FORUM on EDUCATION

of The American Physical Society
Spring 2002

The Physics Major: An Endangered Species?

Jack M. Wilson

In 1999, the last year for which complete data has been made available by AIP, the absolute number of physics majors reached the lowest point since the end of the 1950s. If this is not shocking enough, then it could be compared to the nearly four-fold increase in the total number of bachelor's degrees over this period. By any measure the health of U.S. undergraduate physics degree programs is precarious. A quick look at the trends by type of institution reveals that the trend line for primarily undergraduate institutions has remained relatively level over the last four decades while the undergraduate degrees granted by doctoral and master's degree institutions has declined to approximately half the value of 1970. [1]

These trends are not an accident. They are the inevitable result of the programs and practices of physics departments over the last four decades. As noted in the 1998 APS sponsored report on Challenges in Physics Education [2]:

> *"Departments generally justify their existence to university officials on two grounds: 1) the excellence of their graduate programs and their ability to attract large amounts of outside research funding and 2) the large number of student credit hours produced by the introductory level service courses in physics."*

The relative weighting of the two criteria depends critically on the kind of institution. The Carnegie Research 1 and 2 and Doctoral 1 and 2 Institutions (Doctoral-Granting in the former Carnegie Scheme) focus on item one to a greater extent while the comprehensive universities and colleges, the liberal arts colleges and the two year (or associate granting) colleges put the greater emphasis on the second criterion.

When ABET changed the accrediting requirements for engineering programs to effectively eliminate a requirement for physics, it sent shock waves through the physics community as the second of the two pillars of physics support was suddenly called into question. Research funding (in constant dollars) for physics has remained essentially flat over the last three decades while the life sciences have nearly quadrupled.[3] Again: that is quadrupled in

(Continued on page 2)

IN THIS ISSUE

(Continued from page 1)
constant dollars! This dramatic shift in emphasis in research has weakened the first pillar of physics support.

If undergraduate physics courses were popular with students, then these trends might be easily reversed, but they are not. Sheila Tobias painted an unflattering picture of the introductory physics course in her 1990 book, "They're not dumb, They're different." The Boyer Commission on Educating Undergraduates in the Research University chaired by Shirley Strum Kenney, President of SUNY Stony Brook, was no less critical. Their report: "Reinventing Undergraduate Education" [4] suggested that:

> *"Nevertheless, the research universities have too often failed, and continue to fail, their undergraduate populations. Tuition income from undergraduates is one of the major sources of university income, helping to support research programs and graduate education, but the students paying the tuition get, in all too many cases, less than their moneys worth."*

Bob Park in the APS "What's New" on line newsletter drolly remarked [5]:

> *"'Untrained teaching assistants groping their way . . . tenured drones who deliver set lectures from yellowed notes,' anybody we know? A report released by the Carnegie Foundation for the Advancement of Teaching bluntly accused the Nation's research universities of false advertising."*

I could go on and on by citing additional work that documents the need for improvement in undergraduate science teaching and in particular in physics teaching, but that has been done far too often.

The more interesting question is: why this situation has prevailed for decades? (Some of my retired colleagues would insist that this has been going on for a century.) The Physics Community is widely admired for the excellent work that we have done in research in physics education. We have come a long way in our understanding of how students learn physics. Physics has also pioneered some widely adopted course models based upon physics education research such as Workshop Physics, Studio Physics, Peer Teaching, and so on. These models have even inspired other disciplines to create their own versions. APS and AAPT have tried mightily to focus attention on the situation by creating the National Task Force on Undergraduate Physics [6], conducting the Revitalizing Physics Conference in 1998 [7], doing Workshops for New Faculty and bringing these issues to the Department Chairs Conferences.

With all this innovation, how could things not have changed for the better? The short answer is that this is because the physics community remains largely in denial. The Boyer report cited above led to a furious reaction from the research universities in which they focused their considerable energies on disproving the report rather than fixing the problems identified. Faculty and Chairs go home from the APS and AAPT programs all fired up only to encounter a skeptical department. With all of the adoption of innovative physics educational programs, the experience of most undergraduates is best described by Bob Park's quote and not by the innovative programs that remain marginal in the overall picture. Physics learning for most students continues to be an unpopular regimen of lecture, recitation, and lab. Few students ever chose to major in physics because of the introductory course. Most that go on to major in physics do so in spite of the course. Those few exceptions are always a source of rejoicing.

Innovation has taken a slightly better hold in the liberal arts and four-year colleges. This may explain why the physics undergraduate major numbers have remained constant at the four-year schools while shrinking in the graduate institutions.

Those who chose to remain in denial may do so by reciting a litany of reasons for the declines: Society has changed. Our high schools are doing a lousy job. Engineering pays better. Now the best students are going into life sciences and computer science. We only need a few of the best in physics anyway. Lectures are the stable product of long evolution (Wow! Evolution and stable product?). We cannot afford to do anything differently. These all have the virtue of being partly true and beside the point.

Rather than addressing these problems directly, most universities have chosen denial coupled with coping strategies. Too few U.S. students majoring in physics? No problem! Just turn up the recruitment of outstanding students from other countries. The result? According to the AIP statistics [8], the number of foreign graduate students passed the U.S. numbers in 1998. In the early 70s foreign students represented roughly 20% of the total. I for one am proud to have these outstanding students joining the physics community, but we cannot ignore the trends in U.S. undergraduate physics.

Earlier in the essay, I asserted that the devastating decline in undergraduate physics was the direct result of the policies and programs of physics departments. We have allowed our laudable success in research to distract us from addressing the crumbling foundation. The problems are well documented. The research in physics education points to clear pathways. There exist viable models that can be both adopted and adapted. Better models will be created in future years. We have everything that we need to reverse the decline of physics. Will we focus on solving the problem, or put our energy into denying that it exists? History is a worrisome guide.

(Continued on page 3)

(Continued from page 2)

References

[1] AIP Enrollment and Degrees Report (http://www.aip.org/statistics/trends/highlite/ed/figure1.htm)

[2] APS Report: Challenges in Physics Education; http://www.aps.org/educ/undergrad/main-challenge.html

[3] Research Report 2000; http://www.aaas.org/spp/dspp/rd/discip01.pdf

[4]:Boyer Report: Reinventing Undergraduate Education; http://naples.cc.sunysb.edu/Pres/boyer.nsf

[5] What's New; APS; 24 April 1998. http://www.aps.org/WN/WN98/wn042498.html

[6] National Task Force on Undergraduate Physics; http://www.aapt.org/programs/ntfup/index.html

[7] Revitalizing Physics Conference; http://www.aapt.org/programs/rupc.html

[8] AIP: 1998 Graduate Student Report : First Year Students; http://www.aip.org/statistics/trends/highlite/grad/gradhigh.htm

Jack Wilson is Chair of the Forum on Education. He is the founding Chief Executive Officer of UMassOnline, the University of Massachusetts Virtual University. Prior to this he was the J. Erik Jonsson '22 Distinguished Professor of Physics, Engineering Science, Information Technology, and Management and was the Co-director of the Severino Center for Technological Entrepreneurship at Rensselaer. At RPI Dr. Wilson led a campus wide process of interactive learning and restructuring of the educational program.

Communicating Science with the Arts

Chris Chiaverina

1. Introduction

For the last twenty-five years at New Trier High School in Wilmette, Illinois, we have been incorporating elements of the visual and performing arts in our physics classes. We have found that the arts serve as very effective vehicles for teaching a variety of topics in physics and illustrating applications of physical principles in the humanities.

While there are many ways to incorporate the arts in physics instruction, we have essentially used three approaches. These are: 1) interdisciplinary collaborations with the art and theater departments; 2) the inclusion of art-related material in the physics curriculum; 3) interactive gallery displays. I would now like to elaborate on these efforts.

2. Interdisciplinary Collaborations

Physics and the Theater

Each year we schedule a day of interdisciplinary activities with the performing arts department. The collaboration affords physics and performing arts students an opportunity to examine auditorium acoustics, e.g., reverberation time and interference effects, and the art and science of stage lighting.

Students experience acoustical interference patterns produced by two sources of sound, two speakers that approximate point sources. They move around the auditorium and locate points where the sound level is low. By using a large number of students, an easily discernable nodal pattern emerges.

After investigating auditorium acoustics, we invite students to join us on the stage to observe how the color of objects is affected by color of the incident light. Students first observe the color of their clothing under white light. The white light is then turned off and each primary color is used in turn to illuminate the stage and its occupants. Students are amazed by the dramatic changes in the perceived color of their clothing that accompanies changes in lighting.

The Art and Science of Birefringence

A New Trier art teacher and I have been bringing our classes together to produce works of art using polarized light. Our weeklong program introduces art and physics students to color theory, polarization and artistic composition. The week begins with an exploratory activity on color and color mixing. Following this experience, students hear about color from both physicist's and artist's points of view. Students then return to the lab to investigate polarization. During the course of this activity they encounter birefringence.

A discussion of polarization is followed by a lesson on composition. Students are then ready to produce their tape art.

The birefringent tape used in this activity reveals beautiful colors when viewed between crossed polarizers. Students layer tape on microscope slides to determine how color depends on tape thickness. Once they have created their color key, they produce polarization tape art by placing carefully cut pieces of tape on a plastic substrate. The resulting work is often reminiscent of stained glass or cubist art.

3. Art in the Physics Classroom

Shadows

We begin our study of geometric optics with an exploratory

(Continued on page 4)

(Continued from page 3)

activity on shadows. After students become familiar with the rudiments of shadow formation and rectilinear propagation, we delve into the importance of shadows in visual perception and art.

Artists employ numerous visual cues to produce the illusion of depth and three-dimensionality. Shadows are one of the most potent of these visual devices. Renaissance artists are attributed with initiating the use of shadows in drawings and paintings. This use of light and shadow in painting became known as chiaroscuro ("light and dark").

We introduce our students to chiaroscuro by showing them a number of paintings that illustrate the technique. We also bring in theater instructor Christopher Rutt to give them a lesson in the power of shadows. Using only make-up to create the illusion of shadow and light, he transforms his face with dramatic three-dimensional features (Fig. 1).

Figure 1: Christopher Rutt demonstrates the power of shadows. Using makeup to create false shadows, he has greatly accentuated his facial features.

Anamorphosis

Anamorphosis is a process that stretches and distorts images beyond recognition through the sophisticated application of the laws of perspective. However, when viewed from the proper angle or, in some instances, with the aid of a reflector, the distorted images appear quite normal. Anamorphic art, which flourished during the seventeenth and eighteenth centuries, is now regarded as an artistic curiosity.

Leonardo da Vinci is often cited as the first to experiment with anamorphosis. His form of anamorphic art did not require the use of mirrors, only the correct point of view. Using this approach, known as perspective anamorphosis, distorted images become intelligible when viewed from a particular angle. This technique was later used by Hans Holbein to conceal a skull in the famous anamorphic painting titled *The Ambassadors*.

