alone. And for the first time since the late 1800s, the United States no longer has the world's highest rate of young students going on to postsecondary institutions. That honor now goes to Canada, with the United States and Japan close behind.

At first blush, it seems hard to imagine two less similar entities than a multinational oil company and a prestigious regional research university. Yet they are very similar in this one respect: both must ultimately respond to the fundamental need to go where the resources are. Almost 70 years ago, the Standard Oil Company of California discovered oil in Dammam, Saudi Arabia, after four years of unsuccessful drilling. A similar dynamic is increasingly under way in research and higher education today, propelled in no small part by open borders, jet transportation, instantaneous communications, and over one billion English speakers—the same factors that are fundamentally reshaping international commerce and the creation and distribution of wealth. Universities must prospect for the best brains, skills, and talent. In recent years, it has increasingly become evident that they will have to go far beyond their traditional borders to find those resources. Δ

William R. Brody is President of Johns Hopkins University.

AAPT 2008
Summer Meeting

July 19-23, 2008
University of Alberta
Edmonton, Alberta, Canada

A REGIONAL PARTNERSHIP
EDMONTON TOURISM

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PHYSICS from the Ground Up

Dear Friends and Fellow Members of AAPT,

Be sure to come to this year's AAPT Summer Meeting July 19-23. It's a winner. We're going international—across the border into Canada. Active and energetic Canadian members, led by Terry Singleton, have drawn us to the beautiful city of Edmonton and the University of Alberta, where they are celebrating the 100th anniversary of the university and its Physics Department.

The meeting's forums, lectures, workshops, and sessions range from the latest in teaching and research to historical reviews of techniques pioneered by Galileo and Rumford. You'll hear physics talks by outstanding practitioners of our profession. Among these will be Michio Kaku, theoretical physicist author of *The Physics of the Impossible* and Eric Mazur, noted Harvard physics professor widely known among physics teachers for his imaginative, ingenious, and effective Concept Questions. Prof. Kaku is this year's recipient of the Klopsteg Memorial Award; Prof Mazur has been chosen to receive the Robert A. Millikan Award.

An AAPT meeting is always a wonderful occasion. I love to prowl the exhibits; I dote on the demonstrations; I delight in the variety and ingenuity of the workshops, the talks, the posters. It's a fine pleasure to share the interest and enthusiasm of committed teachers, examining the latest classroom trends, ingenious lab techniques, and creative and imaginative ways to help students learn physics. And, best of all, I love just plain schmoozing with new friends and old. Come to Edmonton; share the pleasure.

And while you're there, enjoy the long summer days and the local attractions. Hike in the Rockies; fish in the northern lakes; or, right in the city, go bird-watching along the North Saskatchewan River. Try out the Taste of Edmonton Festival; visit the TELUS World of Science—always a favorite with AAPTers—and Edmonton's other museums.

Don't miss this meeting. See you there.

Charlie Holbrow

Charles Holbrow

P.S. And remember your passport!

Check our website for updates: ***www.aapt.org***
Photos courtesy of Edmonton Tourism.

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AAPT PHYSICS EDUCATION

edmonton'08
AAPT | PHYSICS FROM THE GROUND UP

www.aapt.org

Make your reservations now!

Program note: *This special section features a preliminary list of workshops and events. Speakers and workshop descriptions are currently being confirmed. Visit www.aapt.org frequently to find up-to-date information.*

Why you should sponsor a meeting event:

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- The most effective way to showcase your product or service
- A captive audience that wants to learn and succeed

For more information on why this is a win-win opportunity, please contact Kristal Watkins at 301-209-3372 or kwatkins@aapt.org

location & lodging

Edmonton – The Festival City

Described as one of the most beautiful places on earth, Edmonton is part of the Alberta Rocky Mountains in western Canada. This city offers a wide variety of places to go and activities to enjoy at any time of the year. Known as Canada's Festival City (www.festivalcity.ca), Edmonton hosts more than 30 festivals annually that celebrate music, food, culture, sports, theatre and more! With lots of blue sky and sunshine throughout the seasons, you can take advantage of many outdoor activities in the city. You will also find Edmonton to be a brilliant educational community that plays an essential role in advancing the economic success of Edmonton and Alberta. The University of Alberta's revolutionary spirit inspires faculty and students to advance knowledge through research, to seek innovation in teaching and learning, and to find new ways to serve the people of Alberta and the world.

Traveling to Edmonton

IMPORTANT - US Citizens: Passport is required!

By Air

Edmonton International Airport is 25 minutes from the Westin Edmonton Hotel. AAPT has chosen Air Canada as our official Canadian airline for the Summer Meeting. This affiliation entitles AAPT meeting attendees to special discounts. In order to take advantage of these discounted fares, please reference Promotion Code 6FMGYA61. Make your airline reservation now at: **www.aircanada.com/en/home.html** or by calling 1-800-361-7585.

By Car

Edmonton is situated on the Trans-Canada Yellow Highway, which provides access from Winnipeg through Edmonton to Prince Rupert and Vancouver. Highway 2 is the main highway from the United States through Calgary, Red Deer, Edmonton and Northern Alberta.

Rental Car Information

Avis is proud to offer special rates for the summer meeting. To reserve a car, contact Avis at 1-800-331-1600 and reference the Avis Worldwide Discount (AWD) number J945158.

Ground Transportation

Edmonton Sky Shuttle: **http://tinyurl.com/297lau or call 780-465-8515**. For more information go to **www.aapt.org/Events/SM2008/index.cfm**.

By Train

VIA Rail's (http://www.viarail.ca/) internationally known transcontinental train, The Canadian, stops in Edmonton. Rail passengers can travel from Saskatoon, Winnipeg or Toronto, Jasper, Kamloops and Vancouver. You can make a reservation via http://www.viarail.ca/

By Bus

Greyhound Bus Lines (http://www.greyhound.ca/) provides excellent service to Edmonton from anywhere in North America. You can make a reservation via http://www.greyhound.ca/

The Scotia Place twin office towers, 28 and 21 stories respectively, stand prominently in the center of Edmonton's downtown commercial and retail properties.

When you visit the Devonian Botanic Garden, there will always be something special to see.

Lodging Information

The Summer Meeting will be held at the University of Alberta.

The Westin Edmonton

10135 – 100 Street NW, Edmonton, AB, Canada, T5J 0N7. AAPT has secured a large number of rooms at the Westin Edmonton Hotel. The rate is $149 per night for single and double occupancy. The Light Rail Transit (LRT) Churchill Station is connected to the hotel and is approximately a 10 minute ride to the meeting site at University of Alberta. To make a reservation visit: **http://tinyurl.com/2l2xca or call 1-800 WESTIN1**.

Located in the heart of downtown and connected to the Shaw Conference Center, The Westin Edmonton is only a few steps from the best shopping, dining, arts and entertainment Edmonton has to offer. The hotel provides a fitness center and heated indoor pool. You can experience regional and international cuisine at Pradera Café or enjoy a cocktail at the Pradera Lounge. Each smoke-free guest room offers a generous workspace and high speed Internet access.

Check-in time: 3:00pm
Check-out time: 12:00pm

Dorms

Rooms are available at the University of Alberta from $50-$105 per night. Read more and apply at: **http://tinyurl.com/2bkghd**

Things to do in Edmonton

West Edmonton Mall: The world's largest entertainment and shopping centre and Alberta's number one tourist attraction, featuring more than 800 stores and services, more than 100 eating establishments, plus nine world class attractions.

Elk Island National Park: Located less than an hour away from Edmonton, Elk Island National Park of Canada protects the wilderness of the aspen parkland, one of the most endangered habitats in Canada. You can find bison, moose, deer and elk roaming freely throughout the park. With the wildlife viewing, hiking, picnicking and overnight camping there is something for everyone.

Devonian Botanical Gardens: This 80 acre garden was established in 1959 and is a component of the Faculty of Agriculture at the University of Alberta. The garden includes an authentic Japanese Garden, attractive floral gardens, collections of native and alpine plants, and ecological reserves, and is situated within a gorgeous rolling landscape of pine trees and wetlands.

