FORUM ON EDUCATION

of The American Physical Society
Fall 1999

Notes from Washington: Science and Math Education

Rush Holt

Many of you are familiar with my passion for improving physics education. And as we sadly know, far too many U.S. students finish high school without mastering the challenging mathematics and science necessary for success in higher education. I have written previously of the need for highly qualified teachers; those with both a strong disciplinary knowledge as shown by a major in the field taught, and also a substantial knowledge of education.

In addressing this need, U.S. Secretary of Education Richard W. Riley announced the formation of the National Commission on Mathematics and Science Teaching for the 21st Century. The Commission is chaired by former U.S. Senator and anstronaut John Glenn and will create an action strategy aimed at improving the quality of teaching in mathematics and science classes nationwide.

I am pleased to be a participating member of the Glenn Commission. Joining Senator Glenn and myself are 22 other Federal, state, and local officials, as well as academics, educators and business leaders from around the country. The Commission will meet periodically over the next year to review the current state of K-12 mathematics and science education, with a focus on teacher recruitment, preparation, retention and career-long professional growth. Our report to the Secretary, due in the Fall of 2000, will contain a detailed statement of our findings and conclusions, together with recommendations for specific action steps that Federal, state, and local policymakers can take in improving the qualifications of teachers involved in science and math education.

During the first meeting of the Commission, on September 23rd, we discussed both ways of supporting teachers directly and ways of improving teaching methods. We continue to hear that teachers need to be treated more like the professionals they are. They need time for professional development and lesson preparation. Teachers generally receive far fewer hours of professional development than professionals in other fields.

Several members of the Commission are concerned that schools are competing for teachers of math and science with high-tech industries that pay much higher salaries. Many qualified teachers are being lost to business.

Richard Ingersoll, sociologist at the University of Georgia, presented a paper for our meeting which specifically points out that math and science teachers are more dissatisfied with their jobs than other teachers and, as a result, they are more difficult to retain. Understanding why math and science teachers are dissatisfied with their jobs might give us some indication of how to address their needs.

The Commission should consider what is the role of the community in dealing with the problems of math and science education. How can community resources be leveraged to address the problems? Businesses are facing problems finding qualified workers. How can business, working scientists, and parents work together with teachers, schools, colleges of education to improve the teaching of math and science?

For more information on the Glenn Commission, please visit the web site at <www.ed.gov/americacounts/Glenncom.html>. At this web site you will also be able to read Commission presentations and concept papers and forward your recommendations. I encourage you to participate in this process.

Rep. Rush Holt (D-NJ) is a physicist and former chair of the Forum on Education. He served as assistant director of the Plasma Physics Laboratory at Princeton University.

Rep. Rush Holt was named to the prestigious National Commission on Mathematics and Science Teaching, headed by Astronaut/Senator John Glenn (left) and U.S. Secretary of Education Richard Riley (right), at a Captiol Hill ceremony.

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U.S. Physics Team Wins Three Gold Medals and Two Silver Medals at the 30th International Physics Olympiad in Italy

Mary E. Mogge

The United States Physics Team had its second best year ever at the annual competition for high school students. Three team representatives (Peter Onyisi, Andrew Lin, Benjamin Mathews) won gold medals and two (Natalia Toro, Jason Oh) won silver medals. Peter Onyisi was the top US competitor, placing 10th. Both he and Andrew Lin had competed in the 1998 Olympiad held in Iceland. Natalia Toro had previously won the top award in this year's Intel Science Talent Search. A tally of scores placed team USA third behind Russia and Iran.

This year's Olympiad occurred from July 18th through the 27th at the University of Padua. The university is the second oldest university in Italy, and its physics building is named after a former teacher - Galileo Galilei. The US representatives were five of 291 physics students from 62 countries who took the two five-hour exams - one in experimental physics and, then two days later, one in theoretical physics. The experimental exam was an investigation of the properties of a torsion pendulum consisting of a variable length cylinder clamped to a steel wire that could be oriented as either a horizontal or vertical rotation axis. The theoretical exam consisted of three problems involving the absorption of laser light by a gas in an expandable container, the magnetic field due to a vee-shaped current-carrying wire, and a model of the slingshot effect used to accelerate a space probe.

The five United States Physics Team representatives who traveled to Italy in July were selected from almost 1200 physics students nominated by their teachers. A preliminary exam in late January narrowed the field to approximately 175 semi-finalists. Using theresults of a second exam in March, as well as letters of recommendation and transcripts, the 24 members of the US Physics Team were selected. They met at the University of Maryland for an extensive training camp in early June. After eight days of tutorials, laboratories, problem sets, and exams, five team representatives and an alternate (Nilah Monnier) were selected. The five were accompanied to Italy by coaches Mary Mogge and Leaf Turner and by AAPT Executive Director Bernard Khoury. The 24 members of the US Physics Team (with their teachers and high schools) are:

- Owen Baker (Michael Morrill, Columbia HS, Maplewood, NJ),
- Raymond Cassella (Dominick Capozzi, Baldwin Senior HS, Baldwin, NY),
- Tanner Fahl (Carey Inouye, Iolani School, Honolulu, HI),
- Nicholas Guise (Penny Valentini, Centerville HS, Centerville, OH),
- Devon Haskell (Robert Shurtz, Hawken School, Gates Mills, OH),
- Steven Hassani (Gregory Matthes, Robert E Lee HS, Springfield, VA),
- Charvak Karpe (Pratima Karpe, home schooled, Stillwater, OK),
- Abraham Kunin (Deborah Ormond, Virgil I Grissom HS, Huntsville, AL),
- Andrew Lin (Jonathan Gadoua, Choate Rosemary Hall, Wallingford, CT),
- Benjamin Mathews (Stephen Balog, St. Mark's School, Dallas, TX),
- Nilah Monnier (Caroline Evans, Brookline HS, Brookline, MA),
- Anthony Nannini (Alan Kersey, Waubonsie Valley HS, Aurora, IL),
- Jason Oh (Edwin Lewis, Gilman School. Baltimore, MD),
- Peter Onyisi (Cynthia Beals, Phillips Exeter, Exeter, NH),
- Paul Oreto (Caroline Evans, Brookline HS, Brookline, MA),
- Marc Popkin-Paine (Mark Kinsey, St. John's School, Houston TX),
- Tomokazu Sato (Jeff Levy, Horace Mann School, New York, NY),
- Alexander Schwartz (Mary Quinlan, Radnor HS, Radnor, PA),
- Katherine Scott (Virginia Baner, Montgomery HS, Skillman, NJ),
- Dmytro Taranovsky (Robert Siskind, Long Reach HS, Columbia MD),
- Ryan Timmons (Leonard Klein, Wylie E Groves HS, Beverly Hills, MI),
- Natalia Toro (Karen Peterson, Fairview HS, Boulder, CO),
- Kevin Wang (Robert Shurtz, Hawken School, Gates Mills, OH), and
- Joseph Yu (Glenn Malin, University HS, Irvine, CA).

The team is coached by Dr. Mary Mogge - academic director (professor of Physics at California State Polytechnic University - Pomona), Dr. Leaf Turner - senior coach (physicist in the Theoretical Division of Los Alamos National Laboratory), Dr. Warren Turner -coach (physics teacher at the Brunswick School, Greenwich, CT), Boris Zbarsky - junior coach (MIT undergraduate, member of the1996 and 1997 teams, and gold medalist in 1997), Jennifer Catelli -senior lab assistant and Ryan McAllister - lab assistant (both University of Maryland graduate students). The support staff is headed by Maria Elena Khoury and Patrick Knox at the American Association of Physics Teachers. Major financial support is provided by AAPT, the American Institute of Physics, and its member societies. The XXXI International Physics Olympiad will be held in Leicester, England from July 8th to 17th, 2000. If you are interested in nominating a student and do not receive an application by early December, please contact Maria Elena Khoury at AAPT [telephone: (301) 209-3344 or email: mkhoury@aapt.acp.org].

Mary Mogge, Professor of Physics at California State Polytechnic University-Pomona, has been a coach of the US Physics Team since 1995, and is currently academic director.

Separate but Equal?

Thomas D. Rossing

One hears much about the pros and cons of separate math and physics classes for girls and boys. A number of teachers report success in attracting girls into physics classes where they don't have to compete with boys. Not surprisingly, however, segregation by gender has received some very strong criticism.

The thinking behind these "experiments" has been that girls tend to lag behind boys in math and science (as boys are likely to struggle more with verbal skills). Boys generally cause more disruptions, while girls shrink from asking questions. Obviously these patterns don't apply to everyone, but they apply to enough boys and girls to suggest that single-sex classes may have some value. The arrangement also has the potential advantage of removing the distraction of the other sex. Many students focus better if they aren't tailoring their classroom behavior on their romantic aspirations.

Naturally organizations such as the National Organization for Women are raising objections to classroom separation of the sexes. Pelleston, Michigan is among schools that have been under fire for offering single-sex schools. NOW officials say the Pelleston program is "based on stereotyping." Some critics even compare segregation by gender to the "separate but equal" racial segregation that took place for many years. But this seems to beg the question. Certainly no one thinks that having a girls' locker room is akin to having "colored" facilities.