Although the popularity of this rather arcane art form waned after the Renaissance, practitioners of anamorphosis may still be found today. For example, contemporary artist William Cochran has created a delightful anamorphic mural of a young woman on the side of a bridge in Frederick, Maryland. Like Holbein's Ambassadors, Cochran's painting is best viewed from a particular vantage point. (Fig. 2).

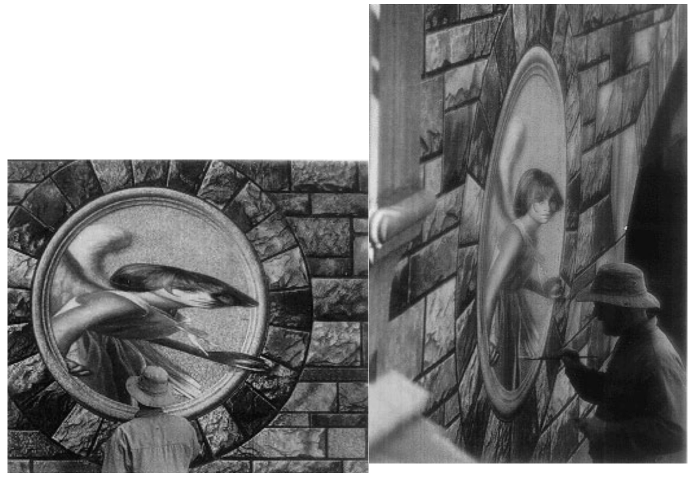


Figure 2: William Cochran's anamorphic mural Archangel on a bridge in Frederick, Maryland (a) viewed straight on; (b) at the intended viewing angle. (Courtesy of the artist.)

We attempt to keep anamorphosis alive by introducing it to our physics students during our unit on mirrors. During their study of curved reflectors, our students create their own anamorphic art by first drawing an image on a rectangular grid. Then, point-by-point, they transfer their image to a cylindrical grid. This deforms their drawing. To see their drawing in its undistorted form, they view it in a cylindrical reflector (Fig.3).

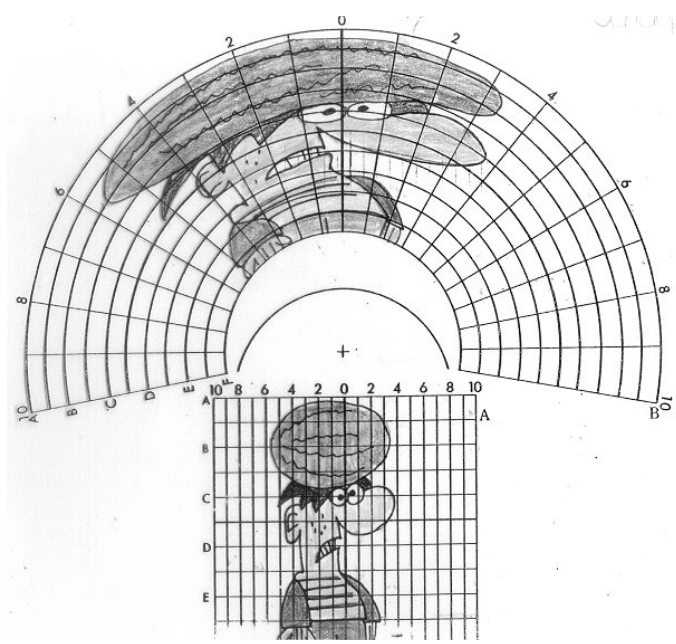


Figure 3: A drawing on a rectangular grid is mapped onto

(Continued on page 5)

(Continued from page 4)

a cylindrical coordinate system; the distorted drawing is transformed into a recognizable image by reflection in a cylindrical mirror.

After Images and Pop Art

The eye/brain system is capable of retaining an image for a fraction of a second after the stimulus is removed. This phenomenon, known as persistence of vision, gives rise to after images. Our students learn about persistence of vision and after images through a series of stroboscopic demonstrations. They also discover the importance of after images to an art movement that was born in the '70's known as optical art or "op art."

Overlaying two identical patterns on the overhead projector produces a Moiré pattern. When one of the patterns is displaced with respect to the other, movement is observed. The same effect is also seen with a single transparency. Due to the superposition of a current retinal image and a previous image that the eye/brain retains, the viewer perceives a Moiré pattern. The eye's constant scanning motion makes the Moiré pattern change in time, giving the illusion of motion. The sense of motion we experience when viewing op art seems to be the result of these constantly changing virtual Moiré patterns.

Camera Physics

Students build pinhole viewers and learn about the workings of a camera by taking one apart. With the popularity of single-use cameras, it is possible to obtain a class set of used disposable cameras from most camera stores.

Students examine the camera's optics (these inexpensive cameras sometimes have up to three lenses!), flash electronics and film transport mechanism. They form images with the camera's principal lens and measure its focal length and f-number. Dissecting and analyzing a camera is one of our students' favorite activities.

Holography

In 1999, Dr. Tung Jeong, professor emeritus at Lake Forest College, spent a week with us as a scientist in residence. He met with students and staff in both large and small groups to discuss the art and science of holography. As a result of his visit, each year all physics students at New Trier (approximately 700) make their own reflection holograms.

While the artistic community is still discussing the merits of holography as an art form, it should be remembered that photography experienced a similar scrutiny a century ago.

4. Gallery Displays

The Connections Project

Teachers and students from three departments at New Trier have produced over 125 engaging hands-on exhibits that allow people of all ages to discover elements common to the arts, mathematics, and science. Supported by New Trier High School and Toyota TAPESTRY and GTE GIFT grants, the Connections Project has developed cross-curricular displays that have been used in elementary, secondary and college classrooms and laboratories, learning centers, art galleries, and other public venues.

Both physiological and cognitive mechanisms come into play when we view a work of art. Consequently, like San Francisco's Exploratorium, many of our exhibits examine how the eye-brain system receives and processes visual information. An exhibition focusing on the relationship between art and visual perception is currently being presented at New Trier High School. To learn more about The Connections Project, see the Fall 1996 issue of the Forum on Education.

Chris Chiaverina teaches physics at New Trier High School in Winnetka, Illinois. With Thomas Rossing, he co-authored Light Science, an optics text written with the visual artist in mind. Chiaverina is currently President of the American Association of Physics Teachers.

Fermilab's Ask a Scientist Program

Peter H. Garbincius

From its earliest days, Fermilab has had a very successful outreach program for students from the surrounding communities. This was most visible in the large number of middle school and high schools visiting Fermilab on field trips during the week and in the Saturday Morning Physics Program (started by Leon Lederman). Laboratory-wide Open Houses for the public have also been extremely well attended by the general public. However, due to the large overhead in staging such open houses, which attract tens-of-thousands of visitors, only two have been held in the whole history of Fermilab. The public could visit the Fermilab site for recreational activities and to attend public lectures and the arts (performance) series. Maps and a self-guided tour brochure made it easy for the public to find the various sites and displays. However, they were pretty much on their own over the weekends.

Upon being asked a question by a Sunday afternoon visitor, I realized that there was no simple mechanism for an interested visitor to ask questions and to interact with a member of the Fermilab staff. I also noted that the casual weekend visitors were not only student-age, but always had at least one adult (driver). Often, these were family groups, or a group of a few adults. Although many of the displays in Wilson Hall (the main High Rise building) were geared to an adult audience, they were not completely self-explanatory or self-contained,

(Continued on page 6)

(Continued from page 5)

and there were questions to be asked. Ah ha! … an opportunity to make some more friends for Fermilab!

So, with a handful of colleagues, I started a very informal trial Ask-a-Scientist session for a few Sunday afternoons. One of us simply posted a small sign at one of the cafeteria tables in the atrium, indicating that he was a Fermilab scientist and "Ask Me". It worked! The Sunday visitors stopped by, joined us while enjoying their vending machine refreshments, and shot the breeze for a while. The questions and discussions were quite informal and neighborly: What is done at Fermilab? Why is such research important? How is Fermilab funded? What is Fermilab's history …and future? Tell us about the foreign scientists working here. What do you do at Fermilab? Why did you choose to be a scientist? Even…can you help my child with his homework problem? This had a snowballing effect. As soon as the first visitors started to chat, others joined in. We often filled the round ten seat table and had a row of others standing around.

When I discussed the proposed program and our initial experience with Fermilab's director, Mike Witherell, he enthusiastically encouraged us to proceed. He noted that although it was a low budget program of volunteers, it had a potentially large public relations payoff.

In addition to answering questions about Fermilab, we also try to present a face, a real person with whom to interact. Our visitors can see that Fermilab scientists are just their neighbors, not someone "different". We can let our neighbors know how we are investing their tax dollars. We hopefully are making friends for Fermilab, elementary particle physics, and science in general. We are somewhat parochial, however, not claiming to know or to speak for all science, but just those parts in which we work. Such new friends will be extremely important if our next major accelerator project is to extend, even underground, beyond the Fermilab site boundary.

We started in September of 2000, with two scientists, for two hours on Sunday afternoons, stationed in the public display/ observation area on the 15th floor of Wilson Hall. The program was publicized through press releases from the Fermilab Office of Public Affairs to local newspapers. A large fraction of our visitors were just walk-ins, who happened to be visiting the site, saw our signs, and decided to stop to chat. We have a team of approximately 45 volunteers, so each scientist averages about 2.5 sessions per year. During 2001, we kept informal counts of the number of visitors we met. Through September 7, we greeted 778 visitors. This averaged 22.5 visitors per Sunday afternoon session (with an RMS of 9.3), with the scientists often continuing their discussions well beyond the nominal ending time. The questions of quality versus quantity are surely at work here. Even when the turnout is low, each visitor gets to spend more time with a scientist. I tried, but failed, to find a correlation between the number of visitors and the weather. Do more visitors come to Fermilab come on nice sunny days, or on not-so-nice days? In fact, a day with a terrible rainstorm surpassed the average. Even Super Bowl Sunday was within 1.5 sigma of the average!

It appears that all of our volunteers thoroughly enjoyed their sessions. Who of us doesn't enjoy talking about and sharing what we do? Almost all who participated once volunteered to do it again.

On September 2, 2001, we celebrated the first anniversary of the Fermilab Ask-a-Scientist program. However, the tragic events of September 11 have drastically changed the way Fermilab interacts with the public. The heightened security has halted or disrupted many of the cultural, educational, and recreational opportunities at Fermilab for our neighbors. Most of our scientist volunteers seemed to suffer withdrawal symptoms. We investigated alternative sites. The volunteers were almost unanimous in preferring to try to re-institute even a drastically reduced program at Fermilab, rather than going off-site. Just recently, Fermilab and the Department of Energy were able to redefine the security perimeter to allow access by the public on Saturdays to the Lederman Science Education Center. Although this outlying, single story building does not provide the sweeping vistas of our accelerator laboratory and prairie, the growing suburbs, and, on a clear day, even the tall buildings in Chicago, the Lederman Center does provide a good forum to meet and interact with the public. We re-started the Ask-a-Scientist program on Saturday, January 19, 2002. Approximately 30 people attended. Half were associated with Fermilab and half were visitors from the general public. We'll try to do better with our publicity in local newspapers. The Lederman Center has many hands-on, interactive demonstrations (many analogs of the machines we use in HEP), so we have to be careful not to get too involved in helping the children play with the demos rather than discussing our science with their parents.