Royal Alberta Museum: This museum tells the story of Alberta—the experience of people and places over time and inspires Albertans to discover and understand the world around them. You will find some of the finest cultural and natural history collections in the country.

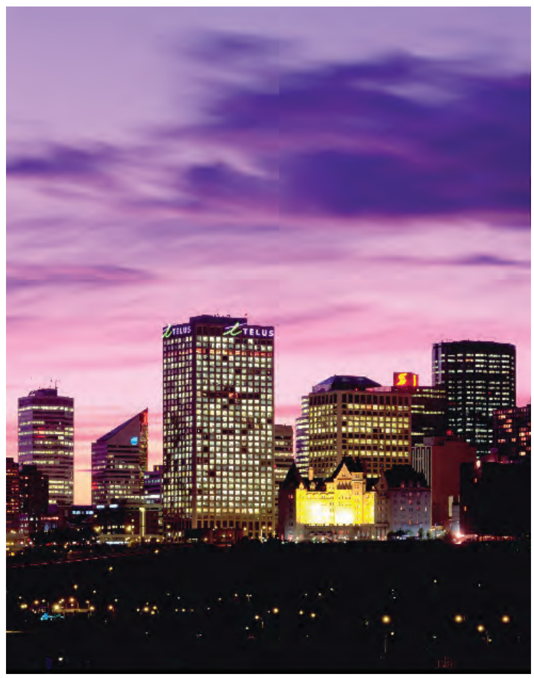
meeting information

Registration Fees

	(thru 6/5)	(6/6 - 7/19)
AAPT Full Meeting	$295	$348
AAPT Retired or Emeritus	$200	$225
AAPT One Day	$150	$175
Nonmember	$385	$410
Nonmember One Day	$295	$310
Student: Undergraduate and Graduate	$25	$35
High School Student	FREE	FREE

First-Time attending a meeting - 50% reduction
Regional Educator (Applies to following states and provinces: Montana, Alberta, Saskatchewan and British Columbia) - 50% reduction
International Attendee - 50% reduction

Physics Education Research Conference 2008:
Physics Education Research with Diverse Student Populations
In this session, PER encourages those who are using research-based instructional materials with non-traditional students at either the pre-college level or the college level to share their experiences as instructors and researchers in these classes.
PERC will be held at the University of Alberta, July 23-24, 2008. Registration fee to attend PERC is $130 (thru 6/5) and $175 (6/6 - 7/19), which includes a banquet. See **www.aapt.org** for more information.



Special Events

Physics Exhibit Show and Daily Poster Session
See modern and historical physics equipment and view the latest research from across the physics education spectrum.

AAPT Summer Picnic and Evening Demo Show
These two popular gatherings feature great food, live music, and physics demonstrations.

Young Physicists Meet and Greet
The place for Generation-X attendees to mix and mingle.

Spouses' Gathering
An opportunity to learn about Edmonton-area activities, shops, and recommended sight-seeing.

First Timer's Gathering
The best time to learn about AAPT and the Summer Meeting and to meet fellow attendees and AAPT leadership.

SPS/AAPT Poster Reception
The Society of Physics Students and AAPT host this reception and a casual discussion of twenty-first century education and research.

award winners

Robert A. Millikan Award

Eric Mazur, Harvard University

Physics Reality Distortion: Why The World of Physics and the Real World are Different in Students' Minds

Eric Mazur is the Balkanski Professor of Physics and Applied Physics at Harvard University. He is an internationally recognized scientist and researcher, who leads a vigorous research program in optical physics. He has strong interests in education, science policy, outreach, and the public perception of science. He believes that better science education for all—not just science majors—is vital for continued scientific progress. He devotes considerable effort to education research and finding verifiable ways to improve science education. In 1990 he began developing Peer Instruction, a method for teaching large lecture classes interactively. His book, *Peer Instruction* has been read widely, and his methods have a large following among AAPT members and others nationally and internationally. The impact of Peer Instruction on physics teaching has been significant. In 2006 Eric Mazur helped produce the award-winning DVD, *Interactive Teaching*. He is a Fellow of the Optical Society of America, a Fellow of the American Physical Society, author or co-author of over 200 scientific publications, and holder of 12 patents.

courtesy of Hyperspace Productions, Inc. (mkaku.org)

Klopsteg Memorial Award

Michio Kaku, City College of New York

Physics of the Impossible

Michio Kaku is a theoretical physicist, best-selling author, and a major popularizer of science in mainstream media. He holds the Henry Semat Professorship in Theoretical Physics at the City University of New York (CUNY), where he has taught for over 25 years. His latest book, *Physics of the Impossible: A Scientific Exploration of the World of Phasers, Force Fields, Teleportation, and Time Travel*, made the *New York Times* Bestseller list. He has appeared on the BBC's TV series *Time*, and the History Channel's *The Universe*, and he hosts the radio shows *Science Fantastic* and *Explorations in Science.* Michio Kaku's other books include *Parallel Worlds–A Journey Through Creation, Higher Dimensions, and the Future of the Cosmos; Hyperspace: A Scientific Odyssey Through Parallel Universes, Time Warps, and the Tenth Dimension; Visions: How Science Will Revolutionize the 21st Century and Beyond;* and *Einstein's Cosmos: How Albert Einstein's Vision Transformed Our Understanding of Space and Time.* He's the cofounder of string field theory (a branch of string theory), and continues Einstein's search to unite the four fundamental forces of nature into one unified theory.

Excellence in Pre-College Physics Teaching Award

Mark Davids, Grosse Point South High School

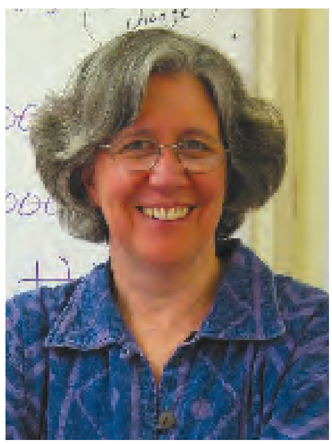
Best Practices

Mark Davids has been a prime mover in the Michigan Section of AAPT, the Detroit Metropolitan Area Physics Teachers, and the Detroit and Michigan Science Teachers Associations. In 2001, he received a Presidential Award for Excellence in Science Teaching from the White House and National Science Foundation. In 2002-03, he served as an Einstein Fellow in the office of Washington's U.S. Senator Maria Cantwell, working on key issues related to education, science, and technology. Recently, he was chosen by the Michigan Science Teachers Association as its 2008 Outstanding High School Teacher. Mark coauthored *Physics: Principles and Problems* with Paul Zitzewitz and Robert Neff, and *Teaching About Lightwave Communications* with Paul Zitzewitz. He developed a curriculum for high school teachers on the physics of cell phones, to reinforce traditional physics topics and introduce students to information theory, all within an exciting context. Mark's workshops have covered Optics and Shadows, Modeling, Lasers—including holography, and other areas. Mark Davids is an enthusiastic teacher with a storehouse of physics demonstrations and great skills as a presenter.