Title IX was enacted to give males and females equal athletic opportunities, not identical ones. Federal law doesn't compel colleges to field only coed athletic teams—it only requires them to give women as many opportunities to compete as men.

If single-sex classes are found to improve the performance of boys or girls or both, a rather strong case can be made for them. But then what about small schools that can't afford to offer separate physics classes for boys and girls? Are students at such schools placed at a disadvantage? We strongly encourage persons who have opinions about single-sex classes or who have had experience with them to participate in a forum by submitting letters to the editor. That's what this newsletter is for!

The APS Mass Media Fellowship Program: A Progress Report

James J. Wynne

The Forum on Education, led by Natalia Meshkov of Argonne National Laboratory, developed a proposal to create the APS Mass Media Fellowship Program as a vehicle to improve public understanding and appreciation of science and technology. Approved for a trial period of three years by the APS Council in November 1995, this program provides an opportunity for physics students or physicists who are early in their careers to work over the summer as science reporters at radio stations, television stations, newspapers, and magazines throughout the country. An APS committee selects the Fellows from a pool of applicants . The Fellows' applications are forwarded to the AAAS Mass Media Science and Engineering Fellows program, which acts as a matchmaker to place the Fellows with host mass media organizations. This article is a synopsis of the first three years of the program.

In its first year, 1997, two Fellows were selected, David Kestenbaum, PhD in Physics, 1996, Harvard, and Jeffrey Chuang, BA in Chemistry and Physics, 1996, Harvard. At the time of his fellowship, Kestenbaum was working full-time at Fermilab. With his APS Mass Media Fellowship, he spent the summer at WOSU, a small AM public radio station in Columbus, Ohio, affiliated with National Public Radio (NPR). That experience thrust him into the real world of journalism and put him in touch with people at *Science* magazine, who subsequently hired him as a science writer. He worked at *Science* until March, 1999, when he was hired full-time by NPR to be a radio science journalist. The APS Mass Media Fellowship program provided Kestenbaum with an entre into science journalism, and he has quickly established himself as a high quality reporter.

At the time of his fellowship, Chuang was a full-time graduate student in physics at MIT. With his Fellowship, he spent the summer at the Dallas Morning News, where he wrote several physics stories as well as math, technology, and chemistry stories. Currently, he is a 3rd year graduate student studying polymer physics, expecting his PhD in 2000. After finishing his PhD, he will consider switching from science to science journalism, but he is likely to stay with science. If so, he feels that the program better prepared him to talk to the media and to explain media issues to his scientist peers.

In its second year, 1998, two Fellows were selected, Nellie Andreeva, MS in Physics and Broadcast Journalism, 1993, Sofia Univ., Bulgaria, and Aziza Baccouche, BS in physics, 1995, William and Mary. At the time of her fellowship, Andreeva was (and still is) a graduate student at the University of Maine, Orono. She spent the summer at Business Week magazine, writing about mathematics, and chemical, electronic, andbiological technology. She was a regular contributor to the "Science & Technology Developments to Watch" page, and has written additional columns since returning to the Univ. of Maine. Upon completion of her PhD, she plans to pursue a career as a science writer. At the time of her fellowship, Baccouche was (and is) a graduate student at Univ. of Maryland, College Park, expecting a PhD in Physics 2002. She spent the fall at CNN in Atlanta, learning how to producescience news packages for television. She worked on biology, internet, and vehicle technology stories. Her experience confirmed her plan to pursue a career in science communication upon completing her PhD. This year, 1999, a single Fellow was selected, Ilana Harrus, PhD in physics/astrophysics. 1996, Columbia University. At the time of her fellowship, Harrus had just completed a postdoctoral fellowship at the Harvard-Smithsonian Center for Astrophysics. She worked this past summer as a science writer at the Raleigh News & Observer, covering local rather than national or global stories. She was writing for the general public, not for a targeted audience of scientifically-literate readers. Harrus points out a problem that she had in accepting the Mass Media Fellowship. She was initially selected in 1998 but had to turn down the fellowship, because she was in the middle of her two-year postdoctoral job at the Center for Astrophysics and felt that taking a leave for 3 months to work as a journalist would have been frowned upon. She believes that even applying for the Mass Media Fellowship was taken as evidence that she was not fully committed to her research project. However, she reapplied for 1999, with the summer Fellowship serving as a bridge between her post-doc and her current job at NASA Goddard Space Flight Center. Her immediate plans are to find science publications for which she could write freelance. Ultimately, she wishes to become a full-time science writer.

Pleased with the initial success of the Fellowship program, at its meeting on March 21, the Forum on Education (FEd) executive committee unanimously passed the following motion: "The FEd executive committee is proud of the APS Mass Media Fellowship program and requests Council to approve a 3-year extension." I placed this motion before the APS Council at its meeting on May 21, where it was amended to state that the program should become an ongoing activity of the APS. Council unanimously approved this amended motion.

So the program will continue. At the end of their fellowship tenure, whether or not they become full-time journalists or return to traditional science careers, the APS Mass Media Fellows will serve as a resource for the physics community to facilitate and enhance our communications with the mass media, and ultimately, the public.

Jim Wynne is Program Manager, Local Education Outreach at the IBM T.J.Watson Research Center. As Forum Councillor, he represents the FEd on the APS Council.

Nominations

The Nominating Committee requests that members of the Forum on Education submit nominations for the following offices: Vice Chair, APS-AAPT member at large, and APS member at large, all of whom will serve on the Executive Committee.

The vice chair will become chair-elect, chair, and past chair in successive years.

Nominations may be made by email <wilsoj@rpi.edu> or by FAX (518/276-8661) to the Vice-Chair Jqack Wilson, who also serves as chair of the nominating committee.

Nominations may also be made through the Forum website which gives details of the nomination process.

Letters to the Editor

Nontechnical Chapter in PhD Thesis?

To the editor:

As I was writing my Ph.D thesis at Princeton University, I had an inspiration for including an introductory chapter written at a relatively nontechnical level, in the hope that I might finally be able to enlighten my family, friends, and other nonspecialists interested in the nature of my research. So I wrote up a discussion of my project with the sort of language one might find in Popular Science, Scientific American or the New York Times, and set it down as Chapter 1. Then I went to see my thesis advisor. As one might expect given the traditional nature of Ph.D. programs, I soon found myself in a protracted "discussion" with my thesis advisors. My advisors felt that my proposed nontraditional approach was to be avoided, apparently since no self-respecting dissertation (Ivy-League or otherwise) should begin with the sort of colorful language I had chosen to help my envisioned nontechnical audience connect with my subject matter. Scientists who absent-mindedly ignored the Table of Contents and started reading Chapter 1 might find it childish, thereby causing my reputation to suffer, etc.

However, I felt strongly that before suppressing all emotion and falling into the dry, objective scientific style of the main thesis text, I should try to present the deeper, more basic truths which had given me the bizarre desire to spend six years wandering through the vast uncharted intellectual wildernesses of cutting edge-research and doing my part to push the Endless Frontier back a little further. I wanted to capture some of the spirit, beauty and value of my field and phrase it in a way that would demonstrate to my friends and family that my adventures in research had been valuable for more than obtaining a doctoral diploma. But how could I persuade my advisors that I had hit upon a good idea?

I argued that scientists working out on the frontiers of knowledge really ought to take more time to "write home", so to speak. It is widely commented (especially in these pages) that science in the U.S. has a glaring weak spot: although our research enterprise is one of the most advanced in the world, compared to other industrialized nations our general population is among the most poorly informed about basic scientific facts and ideas. Research scientists tend to be very good about going to conferences to share their results with one another, but not as good at diffusing their knowledge to the general public and those who teach them. After all, most of us must publish (for each other) or perish. However, there are several reasons why one might wish to encourage or require scientists to develop and practice skills in communication with nonspecialists as part of scientific training and professional conduct. One might well argue that since the majority of scientists conduct research using public funds, we have an obligation to try to make our research results comprehensible to the public who pays for them, as well as other scientists. From a utilitarian viewpoint, meanwhile, civilization is better served if everyone can reap the benefits of the diffusion of scientifically-proven knowledge.

"Everyone" knows that many of the great physicists such as Faraday and Feynman were also masters at sharing the essentials of their research with the public. Where are the Faradays, Feynmans and Carl Sagans of today? Perhaps we in the U.S. should be training our physicists to emulate Faraday and Feynman not only in the quality of their research, but also in their skillful and entertaining dissemination of research results.

It turned out my advisors agreed completely with me about the importance of diffusing scientific knowledge; they just didn't see why that required starting my thesis with a nontechnical introduction. In fact, one of my advisors had been required to give a Faraday-style public lecture, complete with demonstrations and audio-visuals, as a requirement of his own Ph.D. program at the Ecole Polytechnique Federale de Lausanne in Switzerland, and he thought that U.S. schools might benefit from that approach. I thought that was a great idea too, if I'd had more time to plan for it, but under the circumstances it would have been difficult to get a presentation and audience together for a public lecture just as I was scrambling to finish my degree. And, I confess, I didn't want to see my beautiful introductory thesis chapter go to waste.

So instead I tried to make the case for keeping the non-technical chapter in the thesis.