At the conclusion, I would like to add a few personal comments and questions. The name of the program seems to alternate between Meet-a-Scientist and Ask-a-Scientist. Some of us prefer the "Meet" since it seems to imply also learning *about* the scientist, while others prefer "Ask" which seems to emphasize learning something *from* the scientist. Of course, we try to do both. We also considered opening our list of volunteers to *non-Fermilab* scientists, graduate students, engineers, and other *non-scientists*. I wonder whether the public would be as amenable to an Ask-a-Fermilab-Employee program (maybe just a little bit of Fermilab scientist chauvinism on my part). Finally, by meeting visitors who already have come to Fermilab, we have pre-selected those who are already our friends. We will have to do better in bringing the Fermilab name and message to those who do not already know us, or who do not care about our science, or who are even hostile to us. Maybe booths in shopping malls, as we did while trying to get the SSC sited at Fermilab, would be a better way to reach these additional citizens. I'd be happy to hear any of your comments or suggestions.

Please e-mail me at garbincius@fnal.gov.

(Continued on page 7)

(Continued from page 6)

Another article on the Ask-a-Scientist program can be found in the FermiNews for October 19, 2001, available as: http://www.fnal.gov/pub/ferminews/ferminews01-10-19/p5.html

Peter H. Garbincius has been a scientist at Fermilab for the past 25 years.

Fermilab scientists who participate in the Ask-a-Scientist program gathered around the site model on the 15th floor of Wilson Hall at Fermilab.

Fooling Students Into Not Fooling Themselves

Raymond E. Hall

Four activities designed to engage students in the methods of science by showing how personal experience is not always to be trusted

Carl Sagan has argued with some success that "pseudoscience is embraced in exact proportion as real science is misunderstood"[1]. The current situation in the US is that a significant percentage of our fellow citizens believe in many topics either unsupported or even refuted by current evidence. A 2001 Gallup poll[2] indicated that a third of Americans profess a belief in astrology (up from 27% in 1990), that 28% believe it is possible to converse with the dead (up from 18%), and fully half believe in extra sensory perception.

As a science educator, I feel that enabling students to understand science involves an emphasis on how to discern scientific claims from that of the many pseudoscientific claims that abound in our media. What's behind the popularity of these claims? Purported reasons for why astrology, séances, and ESP are so widely believed are covered in a number of recent books[3], and seem as numerous as the unsupported beliefs themselves. In my research and reading of these books I have come to implicate a common factor among those who hold to such claims; the inability to distinguish reliable evidence.

I teach a general education course in critical thinking entitled *Science & Nonsense*. The course involves a study of the nature of the scientific enterprise, and how science, and the knowledge obtained from science, affects our lives and shapes our understanding of the world. I also seek to develop students' critical thinking skills through the study of past and current controversial topics that involve science or claim to be supported by science. The aim of the curriculum then is to enable students to tell the difference between reliable evidence and hearsay, reason and delusion, science and nonsense!

Science as a Safeguard

What follows is a set of classroom activities and topics designed to actively demonstrate to students how much of what they commonly take as evidence is unmistakably unreliable. The ability to distinguish reliable evidence first involves a better understand of ourselves, and the many ways we are prone to misinterpret our perceptions. With these activities I try to convince students that, in the words of Richard Feynman[4], "A first principle [in science] is that you must not fool yourself—and you are the easiest person to fool!"

Of course it is not a simple matter getting folks to question what they think they know. I have found that students of critical thinking are initially uncomfortable with the use of reason, since most are defensive of their current beliefs, and often express surprise at the idea of being asked to support their beliefs rationally. One aspect of science that I initially stress is that scientists employ methods developed to mediate what I will call *pitfalls of perception*, the ways in which our common sense intuition fails us. Many of these pitfalls are documented in the books and articles of Thomas Gilovich[5,] a professor of psychology at Cornell University. Gilovich suggests that the amazing complexity of our cognition, of how the human mind takes in and processes information, makes it inevitable that there will be ways in which the system can subtly betray us. States Gilovich: "At one level, [that common sense is so wrought with pitfalls] should not come as a surprise: It is precisely because everyday judgment cannot be trusted that the inferential safeguards known as the scientific method were developed;"[6] safeguards such as control samples, blind (and double blind) studies, and peer review.

I have found that exploring these pitfalls of perception is an effective way of engaging students to critically examine their beliefs. The following four activities describe why safeguards are needed and employed, and underscore how wrong things can go if one does not adequately guard against such pitfalls.

(Continued on page 8)

(Continued from page 7)

Subjective Validation and Astrology

Most realize that it is easy to read more into a written passage than was intended by the writer, but feel that this doesn't present much of a problem. I demonstrate that it can cause alarming misinterpretations with the following activity, most recently popularized by the famous magician and activist against pseudoscientific thinking, James Randi[7].

Checking up on one's horoscope appears to be a strong American pastime with almost every major newspaper carrying the daily celestial assessments of *sun sign* astrology. A major claim of sun sign astrology is that one's personality is largely determined by the position of the sun against the ecliptic constellations at one's time of birth. Our first activity explores the most prevalent evidence for this claim —that it works!

Activity 1 — Subjective Validation in Reading Horoscopes

First, share with the students that astrology has it roots with the ancient Babylonians, where a study of the nightly positions of the stars and setting sun may have played an important role in decisions of when to plant and harvest. Such a useful connection between human activities and the heavens were extended and further developed in ancient Greece to the level of divination of the personal lives of individuals.

Also mention that there are more that 10,000 professional astrologers in North America alone (compared to the roughly 6000 professional astronomers), and that according to a recent Gallop poll belief in astrology among the US population is at 33%, up from 27% a decade ago. Can so many of our fellow citizens be wrong?

Supply 12 stacks of personality assessments, labeled according to their astrological sign, which the students pick up as they enter the classroom (a list of the signs of the zodiac is in the table below). With ease of identification in mind, the handout for each sign should be printed on a different color paper and the sheet folded to hide the contents. The actual contents of the personality assessment is printed below in italics.

Read this and see how well this description fits you.

You have a need for other people to like and admire you, and yet you tend to be critical of yourself. While you have some personality weaknesses you are generally able to compensate for them. You have considerable unused capacity that you have not turned to your advantage. Disciplined and self-controlled on the outside, you tend to be worrisome and insecure on the inside. At times you have serious doubts as to whether you have made the right decision or done the right thing. You prefer a certain amount of change and variety and become dissatisfied when hemmed in by restrictions and limitations. You also pride yourself as an independent thinker; and do not accept others' statements without satisfactory proof. But you have found it unwise to be too frank in revealing yourself to others. At times you are extroverted, affable, and sociable, while at other times you are introverted, wary, and reserved. Some of your aspirations tend to be rather unrealistic

Now to be a bit quantitative, please assess how well this statement characterized your personality using a scale from 1 to 5, where 1 corresponds to a complete miss and 5 for amazingly dead on. Yes, you guessed it. All twelve of the zodiac personality assessments have this exact same paragraph. Typically my class of 30 students have an average score around 4.2, and rarely does any student rate it lower than 3.

♈	**Aries**	**21-Mar to 20-Apr**
♉	**Taurus**	**21-Apr to 20-May**
♊	**Gemini**	**21-May to 20-Jul**
♋	**Cancer**	**21-Jun to 20-Jul**
♌	**Leo**	**21-Jul to 20-Aug**
♍	**Virgo**	**21-Aug to 20-Sep**
♎	**Libra**	**21-Sep to 20-Oct**
♏	**Scorpio**	**21-Oct to 20-Nov**
♐	**Sagittarius**	**21-Nov to 20-Dec**
♑	**Capricorn**	**21-Dec to 20-Jan**
♒	**Aquarius**	**21-Jan to 20-Feb**
♓	**Pisces**	**21-Feb to 20-Mar**

After collecting the numbers have the students exchange their chart with their neighbors, for one of a different color. The majority of my class is always astonished. I guarantee many will gasp as they read them over, and a wave of laughter will sweep across the room.

The psychologist Bertram Forer was the first to describe this phenomenon, which he labeled *subjective validation*, and utilize it in his class to demonstrate this inherent bias in assessment of claims about one's self[8]. We seem to always notice and count the hits and for the most part ignore the misses. Subjective validation, and the wrong impression it creates, has an important role in why people have such firm convictions about astrology, as well as the fantastic claims of palm reading, graphology, self help ideologies, personality inventories, and most paranormal means of personality revelation.

The pitfall of subjective validation seems to be inherent in how our mind works, and is just one of many known ways our brains can systematically mislead us. The next pitfall we will look at is how we are fundamentally handicapped when assessing probabilities and degrees of randomness.

Misinterpretation of random events and phone ESP

You happened to be thinking about your mother; suddenly the phone rings. It's your mother! Amazing! Come to think of it this has happened to me in the past. There must be some kind of uncanny ESP connection involved.

Research in psychology has demonstrated that the mind has

(Continued on page 9)

(Continued from page 8)
difficulty in correctly interpreting random patterns in time. We seek the unusual happenstance and mark them. The times when we think of our mom and she doesn't call, and the reverse, where she calls and she didn't happen to be on our mind at the moment, are by contrast *non*-events and don't have the same impression on our memories. So after a while the false impression of ESP connection is created out of what is an inevitable overlap of common events. Equally troubling is our inability to comprehend short-range statistics.

A widespread belief among basketball players, professional and blacktop, is that of the hot hand[5]. Michael Jordan and others have spoken on what they feel is the fact that once they have made a shot, they are more likely to make the next; their hand is hot. Conversely, the belief goes, if they miss a shot their hand has gone cold and they are more likely to miss the next. The more shots made (or missed) in a row the hotter (or colder) the hand. This to many a ballplayer's mind describes why shots sometimes occur in streaks.

The question here is understanding what a random distribution looks like. Consider the following flips of a coin (an independent process):

XOXXOXOOXOOXXOXOXXOX
and
XOXXXOXOXXXXXXOXXXOX

Both series are of course equally probable, but most people would say that the second is too orderly, with too many heads ('X's) in a row, and therefore less likely. This is in contradiction to the math! In 20 tosses one would expect 10% of time to get a six in a row somewhere in the sequence, 25% of the time a five in a row, and a 50-50 chance of having at least a four in a row. The next activity demonstrates this "streaky" nature of random sequences. Note that during a basketball game each player attempts around 20 shots.