Excellence in Undergraduate Physics Teaching Award

Corinne Manogue, Oregon State University

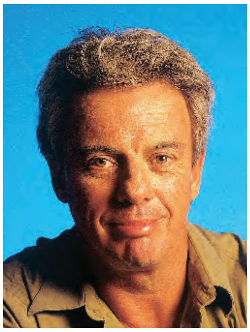
The View From the Other Side of the Mountains: Exploring the Middle Division



Corinne Manogue has been a leader in the development and implementation of the Paradigms in Physics Project at Oregon State University. The goals of this project have been a ground-breaking new upper-division curriculum designed to improve students' analytical and problem-solving skills—emphasizing connections between the fields of physics, and incorporating student-centered activities. Corinne has headed the project, developing junior-year modules on Symmetries and Idealizations, Static Vector Fields, and Central Forces. She also developed the senior-year course, Capstone on Mathematical Methods. After a decade of development and use, the Paradigms project has attracted attention at national meetings of both AAPT and APS in sessions on "Revitalizing Undergraduate Physics." Corinne coauthored an article in *Physics Today* on the Paradigms project, and one in the *American Journal of Physics* on how computational activities are woven into the new Paradigms project courses, which are now being disseminated nationally. She has supervised undergraduate, Master's, and Ph.D. students doing research in physics education.

award winners

2008 AIP Science Writing Award, Broadcast Media Category



Bob McDonald is one of Canada's best-known science communicators. He is in his 16th season as host of *Quirks & Quarks,* Canada's national weekly radio science program. He is also science correspondent for CBC TV's *The National*, and a weekly science commentator for CBC Newsworld. He has won many honors for communicating science, including the Michael Smith Award for Science Promotion from NSERC, and the Sandford Flemming Medal from the Royal Canadian Institute. He has been awarded honorary degrees from three Canadian universities for his work in promoting science.

Pat Senson is a producer with the Canadian Broadcasting Corporation's national radio science program, *Quirks & Quarks*. This is his second time winning the AIP broadcast award, the first was for his look at the physics of time. Physics has always been a secret passion of Pat's, although his scientific credentials lie more in the field of biology, where he honed his scientific skills running many a DNA profile. As well as working behind the scenes at *Quirks & Quarks*, Pat can also be heard weekly across the country on CBC's afternoon shows as their regular science contributor, where he'll discuss anything from the latest discoveries from CERN to the problems of government funding for science. Pat lives in Toronto, Ontario.

Jim Handman has been the Executive Producer of *Quirks & Quarks*, Canada's national weekly radio science program, for the past 9 years. He has been a journalist and radio producer at CBC Radio for more than 20 years. Jim has shared in many awards for science journalism, including the prestigious Walter Sullivan Award from the AGU, and was co-winner of the Science Writing Award from AIP in 2003. He also teaches radio broadcasting at Ryerson University Journalism School in Toronto.

plenary speakers

Plenary Speaker

Robert Wolkow directs research into using scanning tunneling microscopy (STM) and other theoretical methods to examine and control molecules on semiconductor surfaces.

He is a pioneer in STM techniques and instrumentation. At IBM, he pioneered STM for studying surface chemistry. At the NRC Steacie Institute for Molecular Sciences (NRC-SIMS), he and his colleagues used STM and modeling to understand the behavior of organic molecules on semiconductor surfaces. Eventually, they demonstrated self-directed fabrication of organic nano-scaled structures on silicon.

The multidisciplinary Molecular Scale Devices researchers have continued to advance nanoscale structure fabrication, with creation of a single molecule transistor and a reliable method of producing single atom tip probes.

Controlled fabrication of nanoscale structures and devices combining organic chemistry/biological functions with semiconductor-based processors is the goal. Variable-temperature, ultra-high vacuum STM now makes atomic-scale surface chemistry research possible.

Damian Pope is the Senior Manager of Scientific Outreach at Perimeter Institute for Theoretical Physics in Waterloo, Ontario, Canada. He studied in Australia and holds a Ph.D. in theoretical physics from the University of Queensland. After this, he engaged in two years of postdoctoral research in quantum information and the foundations of quantum theory at Griffith University.

Damian also has over a decade of experience in outreach explaining physics to students, teachers and the general public. Most recently, he has been focusing on creating a collection of video-based resources designed to help high school teachers introduce modern physics to their students.

workshops

A Taste of Modeling

A Taste of Modeling is a workshop designed to introduce participants to the modeling method of teaching physics. This workshop is appropriate for physics teachers of all introductory high school physics courses including Physics First. Participants will engage in a sample modeling cycle.

Deborah J. Rice, Rex Rice
Committee on Physics in High Schools

Advanced and Intermediate Instructional Labs

This workshop is appropriate for college and university instructional laboratory developers. At each of six stations, presenters will demonstrate an approach to an advanced or intermediate laboratory exercise. Each presenter will show and discuss the apparatus and techniques used. Handouts will be provided containing sample data and ideas on how to construct or where to purchase the apparatus.

Van D. Bistrow
Committee on Laboratories, Committee on Apparatus

Curricular Materials for Using Visualization in Teaching Introductory E&M

Electromagnetism is one of the most troublesome topics for students to learn. In this workshop, we present an integrated introductory electricity and magnetism curriculum which features three-dimensional visualizations embedded in a guided inquiry environment. Workshop participants will explore a suite of stunning visualizations and will be actively engaged in group work assignments which bridge a pictorial representation to a facet of knowledge.

John Belcher, Carolann Koleci, Sahana Murthy, Peter Dourmashkin, Jennifer George-Palilonis
Committee on Research in Physics Education

Designing a Diagnostic Learning Environment: A Workshop for Teacher Educators

A diagnostic learning environment is one in which assessments are used for formative purposes, i.e., to identify the fine structure of students' understanding and reasoning, and to help the teacher decide which aspects of student thinking might be troublesome so that she/he may address specific student ideas with targeted instruction. Participants of this workshop will experience a diagnostic learning environment and learn about issues that arise in setting up teacher professional preparation programs that are focused on formative assessment. In addition, participants will learn about the Diagnoser Project's free instructional tools to help diagnose pre-college student thinking and guide instructional decisions.

Stamatis Vokos, Lane Seeley and Pam Kraus
Committee on Research in Physics Education, Committee on Teacher Preparation

Effectively Addressing Diversity in Science Courses: Resources and Examples

Engage in four separate activities and leave with an increased awareness of and access to approaches and resources to improve your ability to embrace diversity in your undergraduate and graduate science classrooms. We will work through complex issues of diversity and learn how to address them effectively.

Christine Pfund, Brett Underwood
Committee on Minorities in Physics

EJS and Tipers

TIPERs (Tasks Inspired by Physics Education Research) are a type of problem that is designed to probe student conceptual understanding and help students build their problem-solving skills. Easy Java Simulations (EJS) are modeling and authoring tools that can be used to create dynamical simulations of physical phenomena for teaching. These simulations can be used for computer demonstrations or virtual laboratories, or serve as programming examples and tasks for computational physics. These two pedagogical tools fit together to provide enhanced interactive engagement for students in the classroom. Participants in this workshop will learn how to use and design TIPERs exercises using EJS for their own students.

Tom O'Kuma, Karim Diff, Anne J. Cox
Committee on Physics in Two-Year Colleges

Energy in the 21st Century

Engaging students in predictions of what form and how much energy will be used in the future is a very successful way to generate enthusiasm and further investigation of physics. Participants of this workshop will be introduced to two different group projects that involve designing energy systems. These modeling exercises look at past energy consumption patterns and develop a plan for energy usage in the 21st Century. Other considerations such as population, costs and efficiencies are also used to further expand the discussion and decision-making that takes place.