My reasoning began with the observation that a doctoral research project is typically the first extensive research project carried out by a young scientist, and the Ph.D. thesis represents a summary of what was learned on that intellectual expedition. It serves as a record of achievement for the doctoral candidate, and hopefully blazes an interesting trail into the unknown, pushing back the frontiers of science and marking the way for others who wish to follow or explore nearby areas. The process of documenting one's work is essential to the scientific enterprise, for it ensures that the essential knowledge gained by an individual researcher is added to the sum total of human knowledge and not simply forgotten. The Ph.D. thesis represents the final portion of the training of a new scientist, and is the place where one is required to document one's work.

Building on this, it seemed to me that if the sharing of scientific knowledge with nonspecialists and the public deserves to be considered a professional responsibility of practicing scientists, then, I concluded, it stands to reason that a Ph.D. project should include a component in which the student documents his or her work for an audience larger than his/her own scientific specialty. I said that the natural way to do this would be to incorporate material for nonspecialists into the thesis itself, in the form of a non-technical summary and discussion. I had done mine as an extended introduction, but as I discussed the issue with my advisors we realized that it could also have been in the conclusions or an appendix. Personally I felt that relegating the exciting non-technical summary of the project to the conclusions or an appendix would bury the material where few people would be likely to read it.

At this point I was fired up; some intuitive sense of elegance, rightness, justice and truth was resonating well with this idea I had hatched, and I began to acquire grand visions of taking on the University and the academic establishment. I wanted to advocate that not only should I be allowed to have a nontechnical introductory chapter, but in fact *all* Ph.D. dissertations should be *required* to have such a chapter! It hadn't been much work for me, it was fun, and I thought it was the right thing to do. So why not? I noted that the exercise in presenting one's thesis topic to a non-technical audience would be of practical use for students who are seeking jobs in industry or in different fields or subfields than their Ph.D. research. Meanwhile, after getting the nontechnical background and summary out of the way, the second chapter of the thesis could build upon it and follow up with a more traditional technical introduction suitable for scientists within the author's specialty.

Alas, my vision of transforming the academic world was put on hold when the realities of the student-advisor relationship became clear. In the end my advisors put their collective foot down (very nicely; they were very tolerant of my youthful ambitiousness) and said (in effect) that I wasn't going to graduate with a non-technical introduction. But they were happy to see me include my non-technical material in the thesis as Appendix A: Background for Non-Specialists. And my family loved it!

So I would like to raise this question in the Forum: just what sort of writing and presentation skills do we feel our graduate students ought to be developing in the course of their graduate studies? The APS claims to promote both the advancement *and* diffusion of the knowledge of physics. Why not match reality to rhetoric by revising academic degree requirements? If we want the scientific community to be aware of the value and power of education and outreach, if we want effective science education and teacher training, and if we want public science literacy and improved political decisions about science, then how should we be training our newly-minted scientists in the skills they will need to achieve these goals?

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An Experiment in Physical Science Education Reform

To the Editor:

Your lead editorials, Art Hobson's letter on outreach and Sheila Tobias's APS Centennial Talk on reform (Summer 1999, pp. 1-4) prompt us to report on progress this year to integrate science and technology learning experiences with undergraduate curricula in disciplines other than science. In the spirit of Northeastern University's Academic Common Experience (Science 1996, 27 September, 273:1794), and with NSF support, we have set out to develop laboratory and field science activities and experiences that are naturally embedded within courses in the curricula of other disciplines.

Our intention is to actively engage undergraduate students in the enterprise. During the past two Quarters, we solicited student contributions via two courses: an engineering graphics course primarily for engineering technology students, and an introductory physical science course primarily for students in disciplines other than science and engineering.

In the graphics course (32 students; lecturer: EWH) which taught computer-aided drawing, a term project was assigned to design a 1500-sq. ft studio/laboratory to accommodate about two dozen art, architecture, and music students for weekly 2.5-hr sessions of science activities and experiments tailored to their disciplines. Designs addressed three principal characteristics: aesthetic, technological, and pedagogical. Students developed their designs following a visit to a campus site in initial stages of renovation for this studio/laboratory. For honors credit, several students also prepared comprehensive laboratory manuals of integrated sets of progressive cumulative science experiences for use in their designed spaces.

In the introductory science course (49 students; lecturer: BH), a number of interactive-engagement activities we call Leading Motives (LMOs) were introduced into lectures. LMOs are student-conducted lecture demonstrations based on selected ConcepTests (http://galileo.harvard.edu), with class discussions taking place before and after presentation of each LMO. A term project was also assigned, in which each student proposed a science experience based either on an LMO, or on her/his own major discipline or extracurricular interest. The project, intended primarily as an exercise in preparing an experimental scientific protocol, addressed three characteristics: that the experience be cross-disciplinary, that it mesh seamlessly with study within a particular discipline, and that individuals conducting the experience recognize the direct relevance of the experience to the discipline. Written reports addressed nine specific issues, including the purpose of the experience, scientific question to be asked, interpretation of results, and comparison with theory or with what is known. We were pleasantly surprised to find that students chose topics with little or no duplication and that their written reports are largely commendable models of experimental protocols. Examples of individual topics include: kinetics of slalom skiing; bungee jumping; volleyball serve; geometry of perspective drawing; angular momentum and gyroscopic control; observation of a total solar eclipse; color preference and personality; effect of light wavelength on plant growth; sound and hearing; non-verbal communication; perception of optical illusions; echoesin musical performance spaces.

A primary objective of our experiment is to empower students to take initiatives to examine the general relevance of the scientific method and to apply their own individual backgrounds and interests to proposing science activities and experiments in disciplines other than science. The success was beyond our wildest expectation. The quality and creativity of students' ideas merit publication and dissemination, perhaps via a web site, which we are currently considering. We invite inquiries and comments from Forum readers.

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Science Curriculum Goals at Odds with Academia Supported Pseudoscience

Alan J. Scott

I assigned a non-traditional homework problem the last week of classes this past semester. My objective was to get my calculus based, introductory physics students to actively reflect upon what science is and what it is not. The students were given a reading assignment that discussed the philosophy of science and then directed to answer a simple, yet probing question.

To set the stage, let me provide you with a brief synopsis of a seminar that took place at the University of Wisconsin-Stout during the spring semester 1999. I attended a presentation on Astrology and Life Work at the Third Annual Celebration of Women and Leadership conference. The presenter put forth her knowledge of astrology in a manner that suggested it was founded upon observations and science, and that its foundations were *mostly* accurate. She stated "Everything has a vibration and resonance and this influences or 'imprints' us at birth." I did not engage the presenter or participants in a debate about the accuracy or usefulness of such a topic at a Women's Leadership conference. I only observed.

The students in my physics class were given two reading assignments. One assignment was to read the essay A Public Debate On Science, Pseudo-Science, and Spiritualism[1] from the APS newsletter Physics and Society. The other essay was Cargo Cult Science[2] by Richard Feynman. After having read these essays and my description of the Astrology seminar on campus (similar to the above paragraph), they were directed to complete the following assignment:

Your task in this assignment is to write a brief essay describing your position on this subject and whether you feel it would be OK for UW-Stout to use its resources and tuition money to fund such astrology presentations.* Please provide arguments supporting your position. I will be very flexible in grading this assignment. Such that, there is no "right" or "wrong" answer to this question. I will simply be looking for how well you support your position when evaluating this assignment for credit.

The results were interesting and I was pleased with the candor present in all of the essays from students. Out of 38 students, 24% supported funding such seminars, 53% were against funding, 5% suggested "maybe fund", and 18% wrote at length of their science philosophy but never answered the question! Two of the students elaborated upon their own psychic experiences. *In many cases, the arguments used to support one's position reflected some deficiencies in their philosophical understanding of science.* This was true even for the group of the students against funding astrology seminars. In this group, I found such responses as:

"To me extra tuition money should go to improving the technology and aid experiments with specific benefits that can be shown…(funding astrology seminars) is fine for bigger schools that have continuing research on this sort of information with no specific benefit."

"But I wouldn't be strongly opposed. I don't believe that it is in the best interest of the University to try and change people's beliefs and establish fact from fiction."

"Astrology and numerology are too much of an abstract science."

Some of the student essays that came out in support of funding astrology seminars included statements like

"The person (presenter) should produce an analysis of his/her work on a consistent basis. The analysis should consist of facts….I believe that Stout should put forth money…I have been involved in a psychic experience and I thought that it was really stimulating to know what was about to happen…"

"(Yes)…as long as they back up their information with proof."

"I feel that tuition money should be used to fund presentations. By exposing students to different types of science, they will have a broader knowledge base to form an opinion about pseudo sciences."

It should be pointed out that many of the students that supported funding astrology seminars, did not necessarily believe it to be an accurate field of study. Some believed it was a false science but felt that equal access in presenting viewpoints was a loftier goal. One student that took a religious approach to argue against funding stated "I think the study of astrology and other bogus beliefs are not just wrong but are also evil. The devil put these ideas and beliefs into people's mind to stray them from the truth of the Bible or other natural proven sciences."