Activity 2 – Random Streaks

With one chance in four of a streak of 5 to occur in 20 tosses, this makes for a surprising demonstration. Obviously, flipping a penny 20 times and writing it down would be tedious display to say the least. Instead, hand out 20 pennies, one to each student in a couple of rows of seats. Have them flip their coins and call out heads or tails in order of their seat while a recorder scribes them on the blackboard. This will allow a quick and participatory way to collect the data. Of course, it should take only four trials to get at least one 5 in a row.

As the data is being recorded, you will note that whenever a series of three appears a tension will overtake the class which will either quickly pass, or mount to gasps of astonishment as seeming streaks of 5 or 6 in a row materialize before them.

This activity may sound overly simple from this description, however, I have found that it leaves a lasting impression on students.

Tom Gilovich and Arnos Tversky demonstrate that people have faulty intuition about what random sequences look like. In fact, they have actually researched the hot hand with data from the 76er's basketball team. Gilovich and Tversky found that there is no meaningful statistical correlation between shots, and that a particular player's shooting average is the same for shots made after a basket to those after a missed shot[9]. This analysis has fairly straightforward statistical arguments and is ideal for class presentation in conjunction with the above activity.

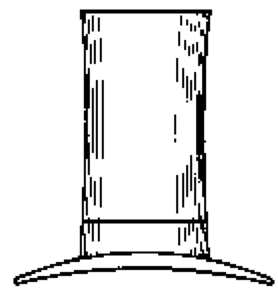


Figure 1. Optical illusion as an analogy to the cognitive clustering illusion. Even once one verifies that the brim of the hat is equal to the height, the eye continues to perceive the hat as taller than wide.

In general most conceive a random distribution to alternate back and forth much more than the math demonstrates; sequences of six in a row seem to most beyond chance. The propensity to assign a causal connection to such random sequences is called the *clustering illusion*, another pitfall of perception related to misinterpretation of random events. Gilovich argues that this bogus intuition is a *cognitive illusion* much like the optical illusion of the hat in Figure 1 in that even once one verifies that the brim of the hat is equal to the height, the eye continues to perceive the hat as taller than wide.

So here is yet further instances of the mind's tendency to misinterpret. But wait, it gets worse!

Expectation Bias and Seeing Things

Here is a short account of a famous instance of expectations bias, or just plain jumping to conclusions. In 1903, during a time of major discoveries of many new forms of radiation, Professor Rene Blondlot of the University of Nancy reported the discovery of a remarkable new radiation he labeled N-rays[10]. He claimed these rays were emitted by all things except green wood and some treated metals, and had similar penetrating properties akin to X-rays. A number of other French scientists had corroborated his findings by duplicating his experiments. In one experimental arrangement, the N-rays were said to refract through a metal prism, and that a spectrum of dark and light N-ray bands could be cast. Instead of an eyepiece the spectrometer had a vertical thread treated with luminous paint. N-ray bands were detected by Blondlot, determining by eye

(Continued on page 10)

(Continued from page 9)
the faint glow of the string as an assistant called out angles and rotated the prism through a set of intervals.

The journal *Nature* sent American physicist James Wood to investigate the amazing claims of the N-ray experiments. Wood was invited into Blondlot's lab for a demonstration, and while waiting in the dark for Blondlot's eyes to adjust, Wood quietly removed the metal prism from the apparatus. Although the prism was in Wood's pocket, thus completely disabling the apparatus, Professor Blondlot nevertheless called out the presence and absence of N-rays exactly where he had reported and expected them to be[11].

The detection mechanism of Blondlot's experiment had an unfortunately large subjective aspect, that of visually distinguishing a very feeble illumination, literally on the threshold of detection. Could Blondlot's strong expectation to see the string glow really manifest in his perception, so that he really saw a glow when none were present? Many have come to this conclusion.

Activity 3 — Observation of Bogus Inference[12]

Students are grouped into teams of four and given the following items; a plain white candle, a ruler, and a magnifying glass. They are instructed to brainstorm in their groups and write down as many observations about the candle as possible. After some allotted time (say 10 minutes), engage the groups to share what they observed and catalog the list on the board. Many aspects of the candle will be listed, including measurements of dimensions, color and texture. Invariably a student will remark that "it's been burned". This comment is used as a lead in to a discussion of the difference between an *observation* and an *inference* from many observations. At this point the students find that things are not as they initially appear.

This activity does take some initial effort to set up. The candles that are distributed to the students are prepared in the following way. Starting with a brand new candle use a small sharp tool to scrape some wax from around the base of the wick to form a small crater. Next, take a permanent black marker and color the wick black. Finally, select one candle, actually light it, and from it drip wax on to the doctored candle, being careful to make the drips fall at odd angles.

Returning to the activity: After a brief discussion on inferences, have the students concentrate on the wick of the candle, again compiling a list of observations. Here they will note that the black color does not come off upon handling (unlike a burnt candle) and that the wick is flexible (again quite unlike a burnt candle). Finally ask what alternative hypotheses could explain the appearance of the candle. Here they will be astonished that someone would actually have colored the wicks black, and indeed it is a bit of a dirty trick. At the same time, however, there were numerous clues that the candle could not have been previously burned: the scratch marks around the base of the wick, the flexible nature of the wick, the fact that the drip marks could not have possibly come from the top of the candle. All these striking inconsistencies were overlooked due to the expectation bias set by the assumptions formed upon first glance.

In the case of Blondlot, perhaps the expectation came from his considerable investment in his own hypothesis, or was reinforced by his lab assistants not wanting to contradict their esteemed professor. Whatever the case, the lesson for the students is that his experimental procedure screamed out for the application of a blind test. If Blondlot had asked his assistant to do in a controlled fashion what Wood had imposed on him, N-rays may never have seen the printed page.

There are other instructive and entertaining incidents in the annals of physics; one of which I highly recommend is the story of Martin Fleischmann and Stanley Pons' announcement of cold fusion in 1989. The account as told in Robert Park's book *Voodoo Science*[13]gets to the very heart of the problem: signal on the threshold of detection above noise, subversion of peer review, lack of use of control samples (what is the result if you do not use heavy water in your vessel?), and of course a wide berth for expectation bias.

The human pitfall of expectation bias is sometimes referred to as wishful thinking, and plays a role in the acceptance of many questionable beliefs including N-rays, cold fusion, ancient astronauts, claims of perpetual motion ("over unity") devices, and many alternative healing claims, to name a few.

Confirmation Bias and Overlooking Opportunities

Related to expectation bias is another human pitfall, that of confirmation bias. Inductive reasoning has preeminence in science, and early on I explain how disconfirming evidence is more powerful that confirming evidence in deciding among competing hypotheses. Yet it seems almost unnatural for us to seek to disconfirm, as illustrated in the next activity.

Activity 4 — Pick a Card

Ask the class to consider the four cards in Figure 2. and to determine which card is the best choice to turn over to test the following statement: *All cards with a vowel on one side have an even number on their opposite side.* After giving the students adequate time for consideration, ask for a show of hands and write down the number of votes for each. Now repeat the process but this time ask them which one would be second best and record the votes accordingly.

Typically for the selection of best card to turn over you will see a majority of votes for the A card, a significant number will choose the 2, a few will choose the 7, and hardly ever a vote for the J. For second best the statistics are similar except the 2 gets the majority and the A gets the second most, with the 7 obtaining a couple votes.

What is the best choice?

Consider the A: If there is an even number then we have some confirming evidence, well and good. If there is an odd number

(Continued on page 11)

(Continued from page 10)

then the statement is refuted, which is actually more decisive evidence— the statement is invalidated.

Consider the 2: If the opposite side is a vowel, again we have some positive evidence. However, if the opposite side of the card is a consonant, we have no new useful data.

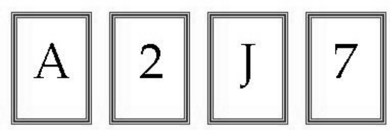


Figure 2. Cards used in evaluation of the validity of the statement*: all cards with a vowel on one side have an even number on their opposite side.*

Consider the 7: Here again, if the opposite side is a consonant we have no useful data. If, however, the opposite side is a vowel we have again refuted the statement— this evidence eliminates the statement as a possible truth.

Consider the J: Of course neither a vowel nor a consonant gives us any useful data.

So we see that to invalidate the statement is to throw it out in one quick step, and such disconfirming evidence is much more powerful than confirmation. The 7 card should be given the second place spot. Yet, test after test shows that human judgment has a bias for confirmation; we automatically seek the confirming instance, that which agrees.

The most telling aspect of this activity is that it shows that even when we don't have a vested interest in the validity of the statement (no wish or need for the statement to be true), we still seek the confirmatory evidence, however more powerful disconfirmation might be. This pitfall of perception is well documented in the psychology literature[14].

Once students have been made aware of these pitfalls, I have them research a number of popular topics with extraordinary claims: ancient astronauts, the Loch Ness monster, abductions by extraterrestrial visitors, palmistry, psychic detectives, bigfoot, spontaneous human combustion, out of body experiences, etc., the list is long! My students learn to recognize the potential role of these pitfalls in the evidence presented by the proponents for these claims, and I have found that these activities leave a strong and lasting impression.

You, yourself, are the easiest person to fool... Once my students are convinced of this, I feel there is hope that many will graduate with the ability to discern the difference between astrology and astronomy.

Notes and References:

1. Carl Sagan, *The Demon-Haunted World: Science as a Candle in the Dark.* New York, Ballantine Books, 1997.

2. Frank Newport and Maura Strausberg, "Americans' Belief in Psychic and Paranormal Phenomena is up Over Last Decade", Gallup News Service, June 8, 2001, http://www.gallup.com/poll/releases/pr010608.asp

3. Theodore Schick and Lewis Vaughn, *How to Think About Weird Things, Critical Thinking for a New Age*, Mayfield Publishing Co., California 1995. Also, Michael Shermer, *Why People Believe Weird Things : Pseudoscience, Superstition, and Other Confusions of Our Time*, W H Freeman & Co., 1998. and, Nicholas Humphrey, *Leaps of Faith: Science, Miracles, and the Search for Supernatural Consolation*, Copernicus Books, 1999.

4. Richard Feynman, Edward Hutchings (Ed), " Cargo Cult Science" in *Surely You're Joking, Mr. Feynman!: Adventures of a Curious Character,* W.W. Norton & Company 1997

5. Thomas Gilovich, "Some Systematic Biases of Everyday Judgment", *Skeptical Inquirer*, pg. 231 March/April 1997

6. Thomas Gilovich, *How We Know What Isn't So; The Fallibility of Human Reason in Everyday Life*, The Free Press, New York 1991

7. James Randi, Secrets of the Physics, NOVA, PBS video, 1993

8. Forer, B.R., "The Fallacy of Personal Validation: A classroom Demonstration of Gullibility," *Journal of Abnormal Psychology,* 44, (1949) 118-121.

9. Arnos Tversky and Tomas Gilovich, "The Cold Facts About the Hot Hand", *Chance,* Vol 22, No. 2 (1980) 18-21

10. Mary Jo Nye, "N-rays: An episode in the history and psychology of science", *Historical Studies in the Physical Sciences* 11 (1), (1980) 127-156. And, Irving Langmuir and Robert N. Hall, "Pathological science" *Physics Today* 42 (10), (1989) 36-48.