Pat Keefe, Greg Mulder
Committee on Physics in Two-Year Colleges
Committee on Science Education for the Public

Exploring Atoms & Molecules Using Molecular Workbench

This workshop will focus on using, customizing, and authoring with the Molecular Workbench, a free, open source software environment based on molecular dynamics (http://mw.concord.org). MW is used to create a wide range of learning activities based on the atomic-scale mechanisms of basic phenomena in physics. MW has some unique features including chemical bonding, photon-matter interactions, and smart surfaces, so it can produce a very wide range of

emergent phenomena such as phase changes, latent heat, diffusion, solubility, osmosis, and black body radiation.
Robert Tinker
Committee on Educational Technologies

Exploring Easy and Effective Ways to use PhET's Web-based Interactive Simulations in your Physics Course

The Physics Education Technology (PhET) Project has developed over 65 simulations for teaching and learning introductory physics at the high school and college levels. These research-based simulations create animated, interactive, game-like environments that are designed to engage students in active thinking, encourage experimentation, and help develop visual and conceptual models of physical phenomena, emphasizing their connections to everyday life. The simulations are free, and can be run from the PhET website (http://phet.colorado.edu) or downloaded to a local computer for off-line use.
Katherine Perkins, Wendy Adams, Noah Finkelstein, and Archie Paulson
Committee on Educational Technologies
Committee on Research in Physics Education

Falsification Labs

Verification labs are a staple in many physics courses, but what about falsification? It is important for students to be able to recognize and test wrong ideas as well as right ones. In this workshop, we will present a number of laboratory exercises based on plausible-but-wrong theories which can be tested in a typical lab period. All of the exercises can be performed with minimal equipment, and are appropriate for high school or introductory college physics labs. Participants will have an opportunity to try the experiments, experience some of the pitfalls involved, and develop similar experiments of their own.
Eric Ayars, Tim Erickson
Committee on Laboratories

Historical Experiments in the Classroom

Every experiment in physics education contains an historical perspective that is usually neglected in favor of the practical elements of the experiment. Consequently, students lack a context for the performance of the experiment. In this workshop, we will re-introduce the context of history back into student experimentation with the use of the interrupted storyline. Many examples including Ohm's law and Rumford's experiments on heat will be presented and participants will experiment with simple apparatus.
Donald E. Metz
Committee on History & Philosophy of Physics

Inquiry-Based Learning for High School Teachers

This is a hands-on workshop designed for teachers interested in using curricular materials that will engage their students in inquiry-based active learning. Participants will work with activities from kinematics, dynamics, energy and optics from the updated *Activity-Based Physics High School* CD (ABP HSCD). The curricula on the ABP HSCD include: RealTime Physics, Tools for Scientific Thinking, Workshop Physics and Interactive Lecture Demonstrations.
Maxine C. Willis, Priscilla Laws and Marty Baumberger
Committee on Physics in High Schools

InterActions in Physical Science: A Coordinated Set of Curriculum and Professional Development Materials for Inquiry-Based Middle School Students and Teachers

InterActions in Physical Science is an NSF-supported, standards-based, guided inquiry physical science curriculum that was built using the research on the teaching and learning of science. In this workshop, participants will be introduced to the InterActions curriculum, experience several activities, watch and analyze video from InterActions classrooms, and work through part of the professional development materials that support teachers and help students do inquiry at the middle school level.
Robert H. Poel
Committee on Physics in Pre-High School Education

Introductory Instructional Labs

This workshop is appropriate for college and university instructional laboratory developers. At each of six stations, presenters will demonstrate an approach to an introductory laboratory exercise. Each presenter will show and discuss the apparatus and techniques used. Handouts will be provided containing sample data and ideas on how to construct or where to purchase the apparatus.
Van D. Bistrow
Committee on Laboratories, Committee on Apparatus

Learning Physics While Practicing Science

Participants will learn how to modify introductory physics courses to help students acquire a good conceptual foundation, apply this knowledge effectively in problem solving, and develop the science process abilities needed for real life work. We provide tested curriculum materials including: The *Physics Active Learning Guide* with 30 or more activities per textbook chapter for use with any textbook in lectures, recitations and homework; a CD with over 200 videotaped experiments and associated questions for use in lectures, recitations, laboratories, and homework; and a set of labs with inexpensive equipment that can be used to construct, test and apply concepts to solve practical problems.
Eugenia Etkina, Alan Van Heuvelen
Committee on Physics in Undergraduate Education
Committee on Teacher Preparation

Lecture Demonstrations 1

Topics in this workshop cover the standard first semester of physics instruction from Mechanics to Thermal. The format allows for and encourages interplay between instructors and participants. It is recommended that both Lecture Demonstrations 1 and 2 be taken as this will cover the complete year of demonstrations needed for a typical course.
Dale Stille, Sam Sampere
Committee on Apparatus

Lecture Demonstrations 2

Topics in this workshop cover the standard second semester of physics instruction from Electricity & Magnetism through Modern Physics with some Astronomy. The format allows for and encourages interplay between instructors and participants. It is recommended that both Lecture Demonstrations 1 and 2 be taken as this will cover the complete year of demonstrations needed for a typical course.
Dale Stille, Sam Sampere
Committee on Apparatus

Low Cost High School Physics Labs

These experiments will employ everyday items or equipment you already have gathering dust in your storeroom. We will make pieces of equipment during the workshop that you can take home with you. The labs will cover many topics from waves to electricity to mechanics.
Diane Riendeau, Shannon Mandel and Jim Hicks
Committee on Physics in High Schools

Mining the Hidden Web

In this digital age, skill in evaluating the information one finds on the Internet is essential. This tutorial is designed to give participants guidelines for fast, efficient searching of the Internet.
Pat Viele
Committee on Professional Concerns
Committee on Physics in Undergraduate Education and Committee on Graduate Education in Physics

New Physics at the LHC and in your Classroom

The Large Hadron Collider (LHC) at CERN is already ramping up. With a center-of-mass energy of 14 TeV, it is expected to produce new science at the frontiers of particle physics. High school teachers and students can and should be involved in ways that enhance classroom learning. In this workshop, you will learn about LHC physics and about LHC-related investigations that you can bring to your students. The emphasis will be on what can work in your classroom so that students are exposed to particle physics at the horizon of new discovery in a way that engages the very skills, methods, and concepts that you cover in class.
Kenneth Cecire, Kris Whelan
Committee on Physics in High Schools

Newtonian TIPERs

This workshop will deal with various alternative task formats that can be used to make instructional materials which impact and improve student learning and understanding of physics concepts in mechanics. The first part of the workshop will explore various formats, their characteristics, and how they can be used. Participants will work in groups to develop a set of TIPERs that address a concept, principle, or relationship in mechanics. These TIPERs sets will be shared with and critiqued by the group.
Curtis J. Hieggelke, Steve Kanim
Committee on Physics in Two-Year Colleges
Committee on Research in Physics Education

Open Source Physics-Statistical and Thermal Physics

This workshop presents recently developed computer-based curricular material that helps to improve the understanding of statistical and thermal physics concepts and that makes many inaccessible topics accessible to students. Participants will receive a CD containing curricular material from the Statistical and Thermal Physics (STP) project as well as a collection of ready to run Java programs from the Open Source Physics (OSP) project. We will discuss the general pedagogical and technical issues in the design of interactive computer-based tutorials as well as how OSP programs can be adapted to your local institution.
Wolfgang Christian, Mario Belloni, Anne Cox, Harvey Gould, Jan Tobochnik
Committee on Educational Technologies
Committee on Physics in Undergraduate Education

Pedagogical Content Knowledge

Lee Shulman identified pedagogical content knowledge (PCK) as a necessary component of teacher knowledge—a blend of content and pedagogy that distinguishes the understanding of a content specialist from that of the pedagogue. PCK involves knowing students' original ideas and potential difficulties, alternative ways to represent those ideas, and various effective instructional and assessment methods within a particular discipline. In this interactive workshop participants will tackle these questions, reflect on their own PCK and develop some strategies for incorporating the building of teacher PCK into their physics courses, methods courses, and teacher preparation programs.
Eugenia Etkina
Committee on Teacher Preparation

Photon Quantum Mechanical Labs

This is a workshop aimed at introducing the theoretical and the practical aspects of a new type of experiments with correlated photons that we have developed. The experiments illustrate fundamental concepts of quantum mechanics at the undergraduate level. This four-hour workshop will involve

discussions on the fundamentals of the experiments and our experience in implementing them for curricular purposes. It will include a discussion on equipment and costs.
Enrique J. Galvez, Mark Beck
Committee on Apparatus, Committee on Laboratories

Physics and Performance

Stanley Micklavzina has been incorporating dance, circus art, poetry, music, and storytelling into public physics demonstration shows. Wendy Sadler runs her own science communication company in the UK called Science Made Simple, promoting physics and engineering to schools and public audiences. Acting coach Colin Funk is well known for his ability to artfully assist individuals, teams, and organizations to enhance their capacity for creativity and innovation. This workshop will be aimed at developing skills, ideas, and themes for the stage.
Stanley J. Micklavzina, Wendy Sadler and Colin Funk
Committee on Science Education for the Public

Physics and Toys II: Energy, Momentum, Electricity and Magnetism

More than fifty toys will be demonstrated, and the physical principles related to these toys will be discussed. This workshop will concentrate on toys that illustrate the concepts of kinetic and potential energy, linear and angular momentum, electricity and magnetism, pressure and temperature, and properties of materials.
Beverley A. P. Taylor, Ray Turner
Committee on Physics in Pre-High School Education
Committee on Science Education for the Public

Physics Front: Capabilities and Possibilities.