So what statements can be made about the results of this student assignment? First of all, the results are anecdotal and merely suggestive, but no solid conclusions can be obtained from such a small data set. A more detailed and comprehensive study needs done. However, a study[3] of the general population done in 1990 indicates 60% believe in astrology and 67% have had a psychic experience. So these results may not be too far apart from the average introductory physics student. One thing seems clear upon evaluating this assignment. *Only a small fraction of the students have formulated a sufficiently refined understanding of science to effectively distinguish between real science and bogus science.*

So how should science faculty respond to having astrology or other pseudo-scientific presentations on campus? point - in the preceding paragraph, I have tacitly labeled acupuncture as being pseudo-scientific. The *American Journal of Physiology* has just reported a study[9] on cats that link acupuncture with a release of endorphins, which in turn produced a lower blood pressure in the animals. So could acupuncture have some merit in humans beyond any psycho-physiological effect?

The road to reduce credulism and increase the general public's understanding of science is exceedingly bumpy. Traveling it requires patience, a humble awareness of the human condition[##] Morris Shamos in his book The Myth of Scientific Literacy[10] indicates that one major obstacle in encouraging scientific literacy is self-delusion. He states "This huge disparity between what average adults actually know about science and what they believe they know strikes at the heart of the problem, for it means that most adults know all they need or want to know about science. Changing that perception is prerequisite to even thinking about ways to encourage adults that attaining scientific literacy may be worth the effort…As the historian Daniel Boorstein put it so well, 'The great obstacle to progress is not ignorance but the illusion of knowledge.' ", and a keen knowledge of the applicability or limitations of scientific models.

Alan J. Scott
University of Wisconsin-Stout

References

*University of Wisconsin-Stout resources were used to support this seminar but I do not know if tuition money was directly used to defray the costs. The students, when completing this assignment, were to assume that tuition money was used.

[1]A. Scott, B. Salt, K. Parejko, "A Public Debate on Science, Pseudoscience, and Spiritualism from the Perspectives of a Physicist, Sociologist, and Biologist," Physics and Society, (APS Forum Newsletter), October 1998, p. 7

[2]R. Feynman, "Surely You're Joking, Mr. Feynman!" (Bantam Books), 1985, p. 308

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www.nctm.org/standards2000/

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www.project2061.org/tools/benchol/bolframe.html

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Developing Robust Technique for Introductory Physics Classes

Gay B. Stewart

Many instructors have had the experience of having the students do extremely poorly on an exam question over a type of problem for which they thought their students well prepared. To partially rectify this problem, we have introduced an additional subdivision of the problems of our introductory E&M course. This subdivision, called a problem type, divides problems into groups that could be solved through the same general reasoning process. This allows the expression to the students of the range of kinds of questions they are responsible for on homework and exams, including conceptual and graphical problems.

Division of the problems into problem types allows an educational designer to ask the following question: "Is the technique for solving the problem type deduced by the student from the class materials accurate, sufficient, and reliable?" That is, does the technique the students deduce from the course materials work for each problem fitting the type and are the solutions relatively free of error? Surprisingly, for some crucial types of problems using tradition introductory textbooks, the answer is no.

We use and compare electric potential difference ΔV exclusively without computing the general potential function V. This strategy lets the student work with a more concrete object and avoids the necessity of providing visualization techniques for another function. The best selling introductory textbooks define the potential difference as $\Delta V = V_f V_i = - \int_i^f \boldsymbol{E} \bullet d\boldsymbol{s}$, where the integral is taken along the path from I to f and $d\boldsymbol{s}$ is an element of that path. The texts stress the relation of the above integral to work and that $d\boldsymbol{s}$ points in the direction of the path.

We applied the above definition of the potential difference to the potential difference between a point a distance r from a point charge Q and infinity, $\Delta V = V_r - V_\infty = -\int_\infty^r \boldsymbol{E} \bullet d\boldsymbol{s}$. $\boldsymbol{E} = kQ/r^3\boldsymbol{r}$ and $d\boldsymbol{s} = -d\boldsymbol{r}$ would be assumed by a student, since the integration path is inward from infinity. Substituting everything and doing the math gives $\Delta V = V_r - V_\infty = -kQ/r$, which is not correct. So a student actually thinking about the physics of the potential difference produces an incorrect sign. Therefore, the technique the student naturally deduces from the textbook examples is inaccurate for many problems.

The problem arises from the conversion of the path integral to a simple integral; with limits $\int_\infty^r dr$, the element dr is negative, so the correct choice for the displacement is dr, which points in the – direction. Students are unlikely to consider the sign of dr when writing the integral. Note it is not that the physics of the textbook is incorrect, but that a student deduces an incomplete technique from a necessarily incomplete collection of examples, because the instructional focus of the textbook is slightly different than that of a specific instructor.

There are many instructional options for eliminating the particular error above that can be delivered in lecture to augment the text. One can teach the correct conversion of the path integral, immediately use the independence of path of a conservative force to write a general integral yielding a potential function, or teach the computation of the absolute magnitude of the potential difference and use of a qualitative argument to fix the sign. We use the last option because it also has the benefit of connecting the potential concept to the work done by the field in each potential calculation.

An incomplete set of examples for a given type of problem can cause the student to deduce an incomplete solution technique. This type of error will only begin to be fully eliminated from physics instruction with careful quantitative characterization of the information actually delivered in a class.

This is an exciting time to be a physics educator. New technology and new methods are introduced at an every-increasing pace. The above piece of educational engineering is a tiny piece of the overall design of a course. However, we strongly believe that progressive improvement in physics education will only come with the kind of quantitative measurement and relentless attention to fine detail that has made physics itself so successful.

Gay Stewart, an assistant professor of physics at the University of Arkansas, Fayetteville, is a member of the FEd Executive Committee. Her research interest is "educational engineering," modeling educational offerings so they can be successfully evaluated, optimized and adapted to other institutions.

Are Definitions and Formulas Important?

Thomas D. Rossing

Are precise definitions and formulas important in physics? Most physicists would probably answer in the affirmative. Should students in a physics course be encouraged to learn them? On this question one hears diverging opinions. Should students be encouraged to memorize them? On this question, most teachers would answer in the negative.

My own feeling is, I guess, that definitions and formulas should both be learned in context. The physics textbooks that I have written incorporate glossaries at the end of each chapter, and I encourage students to keep a bookmark at the glossary page as they read each chapter. Although a term is generally defined when it is first used, this definition may slip away from the reader, and it is important to be reminded of it when the term comes up again.

Many things that are branded as "misconceptions" about physics come from a misunderstanding of definitions. The term "momentum" has been borrowed by politicians, sports writers, and newscasters to describe a "trend," and it is in this connection that a student is most likely to have heard the term used. Likewise a "quantum jump" is used to describe a big change rather than a very small one. In a recent article in *Scientific American* (see "Browsing Through the Journals"), Arthur L. White, Executive Secretary of the National Association for Research in Science Teaching, cites an example: "Density equals mass divided by volume," a child is told–and immediately tries to relate this to firsthand experiences: attending Sunday "mass," turning the "volume" knob on the radio, being called "dense" by a sibling.

Formulas are a different matter. When my students ask what formulas they need to know for an exam, I strongly urge them not to memorize formulas because that will give them a false sense of security. If they have done (or seriously attempted to do) their assigned homework, they will know that $F=ma$ without sitting down to memorize that formula. At the same time, I realize that for many students who have not yet learned to apply abstract reasoning to solve problems, memorizing formulas may be their only hope for obtaining a (barely) passing grade. (I will no doubt catch heck from readers for making that statement, but I'm afraid it's true).

For visual persons like me, it is often easier to remember a graphical representation of a functional relationship between two variables than a formula. I want my beginning students to be able to easily recognize graphs resembling $y=\mathrm{k}x$, $y=\mathrm{k}/x$, and $y=\mathrm{k}x^2$. I want physics or engineering students to recognize that a +graph of $y=\mathrm{k}x^n$ has a slope n on log-log graph paper and that $y=\mathrm{e}^x$ is a straight line on semi-log graph paper. I want all students to be able to read and to draw graphs with linear and logarithmic scales (isn't this an important part of scientific "literacy"?)

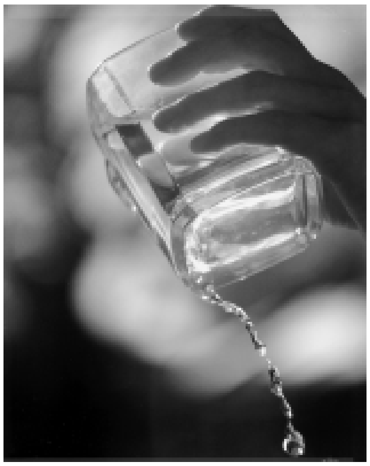
So, I guess my answer to the opening question is that definitions and formulas are both important in physics, but when it comes to learning physics, formulas are not nearly as worth learning as definitions. Do others agree with me?

1999 AAPT High School Physics Photo Contest

Each year, AAPT supports a high school photo contest. Physics students are challenged to submit a black and white or color photo illustrating a physics concept. The students are required to take the photo themselves and include with it a written summary of the physics occurring in the photo. The follow four photos were among the winners in two different categories: Contrived and Natural.

FIRST PLACE — Natural Category

Cohesion, Adhesion, and Refraction



Laura Rosow, Wayland H.S., 264 Old Connecticut Path, Wayland, MA 01778
Teacher: Kenneth Altshuler

Cohesion: Water molecules beneath the surface area of the water exert a stronger force than do the air molecules above. This causes the surface area of the water to be minimized, resulting in the formation of streams and droplets.

