FORUM on EDUCATION

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Message from the Chair: Contribute and they will come!

Wolfgang Christian

One hundred and forty years ago, Samuel Butler wrote: "I venture to suggest that the general development of the human race to be well and effectually completed when all men, in all places, without any loss of time, at a low rate of charge, are cognizant through their senses, of all that be desire to be cognizant of in all other places." It appears that Butler's grandiose vision may be closer to reality now that robust and authoritative digital libraries are coming online. Almost every professional organization is creating digital libraries using web technology to distribute high-quality content to the desktop.

For example: The German Federal Ministry of Education (BMBF) and German Research Foundation (DFG) have developed an Internet portal for scientific information that links 40 German libraries, research centers, and institutes. This portal is publicly funded and on a par with the Google search engine. It can be accessed at: http://www.vascoda.de.

The IEEE provides access to the abstracts of its journals on the IEEE Explore site. Furthermore, the IEEE has reached agreement with Google to display the content from over one million IEEE abstracts in relevant keyword search results. See http://ieeexplore.ieee.org/

The American Association of Physics Teachers (AAPT), the American Astronomical Society (AAS), the American Institute of Physics/Society of Physics Students (AIP/SPS), and the American Physical Society (APS) have initiated the ComPADRE: Communities for Physics and Astronomy Digital Resources in Education, project. This project seeks to discover and organize collections of high quality educational materials in physics and astronomy. See http://www.compadre.org/

Although ComPADRE is still in the development stage, it should be of particular interest to FEd members because it is sponsored by the APS and will almost certainly become widely used when it too is linked into commercial search engines. Researchers and curriculum authors risk missing an exciting opportunity for peer review, discussion, and distribution if they do not take advantage of this digital library. We should be submitting material to ComPADRE just as we submit our research to the arXiv preprint server.

Wolfgang Christian is chair of the Forum on Education and also a member of the Committee on Education. He is a Brown Professor of Physics at Davidson College where his primary job is teaching. His research interests are in computational physics, educational software design, and curriculum development.

Letters to the Editor

Physics First

The lack of science literacy is a serious national problem. All citizens have to be more scientifically literate in order to be able to make informed decisions on matters that could directly influence their lives. In addition, we will need an increasing number of scientists, engineers and mathematicians in order to maintain our technological and hence economic position in the world. The U.S. congress has recognized this and, among other things, has mandated the various scientific funding agencies be involved in trying to improve the situation. The Laboratory for Elementary Particle Physics(LEPP) at Cornell is funded by the National Science Foundation. Our research goals are to study the fundamental building blocks of matter. In addition, education and outreach is an important part of our mission. We felt is was appropriate to host the first workshop of its kind devoted to the Physics First movement which has the potential of having a profound influence on science literacy.

The majority of us learn most of our science content in high school. So, it is only logical to look at the way science is taught there. The present sequence of Biology, Chemistry and Physics was instituted at the end of the 19th century based on the notion that physics is the most abstract and mathematical of subjects while biology is entirely descriptive and, thus should be taught first. Today, in the 21st century, this makes no pedagogical sense. One of the main goals of Physics First is to put the high school science sequence in a rational order. Physics is the foundation of all the sciences, hence it is the basis for understanding important concepts in both chemistry and biology. For example, how can students understand modern molecular biology without some understanding of both physics and chemistry? Yet, they now encounter these topics only after they have finished their biology course, if they see them at all.

Also, presently, in this country, only 30% of all high school students ever take physics. If physics was the first course in the science sequence, then all students would be exposed to the concepts and methodology of this most fundamental science. We fully realize that any time there is an attempt to make a revolutionary change, especially in something as far-reaching as the entire high school science curriculum, there are many logistic, cultural and pedagogic challenges.

The purpose of the Physics First workshop was to gather high school science educators together to explore the nature of these challenges and the possibility of overcoming them with the hopeful outcome being a much more scientifically literate citizenry.

One of these challenges is to answer the arguments of the opponents that if physics is taught too early then students do not have the math background and hence get a "watered-down" course. It seems to us there are two fallacies with this:

1) It assumes physics and math are inseparable. Math is indeed a very valuable tool for the professional physicist but math is not physics. In the present high school courses, too many students lose sight of the concepts because there is so much emphasis on problem solving. Mathematics should be used to enhance the physics concepts, not obscure them.