The Physics Front offers K-12 teachers a place online to find and share high-quality physics teaching resources including lesson plans, labs, simulations, and reference materials. All these materials are organized by subject, grade level, and course type. This web site also gives teachers the tools to collaborate and share expertise. Topics covered in this workshop will include: collecting, organizing, and sharing resources from the collection; submitting new resources; navigating and building Physics Front topical units; and Physics Front discussions, comments, and reviews.
Cathy Ezrailson, Caroline Hall
Committee on Physics in High Schools

Piaget beyond Piaget: at the heart of inquiry

In the late 1970s the first AAPT workshop introduced applications of Piaget's ideas to physics teaching. This workshop will draw the participant directly into Piaget's theory of cognitive development, how people develop in their understanding of the world. The participant will learn about Piaget's equilibration theory. In the style of his experimental method, participants will examine classroom evidence of student understanding of physical phenomena. Instructional practices consistent with the theory and evidence of their effect will be considered.
Dewey I. Dykstra, Jr.
Committee on Physics in Pre-High School Education
Committee on Teacher Preparation

Preparing Pre-College Teachers to Teach Physics by Inquiry

This workshop focuses on how college and university physics faculty can contribute to the professional development of pre-college (K-12) teachers. Participants will have an opportunity to gain hands-on experience with Physics by Inquiry, instructional materials designed to provide teachers with the background needed to teach physics and physical science as a process of inquiry. Excerpts from a video produced by WGBH will be used to illustrate interactions between teachers and instructors during a course based on these instructional materials.
Lillian C. McDermott
Committee on Research in Physics Education
Committee on Teacher Preparation

Research-Based Alternatives to Problem Solving in General Physics

Accumulating research on problem solving in physics clearly indicates that traditional, end-of-chapter exercises in physics texts are not useful and may actually hinder students' learning of important physics concepts. The research also raises questions about the efficacy of such tasks for helping students develop "problem solving skills." In light of these results the question is: What alternative tasks can we use to help students develop problem solving skills and a conceptual understanding? This workshop will review the research and then provide examples of several alternative tasks and their use. Participants will also get practice writing alternative problems for use in their own classrooms.
Kathleen A. Harper, Thomas M. Foster and David P. Maloney
Committee on Research in Physics Education

Teaching Astronomy with Technology

This workshop will survey a variety of educational technologies useful for engaging students in both high school and introductory college classrooms. Special emphasis will be placed on simulation usage and peer instruction. Participants will work on computers gaining familiarity with the astrophysical simulations of the Nebraska Astronomy Applet Project (NAAP) and its web-based assessment capabilities. Participants will also design peer instruction sequences to be used in the classroom using the computer-based modules of the ClassAction Project.
Kevin M. Lee, David Kriegler and Todd Young
Committee on Space Science and Astronomy

TELS—an Online Inquiry-Based Environment for Modeling and Simulation

Appropriate for both high school honors, AP, IB and introductory college courses, the TELS modules are based on an extensive research base in using visualization to help students learn abstract topics in science. Modules in high school chemistry and middle school physical science will also be showcased.

S. Raj Chaudhury
Committee on Educational Technologies

The Classroom of the Future: Human Interaction in an Age of Technology

Participants take part in five "miniclasses": 1. Use of reflective writing to engage students before class. 2. Critical thinking—Feyerabend's view. 3. Use of collaborative groups to promote critical thinking. 4. Critique: a writing tool to enhance critical thinking skills. 5. The course dossier—a supplement to or a replacement for a final essay/examination.

Calvin Kalman
Committee on Physics in Undergraduate Education
Committee on Research in Physics Education

Tutorials in Introductory Physics: A Research-Based Approach to Increasing Student Learning

Tutorials in Introductory Physics is a set of instructional materials intended to supplement the lecture, textbook, and laboratory of a standard calculus-based or algebra-based introductory course. The tutorials are designed to address specific conceptual and reasoning difficulties that have been identified through research. In addition to providing hands-on experience with the curriculum, the workshop will include discussions of instructional strategies and results from assessments of student learning. Important aspects related to implementation of the tutorials will be covered, including preparation of graduate teaching assistants, undergraduate peer instructors, and post-docs. Copies of Tutorials in Introductory Physics will be provided to participants.

Lillian C. McDermott
Committee on Research in Physics Education

Using Authentic Data to Teach Astronomy

Today, a number of astronomical projects are making their data available over the Internet; this allows students to access the data at any time with only a high-speed Internet connection. We have developed a series of interactive labs that use data from a map of the universe to teach basic concepts in astronomy, physics, and chemistry. In this workshop, you will learn how to use these labs with your students. You will also have the chance to conduct open-ended astronomy research using authentic data.

Michael J. Raddick
Committee on Space Science and Astronomy

Using Research-Based Curricula and Tools to Revitalize Your Introductory Course

We will introduce new approaches to teaching based on physics education research (PER) in lectures, labs, and recitations as well as studio and workshop environments. Among the approaches presented will be Interactive Lecture Demonstration (ILDs), Web-Based ILDs, RealTime Physics Labs, Activity Based Tutorials, Collaborative Problem-Solving Tutorials, Live Photo Assignments and Workshop Physics, as well as analytic modeling and video analysis tools. Results of studies on the effectiveness of these teaching strategies will also be presented.

David R. Sokoloff, Ronald Thornton and Priscilla Laws
Committee on Research in Physics Education
Committee on Educational Technologies

Using RTOP to Improve Physics and Physical Science Teaching

The Reformed Teaching Observation Protocol (RTOP) is a 25-item rubric that provides a percentile measure of the degree and type of student-centered, constructivist, inquiry-based engagement in an instructional situation. RTOP scores correlate very highly with student conceptual gains. In this workshop, we will score video vignettes of teaching to learn how to use RTOP for guiding personal reflection and improvement and change of our own teaching; for mentoring peers, novice teachers and student teachers; and to establish a vocabulary for discussing reformed teaching practices. If you wish, you may bring a DVD of your own teaching to score.

Kathleen A. Falconer, Paul Hickman and Dan MacIsaac
Committee on Teacher Preparation
Committee on Physics in Undergraduate Education

What Every Physics Teacher Should Know About Cognitive Research

In the past few decades, cognitive research has made major progress in understanding how people learn. We will discuss and explore, in a language accessible to everybody, how the main findings of cognitive research can be applied to physics teaching and assessment.