11. Robert W. Wood, "The N-rays", *Nature* 70, (1904) 530-531.

12. Terrance Shaw, "Spider Sniffing, Oobleck, Candles and Other Skeptic Creating Activities", *Proceedings of the 1998 California Science Teachers Association Annual Meeting,* (unpublished)

13. Robert L. Park, *Voodoo Science : The Road from Foolishness to Fraud,* Oxford Univ Press, 1999

14. P.C. Watson, "Reasoning", in B.M.Foss(Ed.), *New Horizons in Psychology*. Harmondsworth: Penguin.

Ray Hall is an Assistant Professor of Physics at California State University, Fresno and a High Energy Physics researcher with the Dzero Collaboration at Fermilab

A Coalition to Improve Teaching

John Layman and Warren Hein

The Fall 2001 edition of the Forum on Education Newsletter included an article by Fredrick Stein, APS Director of Education and Outreach, announcing a major NSF award to APS for the Physics Teacher Education Coalition, PhysTEC. The American Institute of Physics (AIP) and the American Association of Physics Teachers (AAPT) are partners in the project. AAPT is pleased to be a participant with APS and AIP in PhysTEC because of the close connection between teacher preparation and the association's mission of "Enhancing the understanding and appreciation of physics through teaching."

Two AAPT programs have addressed improvements in teaching. AAPT's major impact on the teaching of pre-college science has been its very successful Physics Teaching Resource Agents (PTRA) program. The PTRA are more than 400 high school teachers trained to present in-service professional development workshops to teachers across the United States. A second program is the Powerful Ideas in Physical Science curriculum materials that have been developed as models for introductory physics courses for pre-service elementary teachers. Both programs were supported by NSF grants.

Through participation in PhysTEC, AAPT will be able to have greater impact on the preparation of pre-service science teachers and the mentoring of new teachers. The PhysTEC program is dedicated to improving the science preparation of K-12 teachers and should become a long-term activity within the professional associations. In the case of the coalition, its natural home would be within AAPT.

The initial members of the coalition are six Primary Program Institutions: University of Arizona, University of Arkansas, Ball State University, Oregon State University, Western Michigan University, and Xavier University of New Orleans. The PhysTEC Primary Program Institution Components accepted by the six members are:

- A long-term, active collaboration among the physics department, the department of education, and the local school community.
- A Teacher-in-Residence (TIR) program that provides for a local K-12 master teacher to become a full-time participant in assisting faculty in course revisions and team-teaching, and to act as a "reality check" for both pre-service teachers and university faculty.
- The redesign of content and pedagogy for targeted physics courses based on results from physics education research and utilizing appropriate interactive technologies.
- The redesign of content and pedagogy for elementary and secondary science methods courses with an emphasis on inquiry-based, hands-on approaches to teaching and learning.
- The participation of physics faculty in the improvement and expansion of school experiences for their students.
- The establishment of a mentoring program conducted by TIRs and other master teachers to provide a valuable induction experience for novice science teachers.

It is clear that it will take many more than six institutions to improve the way K-12 science teachers are prepared and mentored. Additional coalition members are sought from college or university departments of physics that are also committed to improving the science preparation of future teachers and can provide programmatic resources in support of a smaller set of Coalition Teacher Preparation Principles. These teacher preparation principles include:

- Commit to become actively involved with teacher preparation reform, particularly in the science preparation of future teachers.
- Demonstrate a readiness to work in collaboration with faculty from the School of Education
- Exhibit a degree of enthusiasm to model good teaching practices, particularly instruction based on guided inquiry, student-centered, and in which students are actively engaged.
- Have the capacity to document the department's work and serve as a model for others within the higher education community
- Exhibit a willingness to shift some of the departments resources toward a PhysTEC program and
- Have the capability for program institutionalization over time.

Those physics departments wishing to become members of the Coalition should prepare a request for membership that includes evidence of a commitment to the Coalition Teacher Preparation Principles listed above, a listing of the faculty members that will be active in the department's program, and evidence that the program is approved by the faculty of the department and the department chair.

Membership in the Coalition has the following advantages:

- Have access to PhysTEC information, programs, and workshops
- Receive national recognition for participation in the Coalition
- Enhance the institutional eligibility for external funding for teacher preparation
- Enhance the departmental eligibility for internal resources

(Continued on page 13)

(Continued from page 12)

- Have access to resource persons to help build programs

For more information on the Coalition, contact Fredrick Stein at stein@aps.org or visit the Coalition website http://www.phystec.org

John Layman is Professor Emeritus from the University of Maryland and is a former AAPT President. He is a co-principal investigator for the PhysTEC project. Warren Hein is the AAPT Associate Executive Officer and is the AAPT staff liaison for PhysTEC.

No Child Left Behind? – Teaching Science and the Department of Education Budget – Good Intentions, Political Realities, Unintended Consequences

Kenneth J. Heller

With a great flourish Congress passed and the President signed the law authorizing funding the Department of Education for 2002, the "No Child Is Left Behind Act of 2001." Its primary goal seems to be to give States greater flexibility in spending Federal education money and to hold them accountable for results by measuring student performance on a yearly test. The multifaceted nature of the Federal budget mirrors the complexity of our country's educational problems. As physicists, however, many of us feel a special responsibility to improving the level of science teaching in our schools. We know the survival of our society depends on having a steady flow of young people into science and technology. We also believe that the funding of research in this country requires an increasingly scientifically literate population to support it. Our political leaders are familiar with the problem and often state it as a National Security issue (see for example the report of the U.S. Commission on National Security http://www.nssg.gov/Reports/reports.htm.)

> "The nation is on the verge of a downward spiral in which current shortages will beget even more acute future shortages of high-quality professionals and competent teachers. The word "crisis" is much overused, but it is entirely appropriate here. If the United States does not stop and reverse negative educational trends—the general teacher shortage, and the downward spiral in science and math education and performance—it will be unable to maintain its position of global leadership over the next quarter century."

The difficulty is that the consequences of science education are in the future while schools have to survive the present. Overcrowded classrooms, drugs, weapons in schools, teacher shortages, multilingual classrooms, special education, etc, etc, are the focus of attention. As they say in Florida: "When you're up to your ass in alligators, it's hard to remember you're trying to drain the swamp." Within Congress, there are two strong voices in the House of Representatives calling attention to the importance of Federal funding for improving science teaching in our schools: the physicists, V. Ehlers (R, Michigan) and R. Holt (D, New Jersey). The Congressional Record shows they fought hard in the losing battle to keep the federal funding targeted for improving science teaching. Now the Eisenhower grants that many university and college physics departments used to provide professional development to science teachers have been eliminated. Funding still exists that the States could use for this purpose but they can also be used for other needs. If we believe federal funds should be used to support improved science teaching, physicists, in cooperation with other science and technology professionals, must become more engaged in guiding State and local school funding. There are tools that remain in the law, described below, that can be useful.

The good news is that the 2002 budget of the Department of Education increased about 15% to 51.4 billion dollars with about 2/3 going directly to the states. The law that determines this federal spending comes in three different parts. The first part is the authorization law. This is H.R. 1 or the "No Child Left Behind Act of 2001" signed into law as P.L. 107-110 (public law number 110 from the 107th Congress). It sets forth policy but only gives guidelines for allocating money. The second part is the appropriations law H. R. 3061 signed into law as P.L. 107-116. This is the law that actually allocates the funding and as such modifies the policy set forth in the authorization law. The third part is the Congressional Conference Report 107-342. This report is attached to the appropriations law to specify how Congress intends the budgeted money to be spent. All of these documents are available from the Library of Congress Web Site, Thomas (http://thomas.loc.gov).

Good Intentions

The "No Child Left Behind Act of 2001" contains the good intentions of Congress and the President. There are two parts of the Act that most directly impact science teaching. First, the Act requires the testing of students for mathematics and reading proficiency beginning in 2002 and science in 2007;

> "Each State plan shall demonstrate that the State educational agency, in consultation with local educational agencies, has implemented a set of high-quality, yearly student academic assessments that include, at a minimum, academic assessments in mathematics, reading or language arts, and science that will be used as the primary means of

(Continued on page 14)

(Continued from page 13)

determining the yearly performance of the State and of each local educational agency and school in the State in enabling all children to meet the State's challenging student academic achievement standards, except that no State shall be required to meet the requirements of this part relating to science assessments until the beginning of the 2007–2008 school year."

Second, it authorizes Congress to appropriate $450M for mathematics and science partnerships. This funding was to replace the Eisenhower grants that were previously used to fund professional development for mathematics and science teachers. In the new law the partnerships have the following set of authorized activities:

"An eligible partnership shall use funds provided under this part for one or more of the following activities related to elementary schools or secondary schools:

(1) Creating opportunities for enhanced and ongoing professional development of mathematics and science teachers that improves the subject matter knowledge of such teachers.

(2) Promoting strong teaching skills for mathematics and science teachers and teacher educators, including integrating reliable scientifically based research teaching methods and technology-based teaching methods into the curriculum.

(3) Establishing and operating mathematics and science summer workshops or institutes, including follow-up training, for elementary school and secondary school mathematics and science teachers that—

(A) shall—

(i) directly relate to the curriculum and academic areas in which the teacher provides instruction, and focus only secondarily on pedagogy;

(ii) enhance the ability of the teacher to understand and use the challenging State academic content standards for mathematics and science and to select appropriate curricula; and

(iii) train teachers to use curricula that are—

(I) based on scientific research;

(II) aligned with challenging State academic content standards; and

(III) object-centered, experiment-oriented, and concept- and content-based; and

(B) may include—

(i) programs that provide teachers and prospective teachers with opportunities to work under the guidance of experienced teachers and college faculty;

(ii) instruction in the use of data and assessments to inform and instruct classroom practice; and

(iii) professional development activities, including supplemental and follow-up activities, such as curriculum alignment, distance learning, and activities that train teachers to utilize technology in the classroom.

(4) Recruiting mathematics, engineering, and science majors to teaching through the use of—

(A) signing and performance incentives that are linked to activities proven effective in retaining teachers, for individuals with demonstrated professional experience in mathematics, engineering, or science;

(B) stipends provided to mathematics and science teachers for certification through alternative routes;

(C) scholarships for teachers to pursue advanced course work in mathematics, engineering, or science; and

(D) other programs that the State educational agency determines to be effective in recruiting and retaining individuals with strong mathematics, engineering, or science backgrounds.

(5) Developing or redesigning more rigorous mathematics and science curricula that are aligned with challenging State and local academic content standards and with the standards expected for postsecondary study in mathematics and science.

(6) Establishing distance learning programs for mathematics and science teachers using curricula that are innovative, content-based, and based on scientifically based research that is current as of the date of the program involved.