2) It assumes that students who take the present problem solving based course come away with a good understanding of the physics taught. (Otherwise, why insist that this type of course be maintained?) While there is not enough space to go into the details here, national statistics and the experience of college instructors who teach these students in their physics courses seem to belie this.

Finally, it might be of interest to note that the Physics First idea is becoming a national movement. Over 250 individual high schools plus entire public school districts have already adopted it. For example, the San Diego district with 10,000 students completely switched to the physics first sequence 2 years ago; Prince Georges County school district with 13,000 students is adopting it as well as the Cambridge, Mass. district. For those of you who think that it would be difficult in New York because of the regents, the North Babylon school district on Long Island is also adopting the Physics First sequence. Of course, since we are here in Ithaca, we would hope the Ithaca School system and/or districts in the surrounding area would seriously consider it.

Ahren Sadoff, Professor of Physics, Cornell University
Lora Hine, LEPP Education and Outreach Coordinator, Cornell University

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Random thoughts on the summer newsletter

I enjoyed reading the 'Summer Newsletter' so much that I thought I must share some 'random thoughts' of my own about the issues raised in this online forum.

In the spirit of the title of this letter, I will start with the 'Random Thoughts' of Stan Jones and in particular the critical question (Thought #2): 'Why don't we reform the way we teach physics majors courses?' I think this is a question that needs dedicated discussion, research and ACTION! Along with the technological applications suggested, I think we should also review content and content focus to address this issue and perhaps its close relation to Random Thought # 4 about physics degrees. Physics knowledge and facts have grown exponentially over the last few decades and our undergraduates today participate in meaningful research programs. Do they have to learn everything we tried to and everything we now know? Which part should we emphasize and which part should we perhaps edit?

I do not have answers to the above questions, - and I have to confess that I have not kept up with current work on this, - but most curricula I see haven't really evolved that much! All I can say is that as a community, we should be involved in thinking about this for the long-term health of our field and its growth. References to the international scene have been made elsewhere in the newsletter. As physics research and development becomes increasingly global and collaborative, discussions on course content in undergraduate degrees should transcend geographical boundaries. I hope our forum might be a venue to foster this.

The article by Stan Jones about "No child left behind" also alerts us to a serious situation that we would do well to address from two perspectives. First we should explore 'workable alternatives' that could be implemented. I understand the "Institute of Physics, U.K" has initiated some programs to help alleviate a similar problem in the U.K. Secondly, if and when we have a plan, perhaps we could work at representative level to include this alternative in the legislation? Maybe we could liase with the APS Public Affairs Office and take advantage of the very effective modes they have developed to implement changes. Again, I hope our forum can take some leadership in this.

It was very interesting to learn from Art Hobson' article about the increase in science literacy in our country. I am glad we did something right and have a global edge on this! I hope too that other nations will take heed of this.

The update on the "Saturday Morning Physics' program at Fermilab and the excerpts from Gino Segre's 'A Matter of Degrees' reminded me about these valuable references for non-science students and general readers and Thomas D. Rossing's very interesting selections in 'Browsing Through Journals' did this research effectively for us.

In closing, I would like to share my personal view on 'lectures', the subject of the 'Letter' in the summer issue. Like most educational tools, lectures can be useful if they are used in conjunction with other methods and if they are good and riveting. Unfortunately the majority of class lectures are neither of these!

I did not mean this to be a 'Review of the Newsletter'. It is intended to be a participation in the forum by sharing my reactions, comments and intentions to be more involved in the future.

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Report on Teacher Quality Sent to Congress

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A report issued in July by the Secretary of Education outlines the challenges to recruiting and preparing future teachers and provides information on exemplary programs the Department believes will meet these challenges.

"One of the most important provisions of No Child Left Behind (NCLB) is the requirement that by the 2005–06 school year, all teachers of core academic subjects must be highly qualified," says Secretary of Education Rod Paige in the report, titled Meeting the Highly Qualified Teachers Challenge: The Secretary's Second Annual Report on Teacher Quality. "To meet this challenge, all of us in the education system must do things differently. We must be innovative, not just in theory, but in practice."

The two key principles of recruiting and preparing future teachers, says Paige, are raising academic standards for teachers and lowering barriers that are keeping many talented people out of the teaching profession.