Chandralekha Singh
Committee on Research in Physics Education

sessions

Committee on Research in Physics Education

Disseminating results and resources in physics education
Leon Hsu
Co-sponsor: Committee on Physics in Undergraduate Education

Down from the Ivory Tower: Physics Teachers and Education Researchers as Activists
Melissa Dancy

Getting Started in Physics Education Research
Kathleen A. Harper and Charles Henderson

Learning to Think Like a Physics Education Researcher (a session to honor Alan VanHeuvelen)
Xueli Zou and Kathy Harper
Co-sponsor: Committee on Physics in Two-Year Colleges

PERC Bridging Session
Mel Sabella, John Thompson and Nicole Gillespie

Professional Concerns of PER Faculty
Tom Foster
Co-sponsor: Committee on Professional Concerns

Professional Concerns of PER Graduate Students
Trevor Smith and Mary Bridget Kustusch
Co-sponsor: Committee on Professional Concerns

Professional Concerns of PER Solo Faculty
Paul Engelhardt
Co-sponsor: Committee on Professional Concerns

Transforming University Physics Departments
Charles Henderson and Melissa Dancy

Tutorial: Interactive Lecture Demonstrations
David Sokoloff and Ronald Thornton
Co-sponsor: Committee on Educational Technologies

Tutorial: Tutorials in Intermediate Mechanics
Bradley S. Ambrose
Co-sponsor: Committee on Physics in Undergraduate Education

Committee on Science Education for the Public

Alternative Energy
Richard Flarend

Bringing Science to the Public
Brian Jones
Co-sponsor: Committee on Apparatus

Cracker Barrel: Physics and Society Education
Jane Flood

Energy and Environment
Steve Shropshire

Hollywood and Science Literacy
Costas Efthimiou

K-12 Partnerships and Community Outreach
John L. Roeder

Committee on Physics in Undergraduate Education

Gordon Research Conference Session: Computation in the Physics Curriculum
Bradley S. Ambrose and Wolfgang Christian

PER Issues in Instructional Reform

PER Assessing Student Understanding

PER Content and Problem Solving

Rethinking the Upper-Level Curriculum
Ernie Behringer
Co-sponsor: Committee on Laboratories

Scientific Communication and Writing
Jean-Francois Van Huele
Co-sponsor: Committee on Science Education for the Public

Teaching and Learning Upper-Level Electricity and Magnetism
Ernie Behringer

The Art and Science of Teaching
Ray A. Burnstein
Co-sponsor: Committee on Research in Physics Education

Undergraduate Student Research
Gary White

Undergraduate Student Research (Poster)
Gary White

Committee on Physics in Two-Year Colleges

Favorite Activities/Lessons in the TYC Physics Classroom
Dwain Desbien

High Energy Physics Projects for High School and Two-Year College Students
William Waggoner

College Physics
Paul D'Alessandris

Physics of Our Hobbies
Scott F. Schultz

Committee on Physics in High Schools

Alternative and Formative Assessment in High School Physics
Wayne Fisher and Laura Nickelson

Curriculum Design, Improvement and Implementation: Reports By CASTLE Teachers
Melvin Steinberg

Professional Concerns of High School Teachers
Patrick Callahan
Co-sponsor: Committee on Professional Concerns

State of Physics Teaching in the United States: A High School Perspective
Dale Freeland

Middle School and High School Training Strategies
Patrick Callahan

Voices from the Classroom: Past, Present, and Future
Shannon Mandel

Committee on Teacher Preparation

AP Physics B Redesign Update
Ingrid Novodvorsky
Co-sponsor: Committee on Physics in High Schools

Culturally Responsive Physics Teaching
Ingrid Novodvorsky

How do Master Teachers Help Prepare Teachers of Physics?
Paul Hickman

NSF-Supported Projects in the Preparation of Physical Science Teachers
Fred Goldberg

Use of Research-Based Physics Curricula in Teacher Preparation
Ingrid Novodvorsky and Eugenia Etkina

Physics Teacher Preparation Around the U.S.
Ted Hodapp and Monica Plisch

Committee on Educational Technologies

Best Practices for Teaching with Technology
Tim Erickson

Clickers in the Classroom
S. Raj Chaudhury

Educational Technology
Vern Lindberg
Co-sponsor: Committee on Apparatus

There Ought to Be... (Technologies I Wish I Had)
Leon Hsu

Committee on Women in Physics

Canadian Women in Science
Marina Milner-Bolotin

Committee on Minorities in Physics

Cracker Barrel: Recruiting and Retaining Underrepresented Minorities in Physics
Daryo S. Khatri

Committee on History & Philosophy of Physics

Historical Experiments in Physics
Zoltan Berkes
Co-sponsor: Committee on Apparatus

Committee on Graduate Education in Physics

Hot Topics in GeoPhysics
Steve Turley
Co-sponsor: Committee on Women in Physics

Reports from the Conference "Graduate Education in Physics: Which Way Forward?"
Michael Thoennessen

Committee on Laboratories

The Future of Upper Division Lab Experiences
David Abbott

Incorporating Writing in the Laboratory
Marsha M. Hobbs

Committee on Space Science and Astronomy

400 Years Since Galileo
Susana Deustua and Jordan Raddick
Co-sponsor: Committee on History & Philosophy of Physics

Innovations in Teaching Astronomy
Janelle M. Bailey and Doug Lombardi

Seeing the Universe Without Our Eyes
Louis J. Rubbo

Web Resources for Teaching Astronomy—Cracker Barrel
Kevin Lee
Co-sponsor: Committee on Educational Technologies

Committee on International Physics Education

PER Around the World
Genaro Zavala
Co-sponsor: Committee on Research in Physics Education

Teaching Physics Around the World
Genaro Zavala

Committee on Apparatus

Physics Demonstrations with a Biological Flavor
Steven Wonnell

PIRA Resource Room
Wayne Easterling, PIRA Vice President,
PIRA officers and Resource Room Committee

Professional Concerns of Instructional Resource Specialists
Dean Hudek
Co-sponsor: Committee on Professional Concerns

International Physics and Education

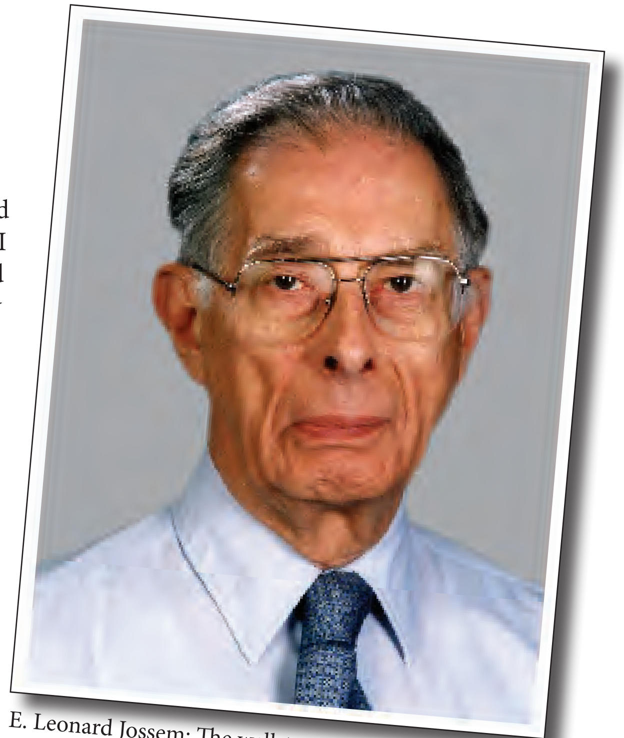
Interview with E. Leonard Jossem

By Daryl Malloy

Born in Camden, NJ, May 19, 1919, Dr. E. Leonard Jossem received his B.S. in Physics from C.C.N.Y. in 1938. During World War II he was a member of the scientific staff at Los Alamos in the Advanced Developments Division. He received his Ph.D. from Cornell University in 1950 for his research on experimental condensed matter physics. In 1956 he joined the physics faculty at The Ohio Sate University.

In 1995 he was awarded the International Commission on Physics Education Medal for Excellence. He is an editor of the International Commission on Physics Education books *Connecting the Results of Research in Physics Education with Teacher Education* and *Physics 2000: Physics as It Enters a New Millennium*.

He has been a consultant for UNESCO projects in Thailand, and a consultant for the World Bank-Chinese University Development Project in China. He holds honorary professorships in Physics at Beijing Normal University, at Beijing Teachers College, and at Southeast University in Nanjing, China.



E. Leonard Jossem: The well-traveled physicist

Given your decades of experience with international collaboration in physics and physics education, how would you characterize its importance and usefulness to physics teachers in the United States?

To begin with, I would paraphrase Saint Augustine and say that the world is a book and those who know only about their own country read only one page.