(7) Designing programs to prepare a mathematics or science teacher at a school to provide professional development to other mathematics or science teachers at the school and to assist beginning and other teachers at the school, including (if applicable) a mechanism to integrate the teacher's experiences from a summer workshop or institute into the provision of professional development and assistance.

(8) Establishing and operating programs to bring mathematics and science teachers into contact with working scientists, mathematicians, and engineers, to expand such teachers' subject matter knowledge of and research in science and mathematics.

(9) Designing programs to identify and develop exemplary mathematics and science teachers in the kindergarten through grade 8 classrooms.

(10) Training mathematics and science teachers and developing programs to encourage young women and other underrepresented individuals in mathematics and science careers (including engineering and technology) to pursue postsecondary degrees in majors leading to such careers."

Political Reality

An authorization law giveth and the appropriations law taketh away. The appropriations law is almost impossible to understand from a simple reading. This is probably because it is

(Continued on page 15)

(Continued from page 14)

designed to amend existing law and because, in this case, it was passed before the authorization bill. It creates a category called "School Improvement Programs" funded at a level of $7.8B. The Conference Report attached to the appropriation law clarifies what is really to be funded and is summarized by tables at the end of the Report. The appropriation reduces science and mathematics partnership funding from $450M to $12.5M. This amount is clearly too little to be distributed to States and in no way replaces the $375M Eisenhower grants allocated last year. However, under "School Improvement Programs" the Conference Report has a section called "Improving teacher quality" funded at $2.85B. The report states:

> "Grants for Improving Teacher Quality consolidates and streamlines the Eisenhower Professional Development program and the Class Size Reduction program to allow greater flexibility for local school districts. The purpose of this part is to provide grants to States, school districts, State agencies for higher education, and eligible partnerships to: (1) increase student academic achievement through such strategies as improving teacher and principal quality and increasing the number of highly qualified teachers in the classroom and highly qualified principals and assistant principals in schools; (2) hold districts and schools accountable for improvements in student academic achievement; and (3) hold districts and schools accountable so that all teachers teaching core academic subjects in public elementary schools and secondary schools are highly qualified."

Although nothing in the purpose of the $2.85B mentions teaching science or professional development, the Conference Report continues with specific intentions about funding for mathematics and science teaching.

> "The conferees believe that providing high-quality math and science instruction is of critical importance to our Nation's future competitiveness, and agree that math and science professional development opportunities should be expanded. The conferees therefore strongly urge the Secretary and the States to continue to fund math and science activities within the Teacher Quality Grant program at a comparable level in fiscal year 2002."

Referring to the $12.5 M for mathematics and science partnerships, the Conference Report goes on to state:

> "The conferees note that, although this is a separate program designed specifically for the development of high quality math and science professional development opportunities, in no way do the conferees intend to discourage the Secretary and States from using other federal funding for math and science instructional improvement programs. The conferees strongly urge the Secretary and States to utilize funding provided by the Teacher Quality Grant program, as well as other programs funded by the federal government, to strengthen math and science education programs across the Nation."

When reading the Conference Report, it is important to note that the Teacher Quality Grant program is not burdened by a special interest laundry list redirecting money to local projects that, however valuable, are not arrived at by allowing the local educational community to determine its priorities. This flexibility is carried even further since, from the authorization law, a State can redirect up to half of the grant to any other educational function funded by the law.

Unintended Consequences

The funding for the School Improvement Programs is to be distributed such that 95% goes to the local school districts, 2.5% is for State activities, and 2.5% is for local partnerships. "Strongly urge" is not the same as "require" but it does give the intent of Congress. However, local school districts must be convinced that allocating some funds for improved science teaching is in their interest. Instead of being recognized as a national priority by targeted funding, science teaching will now compete with other school needs drawing from a federal block grant to the States. This is a victory for those who believe in less federal control of educational policy. However, the playing field for the funding competition is not level. Mathematics and reading tests are mandated almost immediately but science tests will come, if at all, in the future. School districts, especially those in academically disadvantaged communities, will feel the pressure to spend all available money on math and reading basic skills.

One measure of the country's current status in teaching science is the achievement of students on various national and international tests. None of these results show that science literacy is a solved problem so that educational effort can be directed elsewhere. For example, the Department of Education's 2000 National Assessment of Education Progress (NAEP) for science is given on the following table http://www.nces.ed.gov/nationsreportcard/science/results/:

level	4th Grade		8th Grade		12th Grade	
	1996	2000	1996	2000	1996	2000
Below basic	33%	34%	39%	39%	43%	47%
Basic	38%	37%	32%	29%	36%	34%
Proficient	26%	26%	26%	28%	19%	16%
Advanced	03%	04%	03%	04%	03%	02%

There is the very real danger that the country will slide backwards in the preparation of its children for a technologically advanced society. It might be natural for school systems with already above average reading and math scores, typically suburban schools, to fund science teaching improvement while those that are below average, typically inner city schools, to fund only reading and math efforts. This could lead to a larger science and technology gap which, in turn, could lead to a larger gap in earning potential for the graduates of those school systems.

On the other hand, it is not clear that we have been making great progress under the old scheme of Eisenhower funding either. Perhaps it is too early to tell or perhaps the tests are measuring the wrong thing. In any case we now have an opportunity to use the larger amount of funding available to improve teacher quality to significantly improve science teaching in this country. Science will no longer be an isolated item in a school district's budget that teachers and principles view as not a "real" academic subject but is taught only because there is funding available. States and local school districts will now have to decide if science is important enough to compete for funding with other areas. In many places, science teaching will only survive in the schools if there is an effort of concerned citizens and teachers stressing its importance for children. The language of Congress in both the authorization law and the committee report accompanying the appropriation law can give weight to those efforts. It will clearly help if university and college groups in collaboration with school districts design professional development programs for science teachers that also help increase math and reading test scores.

Kenneth J. Heller is Past Chair of the Forum on Education and is a Professor of Physics at the University of Minnesota

Improving the Quality and Quantity of K-12 Teachers of Mathematics and Science: The Collaborative for Excellence in Teacher Preparation in Pennsylvania

Patsy Ann Johnson, P. James Moser, Robert A. Cohen, and Joan E. Mackin

At Bloomsburg University, Professor James Moser watches a student control an electron beam by adjusting the accelerating potential, focus, and field current
(photo credit: Keith Boyer, Indiana University of Pennsylvania)

The National Science Foundation (NSF) from 1993 through 2000 provided funds to start approximately 25 Collaboratives for Excellence in Teacher Preparation, described as "large scale systemic projects designed to significantly change teacher preparation programs on a state or regional basis and to serve as comprehensive national models" [1, p. iii]. The typical award was one million dollars per year for five years. The number of institutions of higher education in a collaborative has averaged about ten, but there has been wide variability.

During the summer of 2000, the NSF awarded funds to the Pennsylvania State System of Higher Education (SSHE) for the Collaborative for Excellence in Teacher Preparation in Pennsylvania (CETP-PA). The 14 SSHE universities are Bloomsburg, California, Cheyney, Clarion, East Stroudsburg, Edinboro, Indiana, Kutztown, Lock Haven, Mansfield, Millersville, Shippensburg, Slippery Rock, and West Chester.

These 14 universities annually have 10,000 – 12,000 students completing teacher preparation programs. Almost one-sixth will become secondary science and mathematics teachers. Almost five-sixths are planning to teach science and mathematics in elementary grades. About one-tenth will become secondary teachers not teaching science or mathematics. In 1998 when the grant proposal was written, the SSHE universities prepared 29% of the teachers obtaining Pennsylvania certification in secondary mathematics, 35% of those in secondary science, and 39% of those in elementary education.

As a demonstration of its commitment to the CETA-PA project, the SSHE is providing one million dollars in matching funds over the five years of the project. A SSHE website is used with Blackboard software to communicate among the campuses about the CETP-PA project. Calendars, reports, evaluation forms, and other documents are available on this SSHE website.

The 14 universities have committed physical space to accommodate mathematics/science/technology education centers, computer equipment and technician time to maintain CETP-PA websites, faculty release or reassignments to accomplish

(Continued on page 17)

(Continued from page 16)

CETP-PA work, as well as over one-half million dollars in hard match and indirect costs for the duration of the project. The centers will continue to function after the end of NSF funding for CETP-PA as the means to institutionalize curricular changes through conducting professional development events, sharing written resources, and loaning out hands-on and manipulative equipment.

Numerous people are involved in CETP-PA. It is led by the Project Director and Principal Investigator. He is assisted by five Co-Principal Investigators. The project has two Community College Coordinators and one K-12 Coordinator (with an opening for another one). There are six State-wide Workgroup Chairs and 67 other members of State-wide Workgroups. Each of the 14 universities has one or two Team Leaders, for a total of 22. Of the 379 people who are team members, 65% are university faculty, 22% are K-12 teachers, 5% are community college faculty, 3% are university students, 2% are business employees, and 3% are other types. Each university has one team member designated as Evaluation Liaison. The Advisory Committee has 10 members, and the National Visiting Committee has six members plus a NSF Representative. The Steering Committee has 49 members, all of whom have a position listed above. Three external evaluators from the National Council for the Improvement of Science Education (NCISE) work on the project's evaluation.

Four statewide workgroups have been formed to provide descriptions of teacher education programs at SSHE universities, lists of resources, and recommendations for curricular change. Both content and pedagogy courses are targeted for reform. These four workgroups are Elementary Science, Secondary Science, Elementary Mathematics, and Secondary Mathematics. Two more workgroups that do not deal with curriculum also have been formed. One deals with supervision of field experiences in K-12 schools for university students preparing to be teachers. The other workgroup seeks to improve science and mathematics teaching by starting with more and better teacher candidates. The issue of how the workgroups might be most helpful has not yet been resolved to everyone's satisfaction. Efforts by local CETP-PA teams have sometimes placed them ahead of the curriculum and supervision workgroups even though the latter were intended to provide guidance to the former. Most of the recruitment activity currently being done is occurring at the statewide rather than the local level.

The NSF funded the Collaboratives nationwide based on the following “basic premise”: “The mathematics, technology, and science that prospective teachers learn as part of their undergraduate education, and the manner in which the courses are presented, have a critical influence on the quality of their teaching” [1, p. iii]. The SSHE proposal for the CETP-PA project stated, "Constructivist teaching practices are recognized by current research as the most consistent with how individuals learn." The proposal went on to say that constructivist teaching involves finding out what students already know and then teaching in ways that help students link, in their own individual learning styles, new information to their already existing cognitive frameworks and knowledge.

The first CETP-PA conference was held August 21 – 25, 2000, at Indiana University of Pennsylvania. Jim Gallagher from Michigan State University was the main presenter. He explained the categories used in three Teacher Analysis Matrices that contrast didactic and constructivist teaching. Participants in breakout groups viewed videotapes of classes and analyzed them using these matrices. The project’s external evaluators also presented information and raised issues.