Adhesion: The streams of water flowing down the side of the glass form because of attractive forces between the water molecules and the glass, which work against the forces of gravity.

Refraction: Light rays pass from one medium into another in which the speed of light is different, causing the thumb to appear bent and broken in places.

FIRST PLACE — Contrived Category

Center of Mass

Lissah Lorberbaum, John Burroughs School, 755 South Price Rd., St. Louis, MO 63124
Teacher: J. Mark Schober

A near empty or full can of soda will topple. However, when a can contains between 40 mL and 200 mL of liquid, due to the redistribution of mass in the can, a new center of mass exists. A perpendicular, dropped from the center of mass to the surface the can sits upon, lands within the can's base. Therefore the can balances.

SECOND PLACE — Natural Category

Puddle of Light

Maria Allocco, Niles West H.S., 5701 Oakton St., Skokie, IL 60077
Teacher: Martha Lietz

Light reflecting off a smooth, shiny surface exhibits specular reflection: incident parallel rays are reflected parallel, thus the image of the sky appears clear. A raindrop falls onto the puddle, and small waves are created because of surface tension. These transverse waves have a direction of motion perpendicular to the wave crests, which occur when particles are pushed upward from their equilibrium position.

HONORABLE MENTION — Natural Category

Reflection

Kendall Brodarick, John Burroughs School, 755 South Price Rd., St. Louis, MO 63124
Teacher: J. Mark Schober

The reflection is so clear because there is no light coming from the surface through the water to the camera. This is because of total internal reflection; the light coming from the surface is reaching the surface of the water at an angle beyond the critical angle, thus instead of being refracted, the light is reflected back through the water such as it does not reach the camera. However, some of the light that comes from the outside scenery is refracted into the water and is not reflected to the camera like the rest of the light. This accounts for the fact that the reflection seen on the water is darker than the actual objects.

Report from the EPS Forum on Education: a Correction

Gunnar Tibell

The Summer issue of the FEd newsletter inadvertently printed an outdated report (see p. 13). The Editor regrets this error. Here is the correct report from Dr. Tibell.

From many different countries in Europe one hears about difficulties in making young people interested in the natural sciences. Things do not look the same everywhere, of course, and there are also differences between topics within the sciences. Closer connections to environmental problems might, for instance, give biology and chemistry a greater significance, compared to physics, in the minds of young people. In a symposium on Physics studies for Tomorrow's Europe (Gent, Belgium, April 1995), many examples were given of the declining interest for physics. There is also a decline at the university level as a natural consequence of the decline in secondary schools. In an attempt to analyze the situation more closely some possible causes for this trend were indicated in the Gent meeting:

- physics is considered difficult,
- in some countries the teaching in schools seems to have stayed behind modern developments in physics which, in turn, could point to a third comment,
- physics teachers are not given the opportunity to continue their own education, or, do not take the opportunities actually at hand.

There is also a lack of balance between the number of boys and girls in physics classes: boys dominate. However, it was recognized that this might also look different in different countries. It is estimated that having examples is an important issue, and in this regard countries like France, Italy, Poland or Spain have definite advantages over, for instance, the Scandanavian countries. There are many women working in physics in the former countries, whereas in the latter it is unusual to find a female professor in the universities.

In 1993 the European Physical Society, EPS, set up a Forum on Education, to be concerned with the situation for physics in the schools. It was hoped that the national physical societies would play a more active role, for example, by encouraging contacts between schools and academic research. Such measures have been taken in many countries, but there are others in which improvements could be made.

An inquiry was made during 1994, under the auspices of the Forum, concerning the conditions in the different countries. About two thirds of the 37 member societies replied. The questions asked were very much geared towards information on the degree of contacts between school teachers and university researchers. Indeed, many physical societies have education or teacher sections as part of their structure, with activities of various kinds. Internationally, many of them engage themselves in the Physics Olympiads and other competitions. They help in organizing preparatory events within their school system in order to select the best national team. In-service training of school teachers is another activity of great concern to some of the interviewed societies. In countries where few teachers are physical society members and therefore few society activities concern school education, there may instead be frequent contacts with existing teachers' associations.

More intense and more frequent contacts between academic researchers and physics teachers working in primary and secondary schools might be one way of curing the last two causes mentioned above of a diminishing attraction for physics. The ambition would be to keep up or even raise the level of the competence of school teachers. It seems reasonable to believe that teachers would be stimulated if they are informed about new results in physics research, if they get help in designing demonstration experiments in physics, if discussions are encouraged on the contents of courses on all levels, and if there is a collaboration in organizing competitions in problem solving or performing model experiments in physics. Of course, the way future teachers are originally trained for their jobs in the schools could also be the subject of discussion.

In most secondary schools in Europe the pupils choose which line to follow in the last few years of their secondary school. In order to recruit more of them to physics one could encourage the pupils to visit research laboratories or physics related industry, or at least have them exposed to some inspiring presentations of modern physics and all its applications in everyday life. CERN has been very helpful in this respect by inviting young people and (beginning a few years ago) teachers to spend a few days in the very stimulating environment of an active, international research laboratory.

The EPS Forum on Education has set up a board to discuss the ways to proceed, with activities on the European scale. A first task was to participate in the jury for choosing the best physics textbook for secondary schools, a competition sponsored by the Amaldi Foundation in Italy. In September 1996 the Forum organized a session on physics education at the tenth EPS Trends in Physics conference in Sevilla, Spain. In was quite successful, and many contributed papers were given orally or presented as posters. Another activity of the EPS Forum has been to set up a pattern for teacher exchanges between different countries. During the school year 1997 - 1998 a pilot project was completed involving teachers from Sweden and the United Kingdom. We hope to continue these exchanges with other countries participating.

Prior to the recent general EPS Conference in London, September 1999, the Forum organized a seminar, labeled "Securing the Future of Physics". During this seminar, which took place at Malvern College in England, there was also time for discussions on the public awareness of physics—part of what was called "outreach" at the APS Centennial meeting in Atlanta. About three fourths of the presidents of the European national physical societies were present as well as the EPS president, Sir Arnold Wolfendale. At the Malvern seminar a new project was demonstrated, Bridges through Physics, intended to become a Europe-wide television series with parallel video production for educational purposes. In this project EPS is associated with the the British Institute of Physics and OMNI Communications. There were also demonstrations of some of the running international physics competitions, like the IYPT, the International Young Physicists' Tournament. An interesting outcome of the Malvern seminar was a set of recommendations to the EPS Executive Committee and Council for furthering the cause of education within the society.

In EPS the so called Interdivisional Group on Education, of which the Forum is a part, also has a branch directed towards university physics education. This is supported by the European Commission and is called EUPEN, the European Physics Education Network. Well over 100 university physics departments are associated with EUPEN, which has now completed its third year of activities. Extensive investigations have been made within the network in order to map the situation with regard to curriculum, examinations and other practices as well as possible didactic research and the student experience within the different departments. There is some hope that the Commission may continue to support these activities for several years in the future.

The EPS initiated a program for student exchanges some years ago. Today close to 200 major universities take part in what is called EMSPS, the European Mobility Scheme for Physics Students. Part of the financing, especially for Eastern and Central Europe, has been covered by grants from the European Union, but EPS also contributes some scholarships. The stay abroad can last from 3 to 10 months. As coordinator for such exchanges at Uppsala University, I have seen how well it works and how much the students profit from such an experience.

For countries with physical societies or corresponding organizations, such as the Institute of Physics in the United Kingdom, which are already very active in promoting the interest for physics on all levels, in schools and universities as well as with the general public, an EPS initiative to activate the national societies may seem superfluous. However, it is my belief that information about the activities in those countries could serve as examples for others and thus increase the efforts in pursuing the important task to promote the interest in physics among young people in Europe.

The Forum wishes to get in contact with other organizations with similar goals, such as the IUPAP International Commission on Physics Education, the Forum on Education of the American Physical Society and GIREP, the International Research Group on Physics Teaching. Some attempts to establish such contacts have been made, and hopefully this article may serve the purpose of getting in touch with the corresponding APS activities. I am thankful for the opportunity to report on some things we are doing in the EPS Forum on Education.

Gunnar Tibell, Chairman of the EPS Forum on Education, is a member of the faculty at Uppsala University.

Molecular Beam Research at a Liberal Arts College: A Physicist's Experience

James W. Cederberg

I needed help. It was the fall of 1964, and I was just beginning a career on the faculty of the physics department at St. Olaf College. Like most new PhDs, I hadn't had anything in graduate school to prepare me to teach classes, and had not even had the common experience of being a graduate lab assistant. At least my graduate advisor, Norman Ramsey, had encouraged me to take a college position, a career many university researchers still treat with disdain. But here I was, facing a class for the first time, not knowing much about how to do it. My new mentor and department chair, Tom Rossing, was there to provide guidance, though he always left the decisions up to me. Many a lunch hour was spent in his office discussing the process. Somehow I made it through that term, and began to feel comfortable about sharing physics with my students in class.

But then, Tom began to exert some pressure in another direction. He believed that physics faculty, even in a liberal arts college setting, should be encouraged to actively engage in research which included undergraduate students. He himself had an active project going, with NSF support, studying spin waves in magnetic thin films. My thesis work, in molecular beam magnetic resonance spectroscopy, just didn't seem to be possible on this scale. Granted, it was "small physics" by comparison with accelerator or reactor work, but the beam was still much too expensive for me to hope to build one at St. Olaf. I just didn't have any good ideas for manageable small research.