"The current system (for recruiting and licensing teachers) dissuades many high- achieving college students and mid-career professionals from entering the teaching profession because it places unnecessary obstacles in their path," says the report, which details how states are working to recruit and prepare teachers.

What Makes a Good Teacher?

The report points out that wide consensus now exists among researchers and policymakers that teacher quality is a key component of school quality. Although consistent evidence shows that effective teachers contribute to student achievement, less information exists about the specific teacher attributes that lead to increased student achievement. In other words, the report asks, "How would you know a high-quality teacher if you saw one?"

According to the report, research shows the following:

•Teachers' general cognitive ability is the attribute that is most strongly correlated with effectiveness.

•Teacher experience and content knowledge are linked to gains in student achievement.

•Training in pedagogy, the amount of time spent practice teaching, and master's degrees have yet to be linked to increases in student achievement.

•Little compelling evidence exists that certification requirements, as currently structured in most states, are related to teacher effectiveness.

The Department does stress that "neither last year's report nor the present report contend that attributes like training in pedagogy or time spent in the field practice teaching are not valuable. All the reports suggest is that the evidence linking these attributes to increases in student achievement is weak, and certainly not as strong as the evidence linking general cognitive ability, experience, and content knowledge to teacher effectiveness."

The report also presents a continued need for research on teacher quality. "Research on teacher preparation and professional development is a long way from the stage of converging evidence and professional consensus," it states, noting that much of the research on teacher quality is dated, methodologically flawed, correlational in nature, and focused on differences among teachers rather than the interventions that raise effectiveness for all teachers.

NCLB's Highly Qualified Teacher Requirement

"By recognizing the link between quality teaching and student achievement, NCLB has refocused the national dialogue on how teachers should be trained and certified as well as who should teach," says the report.

NCLB requires that all core subject teachers be highly qualified by 2005–06. This means they must have earned at least a bachelor's degree from a four-year institution, hold full state certification, and demonstrate competence in their subject area.

Newly hired elementary teachers must pass a rigorous state test of subject knowledge and teaching skills. Newly hired middle level and high school teachers must pass a rigorous exam of the content knowledge, major in their subject as an undergraduate, or earn a graduate degree in their subject or attain an advanced certificate or degree.

Veteran middle and high school teachers must also demonstrate subject-matter competency by passing assessments; obtaining a degree in their subject; or meeting their state's high, objective, uniform state standard of evaluation (HOUSSE).

Raising Standards and Lowering Barriers

Are states making progress in raising academic standards for teachers while lowering unnecessary barriers? Some positive developments highlighted in the report include

•Thirty-five states have developed and linked teacher certification requirements to student content standards. Another six are in the process of linking these standards.

•Thirty-five states require prospective teachers to hold a subject-area bachelor's degree for initial certification.

•All but 8 states require statewide assessments for beginning teachers, and 32 states require teaching candidates to pass a test in at least one academic content area.

Although states have until the end of the 2005–06 school year to ensure all their teachers are highly qualified, the Department of Education points out areas of potential concern:

•Only 54 percent of the nation's secondary school teachers were highly qualified during the 1999–2000 school year; this ranged from 47 percent of math teachers to 55 percent of science and social studies teachers.

•State regulations for certifying new teachers are burdensome and bureaucratic.

•NCLB requires that new teachers demonstrate competency in their subject areas to be considered highly qualified. In 2000–01, 32 states required teacher candidates to undergo academic content assessment for certification or licensure. Twenty-two states administer basic skills tests along with academic content assessments.

•Approximately 6 percent of the teaching force lacked full certification in 2001–02. Seven states report having more than 10 percent of their teachers on waivers. High-poverty districts were more likely to employ teachers on waivers than affluent districts; 8 percent of teachers in high-poverty schools were on waivers in the 2001–02 school year, compared with 5 percent in other districts.

Meeting the Highly Qualified Teachers Challenge

The report concedes that "meeting the highly qualified teachers challenge is too big a project for any one program, school, or state—or even for the U. S. Department of Education—to tackle alone. Only a partnership will prevail."

It goes on to highlight specific examples of "promising reforms and initiatives" designed to address the teacher quality challenge in two areas: improving traditional teacher preparation programs and alternatives to the traditional certification system.