A smaller conference at Bloomsburg University of Pennsylvania on March 9 – 10, 2001 focused on the use of inquiry and learning cycles in teaching science. Advice and examples were given in physics by Lillian McDermott and Paula Heron from the University of Washington, in chemistry by James Reeves from the University of North Carolina, Wilmington, and in biology by Anton Lawson from Arizona State University. Dr. Lawson also talked about project evaluation using the Reformed Teaching Observation Protocol (RTOP).

During the Western Region conference at Butler County Community College on April 28, 2001, presentations were given about three sets of recommendations [2] [3] [4]. Each participant was given a copy of the third publication, which is a report of a NSF invitational workshop held in 1998. Small group discussions on that Saturday were followed by reporting of recommendations concerning community college participation in the CETP-PA project.

On May 9 – 10, 2001, at Millersville University of Pennsylvania, James Gallagher was again the primary presenter at a CETP-PA conference. His topic was teaching science for understanding and application of knowledge.

The second CETP-PA summer conference was held August 16 - 18, 2001, at Bloomsburg University of Pennsylvania. The following presenters each gave a plenary address and led a workshop: Priscilla Laws from Dickinson College about teaching physics, Deborah Ann Moore from the University of Puerto Rico about teaching mathematics, Judith Scotchmore from the Museum of Paleontology at University of California Berkeley about teaching earth science, Gordon Uno from the University of Oklahoma about teaching biology, and Dorothy Waninger from Lakeview School in Ridley Park, PA, about teaching elementary school science and mathematics. Many meetings were held for groups within the CETP-PA project, such as center directors and workgroup chairs. Local teams displayed posters highlighting their accomplishments during the first year of the project
.

On November 29 – 30, 2001, the Indiana University of Pennsylvania CETP-PA team ran a conference about constructivism and the Pennsylvania K-12 standards for mathematics and science. Participants in breakout sessions discussed these topics. James Stith, from the American Institute of Physics, spoke in the final session of the conference about the need for education reform.

(Continued on page 18)

(Continued from page 17)

The next CETP-PA conferences occurring this year will be the Western Region conference at the Community College of Allegheny County on April 27, the Eastern Region conference at Bucks County Community College on May 31 – June 1, and the third summer conference at Millersville University of Pennsylvania on August 15 – 17.

At the local level, the main CETP-PA efforts have been content course revisions, K-16 professional development activities, curriculum materials purchased and made available for loan, pedagogy course revisions, recruitment of K-12 teacher candidates, and supervision of student teachers shared by content and pedagogy university faculty. This list is in descending order for the level of involvement at the present time on the 14 campuses.

Physics 101 class at Slippery Rock. The students are using string telephones to observe the difference in the speed of sound through the air and through the string. (photo credit: Keith Boyer, Indiana University of Pennsylvania)

Each type of activity was incorporated into the project to strengthen what might be a weak link in the teacher preparation process. The content course revisions, for example, try to get content faculty to improve their instructional methodologies. The rationale is that they should model the type of instruction that their students should later utilize. At the same time, they should improve the pre-service teachers' understanding of mathematics and science. Pedagogy course revisions are being done with the intention of incorporating more content. To improve courses generally, local CETP-PA teams have sponsored discussion groups, loaned materials, and held faculty workshops. They have also targeted their efforts at specific courses, usually based on the willingness of the faculty to work on course revision. According to evaluation guidelines adopted by this project, each campus should provide data on changes in at least one pedagogy course and at least one content course. Currently more attention is being devoted to the content courses.

K-12 professional development first of all tries to improve the quality of the teaching by cooperating teachers with whom university students are placed for student teaching and other field experiences. By being an example and by giving advice, cooperating teachers have great influence on university students. K-12 professional development also is aimed at affecting the teaching environments in which graduates begin their careers.

Credible and timely evaluation information is being used to monitor and adjust CETP-PA activities as part of formative evaluation of the project. Baseline data will be compared to subsequent data to measure the project's progress toward accomplishment of its long-range goals. Summative evaluation will begin in 2004. The methods being used for data collection include document review, survey questionnaires, individual interviews, focus groups, and classroom observations. University students, faculty, and administrators are among the people being interviewed by telephone or in person. Observations of student teachers, cooperating teachers, and university faculty are being recorded on the CETP-PA Protocol for Classroom Observation. Multiple data collection activities involving personal and documentary sources are being used to counteract problems associated with respondent bias and self-report data. Responsibility for data collection is shared among the Project Director, Co-Principal Investigators, project staff, campus Team Leaders, campus Evaluation Liaisons, Center Directors, and NCISE external evaluators. Analysis of both qualitative and quantitative data is done mostly by the NCISE external evaluators.

References

[1] National Science Foundation, Division of Undergraduate Education. (1996). *Teacher preparation awards: NSF collaboratives for excellence in teacher preparation awards*. NSF 96-146.

[2] National Research Council, Committee on Undergraduate Science Education. (1999). *Transforming undergraduate education in science, mathematics, engineering, and technology*. http://www.nap.edu/catalog/6453.html

[3] National Research Council, Committee on Undergraduate Science Education. (2001). *Educating teachers of science, mathematics, and technology: New practices for the new millennium.* http://www.nap.edu/catalog/9832.html

[4] National Science Foundation, Division of Undergraduate Education. (1998). *Investing in tomorrow's teachers: The integral role of two-year colleges in the science and mathematics preparation of prospective teachers*. NSF 99-49.

Web sites

- Slippery Rock University Center for Mathematics, Science, and Technology Education http://www.sru.edu/depts/cmste/
- The East Stroudsburg University MaSTER Center (Math, Science and Technology Educational Re-

(Continued on page 19)

(Continued from page 18)

source Center)

- http://www.esu.edu/master
- The Bloomsburg University Mathematics and Science Learning Center http://orgs.bloomu.edu/msc/index.htm
- Electronic Collaborative for Excellence in the Preparation of Teachers http://www.ecept.net/

Patsy Ann Johnson is a Professor at Slippery Rock University of Pennsylvania in the Department of Secondary Education/Foundations of Education and is the Director of SRU's Center for Mathematics, Science, and Technology Education. She serves as a Co-PI and Western Coordinator of CETP-PA. She teaches courses offered by the Department of Chemistry and Physics. She was a high school teacher of physics and mathematics.

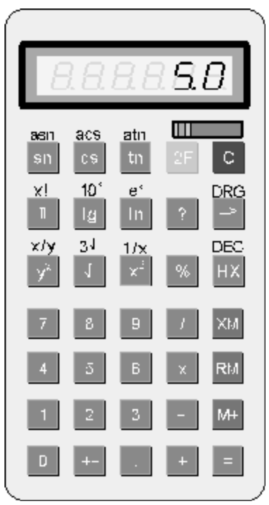
P. James Moser is a Professor and Chair in the Department of Physics and Engineering Technology at Bloomsburg University of Pennsylvania. He serves as a Co-PI and Eastern Coordinator of CETP-PA. Previously, he worked as an electrical engineer and as a government analyst.

Robert A. Cohen is an Associate Professor of Physics at East Stroudsburg University of Pennsylvania and is the Director of ESU's Math, Science and Technology Education Resource Center. He teaches a secondary science methods course. His research is on the structure of winter storms.

Joan E. Mackin is an Assistant Professor at East Stroudsburg University of Pennsylvania in the Department of Professional and Secondary Education. She was a teacher of physics, physical science, and mathematics; a science department chairperson; and a science coordinator in K-12 school districts.

Mathematical Physics for All

Stewart E. Brekke



The advent of the cheap arithmetic and scientific calculator has made the standard high school mathematical problem solving physics course, Physics First or last, available to all students. The use of calculators, both scientific and non-scientific, in a high school mathematical physics for all, is essential (1). Many at risk and even highly motivated students are often weak in their basic arithmetic as well as in their algebra. At one time in the past the standard mathematical course for all, first or last, was not possible because the students were in many cases unable to do long division, fractions and decimals by hand. Solving physics problems was not possible very often. Even though most students could understand how to do the problems, they could not get the correct answer because they could not do their fractions and decimals properly. In the inner city, and probably elsewhere, physics and chemistry courses often degenerated into reviews of basic arithmetic skills instead of concentrating on the physics at hand (2). Therefore, the qualitative course such as Conceptual Physics was invented.

Scientific notation is made easy by simply using a calculator such as the TI-30, provided the students were shown how to enter the quantities. I have found that using a cheap arithmetic calculator to multiply and divide was sufficient for even at-risk students if a review of adding and subtracting signed numbers was done. Therefore, problems using $E = mc^2$, converting the mass of a proton into energy requiring scientific notation was easily done by all students from those at risk to the most motivated. A foundation in scientific notation must be made first however. Using graphing calculators is mostly confusing to first year physics students and a simple scientific calculator such as the TI-30 is much better for all students taking physics for the first time.

Also, when the standard and most widely used high school physics text was Holt, Rhinehart and Winston's *Modern Physics*, many students of all types faltered, especially when the physics teacher provided little direct help and relied erroneously upon the thinking capacity and ingenuity of the novice students. The old *Modern Physics* text often had few examples of how to do the physics problems and there were few drills and practices on each type of problem in the book. Often high school teachers such as myself had to take one problem from a set and make up a worksheet using one formula such as I = V/R and giving three problems solving for each variable I, V and R during the class period. This was followed by assigning for homework six additional problems solving for all variables.

That is why there was an almost immediate shift by many physics teachers from the most widely used high school physics text book, *Modern Physics*, authored at that time by Trinklein et al to the Murphy and Smoot *Physics: Principles and Problems*, published by Merrill, when it appeared about 15-20 years ago (3). This book had an example for each type of physics problem and quite often 7-10 practice problems. Finally, the long established principles of educational psychology, such as drills and practices and

(Continued on page 20)

(Continued from page 19)

examples for each problem type, were used to enhance learning in the standard high school course. Physics teaching was much easier since the teacher did not have to make up a set of problems generating drills and practices using a particular formula and the students could use the example of how to solve each problem if they needed to refer back to the text for help.

Many at-risk students I have found do not learn from examples in the book or from examples on the board. They learn from the teacher going around the room showing them how to do a particular problem and then practicing on two or three more of the same type so that they get the idea of how to do a particular physics problem. As time goes on the students usually become more independent in their problem solving and laboratory work. With this extra help, the many at-risk and less motivated students become good physics problem solvers and even potential physics majors. Many university physics researchers and teachers would be surprised at the variety and kind of high school students capable of doing the standard problem solving mathematical course. With success in problem solving using calculators, all of the students become interested in the course and look forward to coming to the course each day. Also, we provide all the students with a true understanding of physics and the capacity to go on in the sciences as well as enhancing their rationality and organized thinking.

I have found that all students can do basic modeling of laboratory data, using simple models of curves and their formulas put on the board such as lines, parabolas and hyperbolas. They identify the basic equation for the curve after plotting the data if they use an approximate best-fit approach. With repeated help at the beginning of the course most students can find the approximate formula of any phenomena they take data on. Again, the scientific or simple arithmetic calculator has helped enormously in the calculation of various quantities in the laboratory situation such as calculating the approximate height of the school building using the stopwatch to time the descent of a rock. The calculator has made the doing of physics, problem solving and labs, much easier for all students, and allows them to concentrate on the phenomena under study rather than on tedious hand calculations. This is especially true for at-risk type students. Cheap stopwatches also have made many labs possible that were not available to students before such as finding the period of a simple pendulum and even approximating the speed of sound.