In those days the NSF had a program called URP, for Undergraduate Research Participation. St. Olaf had received grants beginning in 1960 that provided summer stipends of $60 per week to students, and a smaller amount for faculty supervisors, and supplies. Several of the projects were related to Tom's thin film work, but there were also others. Duane Olson, another department faculty member, used the opportunity to build up a program in nuclear physics. Two students put together a Mossbauer system which could be used to examine the magnetic fields acting on the iron nuclei in the films. Another student constructed a beta spectrometer.

Where could I fit in to this? Although I did know something about magnetic resonance from my thesis work, there didn't seem to be much that I could contribute to the spin-wave work. Given that the emphasis of the NSF URP program was on the students, I proposed using it to build a Stern-Gerlach apparatus for the advanced laboratory. So, I spent the summer of 1965 building the apparatus, a table-top atomic beam system using the deflection of a beam of potassium atoms by an inhomogeneous magnetic field to show the spacial quantization of electron spin. This was good physics, giving students an opportunity to work with vacuum technology and learn some basic quantum mechanics and statistical mechanics, but it was not research. The student who worked with me on it, however, went on to earn a PhD at UC-Davis.

During the summer of 1967 I worked at the University of Michigan with Prof. Jens Zorn using the molecular beam electric resonance technique to study the hyperfine interactions of NaCl. The use of electric fields instead of magnetic fields made the apparatus seem more manageable. The vacuum system was still much larger, and needed much lower pressures, than the Stern Gerlach, but there seemed now to be a possibility of putting together a system which could be used for real research at St. Olaf. I worked out a plan for a much simplified vacuum system, and received a small grant from The Research Corporation for materials. I got it to the point of seeing a beam, but not any resonance spectra, when some disastrous vacuum failures did it in. My cost-saving shortcuts had not provided enough protection against such things. It was another dead end, and again I needed help. Meanwhile, two students who worked on it with me went on, one (David Johnson) earning a PhD at Harvard and the other (Dave Nitz) at Rice.

The 70s were a stressful time for physics. The bloom of the discipline had faded, with drops in the number of jobs, and with that, number of students and the availability of grant support. I had abandoned my abortive attempt at building a beam apparatus. In the meantime, a new electric resonance spectrometer had been built in Ramsey's lab at Harvard. Initiated by Tom English, one of Zorn's PhD students who went on for a post-doc at Harvard, and designed and constructed by Harvard graduate students Bob Hilborn, Tom Gallagher, and Joe Checci, it incorporated several improvements on the Michigan spectrometers. Its subsequent users included Dave Johnson, who as a St. Olaf student had worked with me on my failed attempt.

When it came time for my sabbatical leave in 1976-77, I returned to Harvard to use it for a study of the hyperfine interactions in ND_3 and CsCl. It worked beautifully—much more dependably than the very difficult to maintain magnetic spectrometer I had used for my thesis. I felt I just might be able to carry on a project using this apparatus if it were at St.Olaf. As the year drew to a close, and knowing that Ramsey would be retiring from the supervision of P.d. theses within a few years, I asked whether he had plans for the spectrometer at that point. He would consider my offer to provide it a good home. Within a couple of years he was ready to say "yes". With this generous gift, I had a chance to finally, after 15 years of teaching, set up a real research project.

But I still needed help. I didn't think I could do it alone. For one thing, I didn't know much about the computer interfacing that controlled the data taking process. To my rescue this time came Dave Nitz, now back as a faculty member. At Ramsey's invitation, Dave and I joined his last PhD student (Dean Wilkening) for the summer of 1980, assisting him with his project of checking for parity and time reversal symmetry violations in the TlF molecule. It gave both Dave and me a chance to learn more about the spectrometer and the improvements that had been made since my previous visit. Dean was expecting to finish his work by the spring of 1981, but, as is often the case, Dean's project took a bit longer than planned. June 1981 arrived, and there were still some experimental checks that needed to be made before he could distinguish between a true PT violation and subtle systematic effects in the apparatus. Finally, we were able to dismantle and pack the spectrometer and load it in a van. The apparatus with its associated vacuum and electronic components, but also the stock of chemicals and other materials, the parts of previous versions of the spectrometer, even some tools arrived at St. Olaf on 3 September, the same day as the entering new students for the class of 1985.

The Research Corporation had indicated a willingness to consider continuing support for our research project, but only if we could show that we could get it working. That meant many long weekends connecting and aligning the pieces of the 21 foot long vacuum system. We had to connect the plumbing for the water cooling of the diffusion pumps, the vacuum pump exhausts, the electrical wiring. With an extra push over the Christmas vacation, we were able to get a first resonance, recorded as a trace on a strip-chart. Research Corporation was satisfied, and we were funded for the summer of 1982. Our first new research was on the molecule KCl. With two students that summer, and three the following summer, we were able to bring the spectrometer under computer control, and complete the study of KCl. Since Research Corporation was primarily interested in start-up projects, they would not provide long-term continuing funding. We needed to turn to the NSF for further support. That began in 1984, the first year that the NSF RUI (Research at Undergraduate Institutions) initiative was opened. This support continues still. I still needed help, however. Dave Nitz moved into his own atomic spectroscopy project, and was not actively involved in the beam work. Amy Kolan, a theorist, joined us a couple of years, learning how to use computer software to calculate molecular wave functions for comparison with our experimental measurements. Duane Olson joined in, contributing his considerable expertise in computer interfacing and programming to successively adapt the newly available desk-top computers for use in operating the spectrometer and analyzing the data. He continues to work on the project though now over three years into his retirement from teaching.

In the 19 years since the spectrometer came to campus, a total of 53 St. Olaf undergraduate physics students have worked on the project, for at least a summer or an academic semester. Of these, at least 22 have already earned PhD degrees, and at least 6 hold faculty positions. Nine papers have been published in refereed journals, including Physical Review A, Journal of Chemical Physics, Journal of Molecular Structure, Journal of Molecular Spectroscopy, and the American Journal of Physics. Eight papers have been presented at the annual Symposium on Molecular Spectroscopy at the Ohio State University (five of them by students), and several additional papers have been presented by students at various conferences.

The students have reported that the experience made a difference in their plans and success as they moved on for further study or work. One early collaborator (Stan Tead, now a Product Development Specialist at 3M) recently wrote:

"I still have vivid memories of my stint on the molecular beam apparatus! I am very much grateful for having had that opportunity, since in addition to being a lot of fun, it helped me in a couple of significant ways. First, it gave me a taste of what graduate research would be like, and self-confidence that I was cut out for it. Second, the Cornell Applied Physics faculty who screened applicants later mentioned that my research experience was one factor in my selection to receive an offer above other students who had higher GPA's. They said that the research work, in addition to my activities with the Society of Physics Students, Blue Key Honor Society and a couple of intramural sports, showed an energetic, well-rounded character and ability to balance responsibilities. We look for much of the same qualities when we interview at 3M."

Although most of the students have found it a very positive experience, there have been a few for whom the experience revealed that they did not wish to become research scientists. But even this result is a useful outcome of the effort. Overall, the opportunity for research has made a significant contribution to the education of all of our physics students. Those who have not participated have still had a chance to see research in progress, and the excitement of their fellow students for learning something new about the way nature works. It has certainly been worth the effort, though I would not have even begun without the prodding of people like Tom Rossing, and the help of other faculty, students, and funding agencies.

James Cederberg, professor of physics at St. Olaf College for the past 35 years, has served as president of the physics/astonomy council of the Council for Undergraduate Research. During sabbatical leaves he has done research at Harvard, Duke, Washington, and University of Canterbury in New Zealand.

Optics Experiments to GO

Mary Beth Barrett and Chris Chiaverina

We all recognize the importance of getting students actively engaged in doing physics. This may be accomplished in a variety of ways. The physics laboratory, of course, is the most common setting for investigation and experimentation. For some time, now, we have been taking advantage of a bit more unorthodox venue for exploration: the home. Using what we call a "lab in a bag" approach, students are encouraged to take home simple materials relating to optical principles in Zip-Loc bags. Everything needed to investigate phenomena ranging from reflection to photoelasticity is contained in a single plastic bag.

The "lab in a bag" experiments are intended to be engaging, thought provoking, and fun. While fun is not the principal goal of science education, these activities allow students to experience physics in a less-structured, more play-like manner. All activities are designed to be straightforward, materials are chosen with safety in mind. And finally, the low-cost nature of the materials used in these kits eliminates worry about loss.

The benefits of this approach are many. Because these activities are designed to be done with family members, parents have an opportunity to get involved in their children's education and see, on a fairly regular basis, what is going on in physics class. We also believe that when younger siblings and friends are exposed to the wonders of physics, they are more likely to take the subject. And perhaps, most important of all, students learn by doing and sharing with others.

Prior to presenting the students with their first activity, we send home a letter to parents explaining the purpose and nature of the activities. It also informs parents that their son or daughter will receive credit upon: (1) the completion of the activity with them and (2) the return of a signed sheet indicating the parents' or guardians' involvement in the activity.