Innovations in Traditional Teacher Preparation

•West Virginia University's Benedum Collaborative. The core of the collaborative's five-year program is a partnership with 29 local professional development schools. Students are admitted to the program after sophomore year, and they immediately begin clinical work in a local school. Over the next three years, they log 1,100 hours of clinical experience while taking courses linked to their clinical work. At graduation, students earn a bachelor's degree in a content area and a master's degree in education. The collaborative also instructs teacher candidates in performing research and gathering data to assess their practice.

•Uteach (Natural Sciences) at the University of Texas at Austin.

•Standards-based Teacher Education Project (STEP). The STEP collaborative is a multi-state effort between the Council for Basic Education and the American Association of Colleges for Teacher Education. Together they work with colleges and universities to link teacher training to state academic standards. STEP convenes task forces of faculty from schools of education, arts, and sciences; K–12 schools; and community colleges to review and rework an institution's teacher training program, with the focus of aligning teachers' knowledge of content with the expectations for students found in the state academic standards. To date, 25 campuses in five states have completed the three-year STEP program, and 15 colleges and universities in Mississippi, Virginia, and Indiana are working with STEP.

Innovative Alternative Routes to Teaching

As of October 2002, all but nine states had approved an alternative certification program. According to the Department of Education, alternative routes tend to attract experienced professionals, as well as more minority and male candidates, to teaching. These teachers tend to work in urban or low-performing schools at a rate higher than traditionally certified teachers.

Several examples of exemplary alternative certification programs mentioned in the report are listed below.

•American Board for Certification of Teacher Excellence. This group is developing an alternative certification program. The "Passport Certification" will be provided to candidates who hold a bachelor's degree, demonstrate mastery of their subject matter, pass a test of professional knowledge, and complete a preservice program of professional development. A Master Teacher credential for those who demonstrate outstanding proficiency in their subjects will be available in 2004.

•California's Technology to Teachers Program. In 2001, California awarded a two-year, $1.6 million grant to five different workforce investment boards to create a program offering laid-off technology workers the opportunity to enter the state's teaching force. Currently about 115 teaching candidates are enrolled in university-based alternative programs; the goal is to attract up to 200 laid-off workers to teach in science and math classrooms.

•New York City Teaching Fellows. During the summer before they enter the classroom, candidates with at least a bachelor's degree receive two months of preservice training that includes courses toward earning their master's in education, field work with experienced teachers, and meetings with an advisor to learn teaching skills and classroom-based management. After completing the preservice training, they enter the classroom as full-time, first-year teachers. After three years, they can apply for state certification.

•Western Governors University. WGU, an online consortium of 19 western states and 45 universities, developed competency-based distance learning programs for teaching candidates. The program is based on a candidate's competency instead of the number of hours he or she spent in the classroom. It is designed for nontraditional candidates, such as paraprofessionals, uncertified teachers, and career-changers, as well as for current teachers who want to advance their education.

•Teach for America. This program recruits high-achieving college students to spend at least two years in a disadvantaged urban or rural school. Since 1990, Teach for America has placed more than 9,000 college students in schools nationwide. These teachers receive five weeks of training during the summer and take courses toward certification during the year while they teach full time.

•Transition to Teaching Partnership. This partnership between the Fairfax County School District in Fairfax, VA, and the George Washington University works to attract high-performing liberal arts and science graduates to teaching. Students make a one-year commitment to serve as permanent substitute teachers in the county high schools while taking the necessary coursework for licensure at the university.

This report is the second teacher quality report submitted to Congress as required by the Higher Education Act. For more information or to access the report, titled Meeting the Highly Qualified Teachers Challenge, The Secretary's Second Annual Report on Teacher Quality, go to http://www.ed.gov/offices/OPE/News/teacherprep/index.html.

Using Computational Physics to Investigate Realistic Projectile Motion

Nicholas Giordano

As computers are integrated ever more tightly into the educational experience, students are becoming increasing comfortable and proficient with computational methods. Software packages such as Mathematica and Matlab are easy to use, and can be employed for quite sophisticated calculations. This makes it possible to incorporate computational methods into many elementary classes, and thereby explore problems that are not ordinarily accessible. One such topic is realistic projectile motion. The motion of "ideal" projectiles is a fixture in introductory mechanics. By "ideal" we mean that the projectile moves with a constant acceleration, due to the gravitational force. Standard problems include calculations of the range of a batted baseball, and the demonstration that the maximum range occurs when the initial velocity makes an angle of 45° with the horizontal. A typical example might be to calculate the range of a batted baseball. In the major leagues, a baseball may leave the bat with a speed of 110 miles per hour (mph), and in the ideal case this would result in a range of more 800 feet (approximately 250 m). A typical major league home-run rarely travels more than 450 feet, and many are much shorter than this. Moreover, the center field fence in most major league ballpark is generally about 400 feet from home-plate. Hence, it is clear that this calculation greatly overestimates the true range. Even so, many classes (and many textbooks) stop at this point, since the natural next step is to include the force due to air drag.