Mathematical Physics First, second, or last, for all high school students, is certainly possible and realistic in my opinion especially with the text formats such as in Zitzewitz (4), the newer edition of the old Murphy and Smoot, and the advent of the cheap arithmetic and scientific calculator. Having worked with inner city students, for many years, I have been repeatedly successful in this endeavor. We can give the many students who are often at risk and weak in their algebra and arithmetic, as well as higher level students, real physics, not the smoke and mirrors of the qualitative course. My experience in the inner city high schools of Chicago in providing the standard mathematical course to all has shown me that there is a great untapped pool of potential high school physics students who are capable of passing a true problem solving physics course. We physics teachers have not reached them and must do so. The mathematical course is needed because it provides the students with the capability of going on in the sciences, a true understanding of physics, and enhances rational and organized thinking.

References

1. Brekke, S., "A Mathematical Physics For All Students," The Physics Teacher (1999) vol. 37, p 557.

2. Brekke, S., untitled letter to the editor, Physics Today, (Aug. 1986) vol. 39, no. 8, p.?

3. Murphy, J. T. and R.C. Smoot, Physics: Principles and Problems (1982), Merrill & Co.

4. P. Zitzewitz & R. Neff, Merrill Physics: Principles and Problems (1995), Glencoe/Mc Graw-Hill.

Stewart E. Brekke is a retired physics and chemistry teacher in the Chicago Public School System. email: sbrekk@cs.com, 100 W. Roosevelt Ave, Bensenville, IL 60106, 630-521-9668

Browsing Through the Journals

Thomas D. Rossing

• In a guest comment entitled "Format and content in introductory physics" in the January issue of *American Journal of Physics*, Peter Lindenfeld reminds us that physics is a subject of insights and ideas. He suggests that we may be spending too much time trying to improve the mathematical facility of our students. Which aspects of physics do we think is most important: Physics is beautiful? Physics is useful? Physics is fundamental to chemistry, biology, and engineering? Physics teaches problem solving? Physics is an essential component of the knowledge of an effective citizen? Let's do our best, he challenges us, to see that students remember the wonder, the connections, the excitement of discovery, and the poetry of the universe.

• An article "Does Class Size Matter" in the November issue of *Scientific American* discusses the results of several recent efforts to reduce class size in elementary schools. Although fewer students in a classroom seems to translate into less noise

(Continued on page 21)

(Continued from page 20)

and disruptive behavior, most of the studies examining whether smaller classes really do improve academic performance have been inconclusive, the authors conclude. This includes a large project in California in which more than $5 billion has already been invested. On the other hand, Wisconsin's project SAGE and Tennessee's project STAR appear to demonstrate performance benefit, especially for minority pupils. A scientific paper by the same authors is in *Psychological Science in the Public Interest* **2**(2), 1-30 (May 2001).

• During much of the 1970s, more than one in three physics students at two of China's top universities was a woman. Today the number has plummeted to fewer than one in 10. This is prompting concern among many academics, according to an article in the 11 January issue of *Science.* "It's a backward movement that must be checked," commented Wu Ling'an, a senior physicist with the Chinese Academy of Sciences. Wu is helping to plan international conference on women in physics next March in Paris.

• "How do we know if we are doing a good job in physics teaching?" is the title of a paper in the January issue of *American Journal of Physics* that is based on a talk by Robert Ehrlich upon receiving the 2001 AAPT Award for Excellence in Undergraduate Teaching. The author believes that we need to consider what effect we are having on our students, both in terms of their understanding of the subject and their attitudes toward it. Two examples of unfavorable student attitudes are that physics is primarily about "memorizing and using formulas" and that physics is "unrelated to experiences outside the classroom." Physics teachers who try to assess their own competence face the same problem as professionals in any field: Incompetent people generally are quite unaware of the depths of their incompetence, whereas highly competent people are highly critical of their own performance and are continually seeking ways to improve.

• According to a note in the January 11 issue of *Science,* a new $160 million NSF program to improve math and science education in the nation's elementary and secondary schools will build on the latest buzzword in science education: partnerships. The intended partnerships are between university scientists and local school districts. According to Judith Ramaley, who head's the NSF education directorate, "It's going to take years and years, and there are no magic bullets." Goals of the new program are to "reduce the number of teachers teaching out of field (without the appropriate degree), increase the availability of material that engages students, and raise the number of students taking courses that prepare them for college."

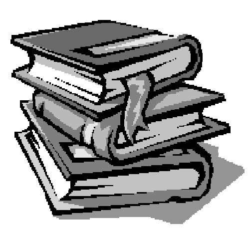
• Stanford economist Paul Romer argues that U.S. universities deliberately under produce science and engineering graduates because they are so expensive to train, according to a note in the 21 December issue of *Science*. The solution is to pay universities to turn out more scientists and engineers. Romer asserts that "Most schools will do the right thing if you make it worth their while." His ideas have already formed the basis for new legislation, the Technology Talent Bill (S. 1549 and H.R. 3130) that would create a competitive grants program at NSF for universities that promise to boost the number of undergraduates majoring in science, mathematics, and engineering. Congress gave the NSF $5 million to start a pilot project to test the thesis even before it took up the authorizing legislation. Romer's argument rests on two assumptions that many educators question: There is a large reservoir of qualified students interested in majoring in science and engineering, and U. S. universities have excess capacity to handle such an influx.

• The largest environmental problem reported in a 1995 survey of U.S. schools by the General Accounting Office was "acoustics for noise control," according to an editorial in the January 21 issue of *Sound & Communications*. Fortunately something is being done about it. A draft standard for classroom acoustics has been submitted for review to the American National Standards Institute (ANSI). The standard establishes minimum requirements for sound isolation and provides limits for reverberation and noise in the classroom.

• A new general education curriculum for undergraduates at the University of Arizona eliminates the laboratory science requirement, according to an article in the December/January issue of *Journal of College Science Teaching.* Instead, faculty are now required to provide students with hands-on, inquiry-based experiences directly in the classroom. To assist faculty with the new course design, an undergraduate peer teaching program was introduced. Peer teachers, called "preceptors," lead group discussions and provide fellow students assistance with writing and problem solving.

• Science teacher Gail Green has an unusual problem that most teachers would be happy to have, according to a story in the January 16 *Chicago Tribune*, The 7th and 8th grade girls in her after-school math and science club are complaining that they're not getting enough math problems. Green leads a Girls in Engineering and Math (GEMS) group each week. The club is just for girls because "girls tend to do better when they are with all girls." Club activities include listening to guest speakers, solving problems, group projects, and an occasional field trip.

Thomas D. Rossing is Professor of Physics at Northern Illinois University, DeKalb, IL. He has been an editor of the Forum Newsletter for six years.



FEd Executive Committee

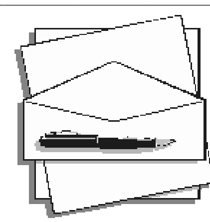
Jack M. Wilson, Chair CEO, UMassOnline One Beacon St. 26th Floor Boston, MA 02108 (617) 287 7160 JackMWilson@JackMWilson.com	Kenneth S. Krane, Chair-Elect (also Chair of Program Committee) Department of Physics Oregon State University Corvallis, OR 97331-6507 (541) 737-1692 kranek@physics.orst.edu	Wolfgang Christian, Vice-Chair (also Chair of Nominating Committee) Physics Dept., Dana Bldg. Davidson College, PO Box 1719 Davidson, NC 28036 (704) 892-2322 wochristian@davidson.edu
Kenneth J. Heller, Past Chair (also chair of Fellowship Comm.) School of Physics and Astronomy University of Minnesota Minneapolis, MN 55455 (612) 624-7314 heller@mnhep.hep.umn.edu	Morton R. Kagan, Secretary-Treasurer 784 St. Albans Drive Boca Raton, FL 33486 (561) 393-1700 mkagan@bellsouth.net	Peter D. Zimmerman, Forum Councillor Zimmerman Associates 10125 Nedra Dr. Great Falls, VA 22066 (703) 759-0600 peterz@erols.com
Ernest I. Malamud, Gen. Mem.-At-Large Fermilab 16914 Pasquale Road Nevada City, CA 95959 (530) 470-8303 malamud@fnal.gov	Ramon E. Lopez, Gen. Mem.-At-Large Univ. of Texas, El Paso El Paso, TX 79968 (915) 747-7528 relopez@utep.edu	Richard W. Robinett, Gen.Mem.-At Large Dept. of Physics Penn.State University 104 Davey Lab University Park, PA 16802 (814) 863-0965 rick@phys.psu.edu
Gay B. Stewart, APS/AAPT Member-At-Large Department of Physics University of Arkansas Fayettesville, AR 72701 (501) 575-2408 gstewart@comp.uark.edu	Dean A. Zollman, APS/AAPT Member-At-Large Department of Physics Kansas State University, Cardwell Hall Manhattan, KS 66506-2601 (785) 532-1619 dzollman@phys.ksu.edu	Paula R. L. Heron, APS/AAPT Member-At-Large Dept. of Physics, Univ. of Washington PO Box 351560 Seattle, WA 98195-1560 (206) 543-3894 pheron@phys.washington.edu

Non-voting members of the FEd Executive Committee

James J. Wynne, WebPage Administrator IBM/T.J. Watson Research Center Yorktown Heights, NY 10598-0218 (914) 945-1575 jjwynne@us.ibm.com	Fredrick Stein, APS Director, Education and Outreach Programs, One Physics Ellipse College Park, MD 20740-3844 (301) 209-3263, stein@aps.org	John L. Hubisz, AAPT Representative 1604 S. Salem St Apex, NC 27502-7251 (919) 362-5782 john_hubisz@ncsu.edu

APS COMMITTEE ON EDUCATION (COE): Robert Clark (Chair), Beth Cunningham, E. Dan Dahlberg, Shila Garg, Martin Paul Gelfand, Leon Lederman, Usha Mallik, Helen Quinn, Kenneth Krane, Jack Wilson

The Newsletter Editors invite you to write a letter to the editor or propose an article for the next issue



Spring issue **Deadline for Contributions February 1**	**Summer issue** **Deadline for Contributions June 1**	**Fall issue** **Deadline for Contributions October 1**
Ernie Malamud Fermilab 16914 Pasquale Road Nevada City, CA 95959 (530) 470-8303 malamud@fnal.gov	Stanley T. Jones College of Arts and Sciences University of Alabama, Box 870268 Tuscaloosa, AL 35487-0268 (205) 348-5050 stjones@bama.ua.edu	Thomas Rossing Department of Physics Northern Illinois University De DeKalb, IL 60115-2854 (815) 753-6493 rossing@phys.niu.edu