In physics itself, the names of the units we use: Ampere, Becquerel, Coulomb, Faraday, Fermi, Gauss, Hertz, Joule, Kelvin, Maxwell, Newton, Oersted, Ohm, Pascal, and Watt, remind us of the contributions of physicists in other countries. In 1990, *Physical Review Letters* took note of the fact that it had had more submissions from outside the United States than from within. Similarly, in 1997 the journal editors at the American Physical Society consulted more referees from outside the United States than from within. The LHC —the world's largest high energy accelerator—is an international project at CERN in Geneva, Switzerland.

There is an old Japanese proverb, "There are no national frontiers to learning." Especially in the Information Age, physics research knows no national borders.

The situation with physics education is a bit more nuanced by the social facts that there are many different languages and many different educational systems in the world; and that K-12 educational systems deal with young, relatively inexperienced students. However, at all levels the basic educational questions remain the same the world over: Who do we teach? What do we teach them? How do we teach it? How can we help them to learn? How do we know if they have learned it and are able to use the knowledge independently?

In answering such questions the ideas and insights that can be gained from societies other than our own can serve to broaden and stimulate our own thinking.

International concern with the problems of physics education has a long history. The International Union of Pure and Applied Physics (IUPAP) established the Commission on Physics Education (ICPE) in 1960 "To promote the exchange of information and views among the members of the international scientific community in the general field of Physics Education."

Since 1945, UNESCO has been sponsoring conferences and workshops in science education. Regional associations such as the European Physical Society (EPS), The International Research Group on Physics Teaching (GIREP), The Asian-Pacific Physics Education Network (AsPEN), The InterAmerican Council on Physics Education (IACPE), the Latin American Physics Education Network (LAPEN), and others are all active in sponsoring conferences and workshops on physics education and have websites that are very accessible.

Since the first in 1960, there have been more than 80 international conferences on physics education that I know of. Although AAPT has sponsored a few of them, and the AAPT Committee on International Education holds sessions on *Teaching Physics Around the World* at AAPT National Meetings and provides information about upcoming international conferences, relatively few physics teachers in our country take advantage of the resources such conferences provide. There are also websites and listservs which allow interactions with physicists and physics teachers in other countries.

In short, there is a tremendous set of resources available outside the United States, and there is much to be gained by personal interactions with colleagues in other countries.

In your experience, how does geopolitics affect international collaboration and knowledge transfer? Also, is scholastic censorship and isolationism ever justified for political reasons?

The international scientific community is very clear on these issues. I would refer you to the statements—too long to reproduce here—of ICSU on the "Freedom in the Conduct of Science" and "Universality of Science in a Changing World," and to the APS statement on "The International Nature of Physics and International Cooperation," which are available on their respective websites. The UNESCO document, "Universal Declaration of Human Rights," is more general, but also pertinent.

What can, or should, organizations like AAPT do to reach across international boundaries to foster collaboration and cooperation?

AAPT has an active Committee on International Education, which does good work, and AAPT has on occasion acted as a sponsor or co-sponsor of international conferences, most notably for the three U.S.–Japan–China Conferences on Physics Education. It should certainly continue such activities.

AAPT can cooperate with other organizations, for example, APS and AAAS (American Association for the Advancement of Science) in advocating changes in current visa policies which tend to discourage colleagues and students in other countries from visiting the United States.

With the single exception of Canada, the items in the AAPT website "Links to Physics and Related Organizations" are all to U.S. organizations. It would be profitable to add another heading entitled "International" to this site. There are many excellent links that would fit there.

AAPT can encourage individual members traveling abroad to interact with peers elsewhere by providing lists of contact persons in other countries. Δ

Dr. E. Leonard Jossem is Professor of Physics, Emeritus, in the Department of Physics of The Ohio State University. He is a former president of AAPT.

Resources on International Physics Education

1. CERN (www.cern.ch/)
2. IUPAP (www.iupap.org/)
3. ICPE (http://web.phys.ksu.edu/ICPE)
4. UNESCO at (http://unesco.org)
5. European Physical Society (www.eps.org)
6. GIREP (www.girep.org)
8. IACPE (www.physics.ohio-state.edu:/~aubrecht/IACPE.html)
9. LAPEN (www.lapen.org)
10. APS (www.aps.org)
11. ICSU (www.icsu.org) [Editor's note: Go to "Resource Centre," place cursor on "Statements," then click on "ICSU" for list of position statements.]

Walls Tumbling Down

Open access to physics research aims to remove the barriers to scientific knowledge

By Ken Peach

The Internet has revolutionized the way we share information. The Web allows for the dissemination of knowledge on a wider and far more interactive scale than was possible with the printed page. What we now need to consider is how this new, and potentially disruptive, technology affects the dry world of academic publishing. And, because this is a new technology, we need also to consider how the new capabilities can be exploited.

The open access movement in scientific publishing is a response to the challenges of this new technology. It allows anyone in the world to find and read peer-reviewed, scientific research articles, and to use their contents in the course of scholarship, teaching and personal inquiry. The movement has inspired great support throughout the scientific community, because it frees access to knowledge and, as a result, accelerates the pace of discovery. In some ways, it is the Internet equivalent of the Free Public Library movement in the late 19th century, endowed by Andrew Carnegie and others, which allowed access to knowledge and literature to all, whatever their circumstances. However, the library is a very limited form of "open access," whereas open access on the Web is in principle available world-wide.

The challenge of Internet publishing is how to guarantee the quality of the work.

As John Naughton wrote in the July 23, 2000, *The Observer* "because any fool can create an e-commerce website, many fools do." This means that, unfortunately, the general public will have greater access to rumors about the discovery of, say, the Higgs boson than to peer-reviewed research conducted in the service of this ongoing quest. The traditional subscription publishing model in physics creates barriers to the discovery process in research through the retention of exclusive copyrights by publishers, who derive their income from subscriptions, which is in effect a tax on access. Of course, the costs of publishing have to be covered, and this is usually through a publication charge, which should be seen as part of the research costs. This could mean that there is a bias in favor of publication, since each published article represents income. However, this is unlikely to happen—publishers need to create high quality, high impact journals, and this would be hopelessly compromised if standards were lowered to generate income.

There is a second consideration. Very often, the research has been paid for by the taxpayer, and yet the taxpayer must pay again to read the results of the investment, Open access journals allow anyone—the professional researcher, the journalist, the curious, and the student—to read and learn about the research.

One feature of the traditional publishing model that must be retained is the process of rigorous peer review, which is the guarantee of quality. It is, of course, an imperfect process, but we have so far not devised anything better. It might be that, when the open access publishing model is more pervasive, new methods of quality control could be developed, for example, open review comments about articles.

However, it is now clear that peer reviewed research published through open access platforms is just as sound as that in print; further, successful business models for open access publishing have emerged. In addition, funding agencies around the world are now heeding the call to open up access to research by mandating that research supported by their funds be freely available online through open access resources.

In biomedical research, where open access publishing has seen the greatest amount of acceptance so far, over 90 percent of all UK-funded medical research funding agencies now have some sort of open access publishing requirement. The trend is catching on in the United States as well. The Howard Hughes Medical Institute, the second largest funder of medical research in the U.S., also has an open access policy. In addition, as of April 7, 2008, voluntary compliance with the National Institute of Health's (NIH) public access policy became mandatory for all peer-reviewed articles resulting from NIH-funded research.

Such mandates are becoming the rule in the world of physics research publishing as well. In November 2006, at the same time that many of the other open access mandates discussed here were being developed or implemented, CERN (the Euopean Centre for Particle Physics in Geneva, Switzerand), the world's largest particle physics laboratory, encouraged open access archiving for all work carried out using its facilities. As a result, CERN's Institutional Repository is in the process of housing and providing open access to all of CERN's own current published research article output. The organization is archiving and providing access to previous research as well. CERN has also set up an international consortium, the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP3), to pay fees associated with publishing open access research.