The difficulty with including the effect of the drag force on such a projectile is that this force is a function of the velocity, and a simple analytic treatment of the trajectory is not possible when the drag is included. A few texts mention the result of Stokes for the drag force, and use this to introduce the notion of a terminal velocity, but the effect of drag on a projectile is rarely discussed. Stokes showed that for an object moving slowly through a fluid, the magnitude of the drag force is

$$F_D(Stokes) = 6\pi\eta r v \qquad (1)$$

where η is the viscosity of the fluid, r is the radius of the object (assumed to be a sphere), and v is its velocity.

With this form for the drag force one can readily calculate the terminal velocity of a sky-diver, etc. However, it turns out that for a real sky-diver this expression for the drag force is completely wrong. The Stokes result applies only for slowly moving objects. Stokes did the calculation so that he could understand the motion of a Foucault pendulum and similar slowly moving things. For nearly all "every day" projectiles, such as baseballs, the Stokes result applies only at velocities below about 1 m/s. At higher velocities the drag force is given instead by

$$F_D = C_D \rho A v^2 \qquad (2)$$

where ρ is the density of the fluid (usually air), A is the cross sectional area of the object, and C_D is known as the drag coefficient. As you might guess, the calculation of C_D is quite complex, as it depends on the nature of the air flow (the aerodynamics) around the object. One can give a very simple argument that leads to C_D~1/2 and this value works surprisingly well for many objects (to within a factor of 2) if the velocity is not too large. Figure 1 shows the behavior of the drag coefficient as a function velocity as measured for a baseball.

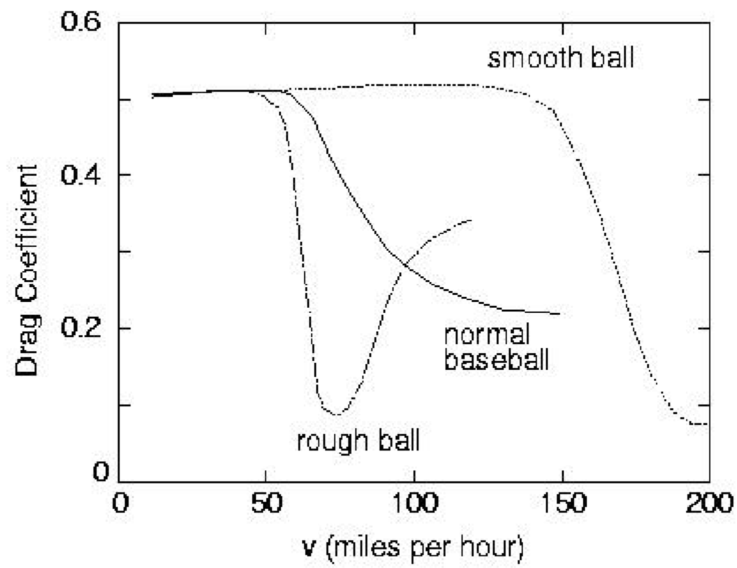

Figure 1. After Ref. 1.

This figure shows the behavior of the drag coefficient for a normal baseball, and also for a rough ball and a smooth ball. Here a "smooth" ball would be one without stitches while a "rough" one would have many more stitches than a regular baseball. While the drag coefficient for all three balls is close to 1/2 at low velocities, it *drops* at high velocities, and the threshold at which it drops is lowest for a rough ball. The reason for this is the onset of turbulence in the air-flow around the ball. When the flow is turbulent, the air is able to slip past the ball more easily than when the flow is normal (laminar), resulting in a smaller drag coefficient. Note that while the drag coefficient is smaller at high velocities, the drag *force* is not; F_D continues to increase due to its dependence on v^2 (see Equation 2).