The following descriptions of "lab in a bag" activities are meant to convey the flavor and scope of our carry-out optics experiments.

• Construct a Kaleidoscope—Just three weeks into the course, students are given their first "lab in a bag." In addition to three 1" by 6" mirrors and colored beads, the bag contains an instruction sheet that provides a brief history of and theory behind the kaleidoscope. The sheet also explains how the three mirrors should be arranged to form a kaleidoscope and offers suggestions for creating a variety of objects to be viewed through the scope. The resulting kaleidoscopes are absolutely stunning! Many students give their finished products to family and friends as gifts.

• Camera Physics—Students 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 virtually any camera store.

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

• Exploring Color—This lab allows students to explore the principles of additive and subtractive color mixing. Along the way, they are made aware of examples of color mixing going on all round them. Each student is given six color filters (red, green, blue, cyan, yellow, and magenta) and a pair of inexpensive diffraction glasses. Students examine the makeup of white light by looking at an incandescent bulb through the diffraction glasses. They record what they observe with crayons or colored pencils. They then place each colored filter over the glasses and see that each filter removes a different portion of the spectrum. They again record their observations with colored markers.

To observe the effect of overlapping filters, they view white light through various combinations of the filters. The hope is that students will "discover" the rules of subtractive color mixing. Placing a drop of water on the screen of a television or computer monitor reveals the wonders of additive color mixing. The drop, acting as a magnifying lens, reveals dots or rectangles of red, green, and blue. Students realize that the myriad colors seen on the screen result from the additive mixing of these three primary colors.

• Polarization—Using two small Polaroid filters, a roll of inexpensive transparent tape, a clear plastic fork, a microscope slide and small squares of acetate, students are guided through a series of activities that introduce them to the phenomenon of polarization and methods for producing polarized light. Plastic objects, such as protractors and forks, exhibit photoelasticity when viewed between Polaroid filters. Squeezing a plastic fork's tines together produces changes in the colorful stress lines revealed by polarized light. Birefringence is observed in some transparent tapes. As a result, when observed between crossed polarizers, these tapes exhibit beautiful colors. Students layer tape on a microscope slide to determine how color depends on tape thickness. Once they have created a color key, they are ready to produce polarized light art by placing carefully cut pieces of tape on an acetate substrate. The resulting artwork, intricate patterns reminiscent of stained glass and cubist art, is quite wonderful.

From the overwhelmingly positive response we receive from parents, this informal learning strategy does get families involved with physics. We have found that the activities are suitable for virtually all ages. They have been used in both elementary and secondary schools and are currently being employed in a physics course at Northern Illinois University aimed at students in the visual arts (at the university level "home" experiments are intended to attract the attention of boy friends, girl friends, and roommates, not parents).

For those interested in more "lab in a bag" activities, over 100 exploratory activities may be found in the recently published *Light Science: Physics and the Visual Arts* by T. D. Rossing and C. J. Chiaverina (Springer-Verlag, New York, 1999).

Mary Beth Barrett and Chris Chiaverina are both physics teachers at New Trier High School in Winnetka, Illinois. Mary Beth received her bachelors degree from Indiana University and is currently enrolled in the Masters in the Advanced Teaching program at Northwestern. Chris Chiaverina, who holds bachelors and masters degrees from Northern Illinois University, has taught high school physics for thirty years. He is the co-author of a textbook Light Science: Physics and the Visual Artists *(Springer-Verlag, New York, 1999).*

Browsing Through the Journals

Thomas D. Rossing

• Presidents of Europe's physics societies met last week to discuss their growing concern over the lack of students and teachers studying physics, according to an article in the Sept. 9 issue of *Nature.* In Germany, the number of first-year physics students, which peaked at 10,000 in 1991, fell to just over 5,000 last year. In Britain, the number of physics graduates training to be schoolteachers fell from 568 in 1992 to 181 in 1998. "It is a crisis situation," commented John Lewis, treasurer of the European Physical Society. Sir Arnold Wolfendale, president of the EPS, points to a lack of well trained teachers and to the low salaries they receive. "Teachers of all sorts have slipped way behind the average pay scale." The situation is not much different in the United States, where the number of students completing first degrees in physics is the lowest in 40 years, although the number of graduates in all subjects has quadrupled in that time.

• High school physics reinforces an unfortunate system of "haves" and "have nots," according to a summary of an AIP report discussed in the Sept. 17 issue of *Science.* Results from the fourth national survey of some 3500 high school physics teachers depict a two-tiered system in which well-trained teachers with adequate resources spend most of their time teaching physics to well-prepared students, while less capable students are taught by teachers with less time and resources to devote to the subject. It was found that 74% of physics teachers in schools where students are much better off than average teach mostly or exclusively physics, compared with only 21% from schools where students are much worse off than average.

The good news in the report is that the percentage of high school seniors enrolled in physics, which hit a low in 1986, has been steadily rising ever since and now exceeds 25%.

• Guaranteed to stimulate debate is an article entitled "The False Crisis in science Education" in the Oct. issue of *Scientific American*. After viewing the results of the Third International Mathematics and Science Study (TIMSS), in which America's high school seniors placed near last, national leaders (including President Clinton and Bruce Alberts, president of the National Academy of Sciences, declared a crisis to exist in America's schools. "Americans have always risen to a crisis. Let us act now to heed this important wake-up call," Alberts challenged us. However, Gregory Cizek of the University observed that declaring such crises to exist is a cyclical ritual, repeated in every decade since the 1940s. The launch of Sputnik in 1957 set off an orgy of anxiety, culminating in Admiral Rickover's book *American Education: A National Failure.* Beginning with the 1983 publication of *A Nation at Risk*, one blue-ribbon panel after another warned that massive educational failure had ceded the technological lead to Japan and other competitors. Combing the education literature of the past 30 years, Cizek says he turned up more than 4,000 articles and books in which scholars declared some sort of crisis in the schools. Each episode has eaten away at public confidence in schools.

The false crisis in science, according to the article, masks the sad truth that the vast majority of students are taught science that is utterly irrelevant to their lives. "Scientists are a major part of the problem; many think that the system is a good system because it produced them," argues William McComas of the University of Southern California. "What they need are higher thinking skills to distinguish evidence from propaganda, probability from certainty, rational beliefs from superstitions, data from assertions, science from folklore, theory from dogma," comments Paul Hurd of Stanford University. "And opportunity from crisis," the authors add.

• In spite of the fact that U.S. 12th graders fall behind on international tests, Americans have consistently demonstrated a firmer grasp of basic science facts than citizens of many countries that dramatically outperformed the U.S. on TIMSS, according to a sidebar on the above *Scientific American* article. Biennial surveys conducted by Jon Miller or the International Center for the Advancement of Science Literacy reveal that science literacy has increased among U.S. adults since 1985. Miller attributes the good showing the U.S. to its college attendance rates, which are higher than those elsewhere. College students in the U.S. are also more likely than their international counterparts to take general science courses.

• A Conference Experience for Undergraduates program arranged by the University of New Mexico and the Los Alamos National Laboratory is described in the Aug. issue of *American J. Physics.* The conference program, which centered around the APS Division of Atomic, Molecular and Optical Physics (DAMOP) meeting in Santa Fe, May 1998, included a pre-conference and a post-conference. Most of the students had never attended a major scientific conference, and therefore considerable effort was concentrated on providing them with a general impression of what to expect scientifically, socially, and logistically. Introductory lectures on three selected areas (Bose-Einstein condensates, quantum control, and manipulation and quantum computing) were presented by staff members from UNM and LANL. The conference included the Nobel Lectures by Steven Chu and William Phillips planned for the general public.

• "Resource Letter PER-1: Physics Education Research" by Lillian McDermott and Edward Redish, in the September issue of *American J. Physics*, provides an overview of research on the learning and teaching of physics as well as a wealth of references to the current literature. Most of the entries include a one or two sentence summary of content by the authors, both of whom are experts in the field of physics education research. The list of references will be especially valuable to physics teachers that aren't familiar with some of the science education journals in which important papers have been published.

• An article entitled "Deconstructing the Intellect" in the Nov. 30, 1998 issue of *Forbes* magazine reminds us that we are all either *figural, semantic,* or *symbolic* learners. Figural learners process information best by concrete pictures—say, an image of a hand with five fingers to relate the notion of "five." Semantic learners process that information verbally—the world "five" spelled out or spoken. Symbolic learners do better focusing on a symbol, like "5." The type of learner we are affects the means by which we memorize things, evaluate and classify information, the way we solve problems, even the means of our creativity.

• Although a significant number of students with disabilities are graduating with degrees in science and technology, getting a job in which they can use their skills can prove more difficult. AAAS has a program called Entry Point! That helps them get the experience they need, according to an article in the Aug. 27 issue of *Science*. The program, which was first launched in 1996 with 6 students, placed 54 students this summer at 9 NASA sites, 11 IBM locations, and at NSF. Eight of the Entry Point! students in the Washington, D.C. area capped off their internships with a visit to Capitol Hill, where they met with members of the Congress.

• German science and education were exempted from the 7.4 per cent across the board cut from the general budget for 2000, according to a note in the July 1 issue of *Nature*. The science budget, if approved by parliament, will remain at its 1999 level of DM15 billion (US$8 billion). The Max Planck Society and the Deutsche Forschungsgemeinschaft, Germany's universities granting agency, will find their budgets increased by 3 per cent, rather than the 5% originally promised.