Other funding agencies for physics research are expected to follow CERN's lead in the near future. Open access publishers are also taking CERN's lead and offering new open access publishing outlets for physics research. In addition, these publishers are leveraging the power of the Internet by incorporating multimedia enhancements to research and offering blogs and wikis that add value to the research presented.

the public have access to the physics research funded either directly or indirectly with public monies.

Those publishing platforms will likely be designed to accommodate needs specific to the physics community. Recognizing the central role of arXiv.org, the article preprint service set up in the early 1990s, the PhysMath Central platform is providing a two-way integration with arXiv that allows authors to submit from arXiv, but also to deposit their research into arXiv as part of a single submission process. There are also a number of other features (such as standard TeX typesetting templates popular among physicists, uploads for author collaboration groups and use of Physics and Astronomy Classification Scheme codes), which are intended to cater to the specific needs of scientists in these fields. This is in addition to other online features such as reader comments on an article, and the use of multimedia to demonstrate specific phenomena.

Finally, publishers who adopt a full open access platform will publish physics research under Creative Commons licensing. Creative Commons licensing explicitly allows and encourages reuse, redistribution, and the creation of derivative works such as databases or search engines. Such licensing strategies will free physicists' work from the copyright constraints of the traditional publishing model that give the publisher sole ownership of the research article and prevent its results from being utilized to its full extent by the scientific community.

by bringing a sustainable open access publishing model to physics, open access publishers and their advocates are aiming to change the way scientific research will be published…

For example, BioMed Central, the world's largest publisher of peer reviewed, open access scientific research, has recently expanded the range of the open access research it publishes with its new venture, PhysMath Central. The independent publishing platform, based on the successful open access model created by the company, publishes original peer-reviewed research in physics and mathematics and is now accepting submissions for its first series of journals. PhysMath Central has created a journal series that covers particle and nuclear physics, cosmology, gravity, astroparticle physics and instrumentation and data analysis; condensed matter, atomic, molecular and quantum physics; soft-matter and nonlinear physics.

Another rapidly growing open access publisher of scientific research, Hindawi Publishing Corporation, is also now offering a high energy physics journal. In addition, the company is planning journals that cover such areas as astronomy, gravitational physics, atomic and molecular physics, and condensed matter physics. Other open access and traditional publishers are expected to get into the business of open access publishing as more funding organizations and governments mandate that

By bringing a sustainable open access publishing model to physics, open access publishers and their advocates are aiming to change the way scientific research will be published in the near future. Increased access to peer-reviewed research will be particularly fruitful for developing nations as they can access the latest research unhindered by subscription or copyright concerns and can help accelerate change in the way science is advanced around the world.

Open access publishing is here to stay. The challenge is to create viable publishing models that preserve the best of the academic publishing traditions while allowing the power of the internet to be harnessed for the public good. Δ

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From Iran With Love of Physics

By Zahra Baqheri


Mahmood Hesabi: Father of Iranian Physics

I am reading the biographies of early Iranian scientists, all of them pioneers in physics, mathematics, chemistry, astronomy and other fields. An Iranian scientist discovered alcohol, another invented algebra. I close the book and think, "Oh my God! For more than 1,000 years Iran has produced many important scientists."

I look at the picture of Professor Mahmood Hesabi sitting on my desk: I will be a physicist one day too. Professor Hesabi is honored as the "Father of Iranian Physics," and among his many contributions are the sensitivity of photoelectric cells and his famous theory on continuous particles, about which Einstein is said to have remarked: "In the near future your theory will make a vicissitude in physics."

I will do my best in order to add my name to such a long list of renowned Iranian scientists. I started seven years ago at a high school in Tehran, the capital city of Iran. At 7:30 a.m. I sat in a classroom waiting for the physics teacher to arrive. Moments later the teacher walked in, looked around, and without introducing herself or asking for students to give our names (something I assumed all new teachers do when they enter a classroom for the first time) she started to tell a story about an experiment she did when she was our age. It did not take long for me to realize that she was not like other teachers.

Her stories became a regular part of our instruction. She had a real-life or a fictional story for each topic, and sometimes she played the role of some physical element. For example, when she taught about resistors, she'd asked us to "imagine quite a few dwarves living in this wire which we use in our circuit. As the switch is closed, the dwarves, which were sleeping, awake and form obstacles for the electrons with their hands." Then, she'd play act the role of a dwarf, and all the students would laugh.

Because the teacher used funny examples and analogies, we were able to understand the concepts without a hitch. She made physics interesting—we became enthusiasts. Four years later, 10 out of the 24 students in that class were accepted by universities as physics majors, though it is common for students in my country to major in engineering. (Also, two students from that physics class competed in the International Physics Olympiad.)

In Iran high school students are classified into five groups: 1) mathematics and physics, 2) biological sciences, 3) literature, 4) arts, and 5) technical students. Obviously, the first group take the most math and physics courses.

Generally, high school physics covers different topics such as motion in one and two dimensions, Newton's Laws, energy, fluids, oscillations, thermodynamics, electric charges and Coulomb's Law, magnetic fields, capacitance, DC circuits, Faraday's Law, and optics. Students take calculus during their final year in high school and during their first and second semesters at the university.

Based on an informal survey of my friends who are studying physics at the other universities in Tehran, the majority of undergraduate students studying physics are girls (in my class there were 29 girls and 16 boys.) At the master's level, we are of equal number. Unfortunately, at the Ph.D. level there are far more men.

Often, the top student in an undergraduate class is a girl. But to be honest, I should add that when I discuss physics problems with boys, they seem to analyze the problem better than most girls. I think boys study their favorite subjects more, so their scores are lower in their other courses.

On the other hand, most of our professors are men, suggesting that boys who receive a degree in physics are more successful, compared with girls. Most Iranian scientists are men, but women physicists teach in a way that makes physics truly amazing, like my dear high school teacher who encouraged my interest in physics.

Another source of encouragement is news stories in Iran and all over the world about advances in science and technology through physics research. Today physicists are well respected in our society because of the many recent improvements.

Actually, studying physics has been my dream since childhood. During the summer, I would lie on the grass in a garden outside the city and stare at the stars and try to identify the constellations. I wanted to discover and attain the world's mysteries, the keys to which are found in physics. Δ

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The Global Physics Department

Academic Hires Are Not All Home Grown

By Rachel Ivie and Patrick Mulvey

In the academic year 2005-06, physics departments in U.S. colleges and universities hired 600 faculty members, with 361 of them coming in as tenured or tenure-track. Physicists who teach and do research in U.S. colleges and universities have varied backgrounds. Faculty members hired by Ph.D.-granting departments have a different profile from those hired by bachelor's-granting departments. The accompanying table is based on those faculty members hired into tenured and tenure-track positions in the academic year 2005-06. Thirty-five percent of new faculty members in Ph.D.-granting departments earned their Ph.D.s at a university outside the U.S.. Even at bachelor's-granting departments, one in eight new faculty members earned their Ph.D.s abroad.

Background of New Physics Faculty, 2005 and 2006.*

	Highest Degree Offered by Department	
	Ph.D. (%)	Bachelor's (%)
Earned Ph.D. in U.S. within last 5 years	31	62
Earned Ph.D. outside U.S., any year	35	13
Earned Ph.D. in U.S. > 5 years ago		
Previous Employer		
U.S. Academic Institution	27	20
Industry, National Lab, other	7	5

AIP Statistical Research Center: 2006 AWF Survey

*Includes permanent non-tenured faculty at schools without tenure, and tenured and tenure-track faculty at other schools.

This is an undercount of the representation of foreign-born among all physics faculty members. Some came to the U.S. as graduate students and subsequently became naturalized, while some immigrated to the U.S. at earlier ages. Non-U.S. citizens currently account for about half of the physics graduate students enrolled in U.S. universities, and about 7 percent of the physics majors studying at the undergraduate level. Physics is a global enterprise, and this is nowhere more true than in U.S. physics departments. Δ

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