It is not possible to give an analytic calculation of the trajectory of a baseball with the drag force in Equation 2 (with the drag coefficient in Figure 1) included. However, this trajectory is easily found using a computational approach. When I teach computational physics, I use this as one of the first exercises, since the physics is easily explained (and most students even find it to be interesting!). The trajectory of this realistic projectile is readily computed with a finite difference algorithm, as discussed in Ref. 1. In fact, this problem can be used to introduce and compare different types of algorithms for the numerical solution of differential equations. Some typical results from such a computation are shown in the figure below.

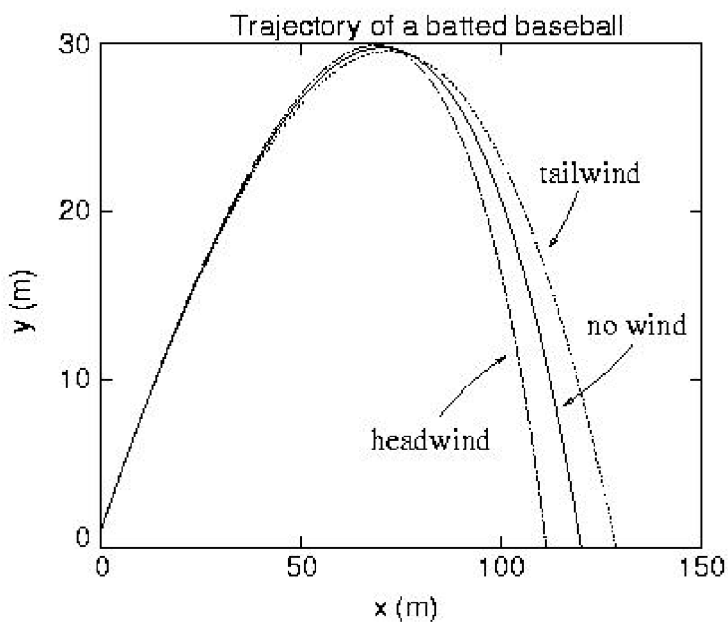

Figure 2.

Figure 2 shows the trajectory of a baseball (the regular ball in Figure 1). Here the ball was given an initial velocity of 110 mph (approximately 50 m/s) at an angle of 35° with respect to the horizontal. The effects of a gentle (10 mph) wind, either at the batter's back or in his face, are also shown. These results were calculated at the angle that gives the maximum range, which is approximately 35°. Students are quick to recognize that this is a more realistic angle than the value of 45° that yields the maximum range for an ideal projectile. The magnitude of the range found with air drag is also in good accord with observed values.

We believe that there are several morals to be learned from this exercise. First, this is a nice vehicle for introducing computational methods into the classroom. It is an elementary problem, and the computational methods are straightforward, yet this is a problem that can be attacked in no other way. Second, it lets students see that physics can treat the "real" world. They tend to get tired of frictionless inclines, etc.; it is useful for them to see how physics can deal with a realistic situation. Third, this example can be extended in various ways. For example, it can lead into a discussion of the physics of air drag, and similar methods can be used to deal with the motion of a spinning projectile, such as a curve-ball or a golf ball. It can even address the eternal question of why golf balls have dimples (see Ref. 1 for more on this).

(1) *Computational Physics*, N. Giordano, Prentice-Hall, 1997.

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What Makes a Physics-Outreach Program Family Friendly?

Robert Greenler

I was invited to give a talk at the 2003 Summer Meeting of the AAPT. The talk was in a session titled "Family Physics" sponsored by the AAPT Committee on Science Education for the Public. I agreed to do it and assumed that the talk would be about a series of public science programs—The Science Bag—with which I have been involved for the past 30 years.

As is commonly the case, the talk didn't really begin to take shape until I sat down to organize it, and that process caused me to consider some different questions than I had thought about before. I have developed a number of ideas about what makes Science Bag programs work, but I had never considered the question phrased as it is in the title of this piece: What makes such a program family friendly? After the meeting a few people asked me to write an article to share those comments with others—with the result that you are now reading.

My greatest regret is that I must leave out the visual aids that, I believe, add interest to any presentation. It means that I must just tell you about some of the ideas, rather than illustrating them with pictures and video clips.

I will begin by describing the program that is the subject of these comments.