• Poor supervision, heavy teaching loads, and a lack of decent research training are some of the problems faced by PhD students at UK universities, according to an interim report published by the Association of University Teachers cited in the July issue of *Physics World*. The report finds that the traditional one-on-one supervision of research students is becoming a thing of the past. "I've got an industrial supervisor, who's actually sponsoring me, and two academics," one student is quoted in the report. "They all want different things, so I'm basically doing three projects." Although most participants in the survey had received some formal training in research methods—mostly in their first year—it was often found to be irrelevant or too simple.

• "Creating a virtual physics department" is the unusual title of a paper in the June issue of *American J. Physics*. According to an AIP survey, 58% of colleges and universities granted fewer than 5 bachelor's degrees in physics during 1996. To address the enrollment problem, three Texas institutions use the Trans-Texas Video Network system to teach upper division courses at all three campuses in a distributed manner. A set of eight upper division courses was chosen, with two courses being offered each semester. Teaching classes via closed circuit television presented a new set of problems to the instructors, who quickly learned that traditional lectures did not work. The barrier created by television isolated the students from the instructor. Those who monitored the classes noted that the attention of the students dropped dramatically when they knew they were not on camera. The amount of material that could be covered in a TV course was found to be considerably less than in a local course.

Adding the Internet improved the course substantially, and now the Internet is used as the primary teaching medium, with the TV sessions used mainly for discussion, working out examples, and answering questions. The shift from TV to the Internet apparently allowed the amount of material covered to be comparable to traditional local courses. The question of how to include laboratory experiences in upper division courses has not yet been solved.

• A thoughtful review of *Just in Time Teaching* by Gregor Novak, Evelyn Patterson, Andrew Gavrin, and Wolfgang Christian appears in the October issue of *American J. Physics.* The book is a series of essays based on classroom experience advocating an "Active Learning" method for the use of computers and the Internet in the introductory physics course. The authors also offer a collection of free software to supplement their approach. Included in the software is a collection of simulation JAVA applet programs called "Physlets," mainly written by Christian, which the reviewer finds preferable to most commercial software. One great advantage is that they are "scriptable," meaning that they can be modified by using JavaScript, which is an interpreted language with the code embedded in the web page and interpreted when the page is loaded.

• A web debate on issues facing women in science has been opened at the *Nature* website <http: / / helix.nature.com / debates>. According to an editorial in the Sept. 9 issue, contributors to the debate are encouraged to discuss such issues as discrimination at MIT, the problems faced by women researchers in Germany, how different national governments and agencies are attempting to improve the situation, and the challenge of the issue at a European level and in the Third World.

• One hundred and twenty-three years after Daniel Gilmen, the first president of Johns Hopkins, came up with the novel idea of awarding $500 fellowships to 4 men in the class of 1876 with doctoral degrees, there are nearly 40,000 science postdocs in the United States. Many feel that they are the key to U.S. research productivity, while others feel that their contributions have not been adequately recognized. The Sept. 3 issue of *Science* has a special 22-page report on "The World of Postdocs," and they are also hosting a forum on issues related to this special report at <nextwave.org / feature / postdocforum.shtml>. Also included in the report is a sidebar on the German tradition of Habilitation, a post-PhD degree for aspiring professors in the sciences.

• The Yale University Physics Department organized a day long Physics Olympics competition for high-school students, according to a report in the October issue of *The Physics Teacher.* Unlike the International Physics Olympiad, (see article elsewhere in this newsletter), which is designed to challenge the very best students, Physics Olympics competitions focus on experimental measurements using simple fundamental physics. The underlying theme is: *Physics is fun*. The Yale Olympics was organized jointly and run simultaneously (allowing for time zones) with similar competitions in Liverpool and Perth. The competition, which took place both indoors and outdoors, consisted of five hands-on events for four-person teams. The students had no advance knowledge of the specific events, although sample events were sent to participating schools in advance. The winner this year was Guilford High School, Connecticut.

• "At a time when other countries are stepping up their efforts in research and education, Denmark risks becoming a second-rate nation," University of Southern Denmark president Henrik Tvarnø is quoted as saying in an article in the Oct. 1 issue of *Science.* Fueling this remark is a report published last month by the presidents of the country's 10 university which are publicly funded. Science teaching has suffered severely. A recent 15% cut in the staff of Copenhagen University's science faculty sent the number of undergraduate courses into a nosedive. The total number of students has remained unchanged, however, so the remaining courses are forced to admit many more students. Academic and industry leaders lay part of the blame for this sorry state of affairs on the low political esteem in which science is apparently held.

• A report on three semesters of testing a one-semester conceptual astronomy course appears in the August issue of *American J. Physics*. The course, which was described in *Am. J. Phys.* **65**, 987-996 (1997), was based on the opinions of 18 astronomy professors as to the concepts they considered most essential for their courses. These concepts were sorted into four concept clusters: cosmic distances, heavenly motions, celestial light and spectra, and scientific models. Two key pedagogical strategies used in the course included instructional concept maps and small student-centered discussion groups. The instructors used 18 focused lectures, demonstrations, and computer simulations as part of the course delivery. Over each of the three semester, large gains in conceptual understanding were recorded. On the other hand, attitude items showed no change across the course, remaining centered in the "mildly positive" range.

• The November issue of *Popular Science* has the first part (of a 3-part series) on "The Business of Education," which highlights education programs sponsored by corporations, such as the Toyota Tapestry program (which makes grants to high schools), the Intel Science Talent Search, and the Exxon Education Foundation.

• This past summer, CERN invited a group of school teachers for a program designed to enhance the teaching of particle physics, according to a report in the September issue of *Physics World*. In attendance were 23 teachers from the United States as well as nearly all CERN countries. Besides attending lectures on particle physics, the group compiled material that schools could use to carry out cheap experiments in modern physics, including experiments using homemade cloud chambers and Geiger-Müller counters. Some of the material is on the teachers' website <http: / / teachers.cern.ch>.

• A guest editorial entitled "Science Learning, Science Opportunity" by Rita Colwell, director of NSF, and Eamon Kelly, chairman of the National Science Board (NSB), in the October 8 issue of *Science* reminds us of the four key areas for action outlined in the NSB report on mathematics and science achievement (March 1999). They are (1) increased research on learning, leading to more effective educational practices; (2) coordinated K-12 and college-level academic requirements to create a seamless education system; (3) better teacher preparation and professional development; and (4) improved instructional materials.

In each of these areas, the authors point out, active contributions by the scientific community are essential for success. NSF is committed to advancing each of these goals and is making opportunities available to scientists and engineers in all disciplines. However, the authors remind us that the world of future opportunities and economic leadership will depend on broadly educated people who can understand complex problems and learn new things. "Scientists who contribute to education today have the power to open those doors for everyone."

• "Are we cultivating 'couch potatoes' in our college science lectures?" asks a biology professor in the September / October issue of *Journal of College Science Teaching*. To qualify as a couch potato, according to one marketing executive, a TV viewer has to watch more than 25 hours of TV per week (a level reached by 78 percent of the American public) and attention to specifics can be no more than 50 percent of his / her capacity. In today's highly competitive commercial marketplace, advertising need not be overly detailed to convince consumers to purchase the product. The author draws interesting analogies with what happens in many classrooms where students attend class but put little effort into the learning process. When students *are* listening, they are too busy scribbling notes to think about the substance of the lecture. Instead, students need to be challenged to try to figure things out on the basis of what they already know.

• Another interesting commentary on balancing research and teaching is given in a book *Gone for Good: Tales of University Life After the Golden Age* by Stuart Rojstaczer, reviewed in the 24 September issue of *Science*. In Rojstaczer's view, research universities are no longer focused on what should be their most important objective: providing an educational experience that enhances the intellectual talents of all students. Instead , they are primarily concerned with obtaining outside funding, and this preoccupation pressures faculty to obtain extramural funds. To keep the students happy, both the severity of grading and the rigor of course work have been decreased. In the eyes of the reviewer, however, Rojstaczer offers no new insights into how to establish a better balance, and he chooses to ignore the obvious point that there are plenty of excellent colleges and universities where the emphasis is not on grant-funded research. For research universities, the challenge of how to develop the full capabilities of students while staying at the cutting-edge of scholarship remains an open question.

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The American Association of Physics Teachers (AAPT) offers an introductory half-price membership to AS members who have not previously belonged to AAPT. The half-price membership rates are as follows:

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Qualified applicants will be considered for both programs. All application materials must be postmarked by January 15, 2000 and sent toAPS / AID Congressional Science Fellowship Programs, One Physics Ellipse, College Park, MD 20740-3843.

This Newsletter, a publication of **The American Physical Society Forum on Education**, presents news of the Forum and articles on issues of physics education at all levels. Opinions expressed are those of the authors and do not necessarily reflect the views of the APS or of the Forum. Due to limitations of space, notices of events will be restricted to those considered by the editors to be national in scope. Contributed articles, commentary, and letters are subject to editing; notice will be given the author if major editing is required. Contributions should be sent to any of the editors. The Forum on Education website is: http://www.aps-fed.org

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