In Milwaukee, on every Friday evening, for 5 months of the year, you will find an eager and enthusiastic audience of people from the community, generally filling a 250-seat lecture room in the Physics Building at the University of Wisconsin-Milwaukee. On one Sunday afternoon of each month a group also shows up for a matinee performance. So the same program is given five or six times in a month, but each month has a different program presented by a different faculty member. The audience comes to see The Science Bag, a series that has finished its 30th year, with a cumulative attendance of over 140,000 people.

Although the presence of children is obvious, this is not a children's program. Our surveys have shown that about 70% of those who attend are beyond high-school age. About 40% are in the 30 to 50 year bracket with significant numbers of attendees in each decade of their lives—only up to the 9th decade as far as I know. So, a wide age-range of people is represented—and many of them are families

A number of times I have had the comment, made to me by people who recognize me from the programs I have given, to the effect, "Oh, we raised three children on the Science Bag. We came to almost every program…."

A few times people have gone on the make the next comment, mentioning that, “After the kids left home we quit coming for a year or so until I said to my husband, ‘We like those programs; why aren’t we going to them?” and then we started coming again without the kids as an excuse.”

Gennn Schmieg and I started those programs 30 years ago out of our concern for the general poor state of the public’s understanding and interest in science. We also believed that it is appropriate for the university to contribute in informal ways to the life of the community. We ran the program together for a few years, then Glenn went on to other things. After 25 years of programs, I decided that things were well enough started that I could turn the programs over to Norm Lasca of the Geosciences Department, and the program continues, just finishing its 30th season.

In terms of attendance and the enthusiasm of the people who come to these programs, they have to be considered a significant success. The question relevant to the intent of the AAPT session is “What makes them attractive to families?”

I have no claim to authority in answering this question, but I have developed some opinions—over the years of being involved with this program—and I am willing to share them, as such.

WHAT HELPS TO MAKE A PRESENTATION ATTRACTIVE TO A FAMILY?

While preparing my remarks for the meeting, I realized that while thinking about techniques for making the programs successful, I had overlooked a basic principle, lacking which, nothing else matters. I assume that it is stating the obvious to say:

The Presentation Must Contain Interesting Ideas.

Those of you who have read books to children know that some books appropriate to a particular age are interesting to the adult—even when read again and again—while others, also age appropriate, are boring, boring, boring to the adult, through perhaps not to the child. For the whole transaction (the reading and the listening) to work best, the story needs to be interesting to both parties. Clearly the same is true of a family science program. If it is a Bozo-the-Clown performance, the kids may love it—and the parents may drop them off for the show and pick them up later. So, this also may be obvious, but some things are only obvious after you think about them:

The Program Must Be Interesting to Both the Children and to the Adults.

An idea, with which I strongly agree, was stated in a flowery way by Michael Faraday. He was convinced that when we talk of science to a public audience, it is important to use demonstrations as a part of the presentation. Faraday wrote:

> “…for though to all true philosophers science and nature will have charms innumerable in every dress, yet I am sorry to say that the generality of mankind cannot accompany us one short hour unless the path is strewed with flowers.”

So, when recruiting a speaker or interviewing a volunteer, I insist on “flowers.“ I have told potential presenters, “No matter how good a lecture you can give, if it is just a lecture, it is not good enough. It should have slides and video clips and demonstrations that are bigger than a breadbox and the things it takes to make it a show.” Faraday”s “flowers” are attractive to both children and adults. Colorful demonstrations, video clips, and a frequent changing from one medium of presentation to another helps to stretch the attention span of both young and old. So I summarize this idea by:

The Presentation Should Contain a Generous Allotment of “Flowers.”

It is attractive to choose children (and important to pick both boys and girls) from the audience to help with demonstrations, and I recommend it. But I think there is a trap here. It is fine to use a 10-year-old to help with a demonstration. But, If you do the explaining to the 10-year-old, it may be the kiss-of-death to a high schooler’s interest, and it may give permission for an adult not to listen carefully to what you are saying. If the explanation is given to the adults, in language clear enough for the 10-year-old and the high schooler to understand, you may be able to have all of their attention. So I suggest that you

Involve Children in the Demonstrations but Address the Program to the Adults.

I mentioned earlier that the Science Bag is not a children’s program, but it is a program for nonscientists—which includes some children. I am frequently asked, “How old must my children be to attend the Science Bag programs?”

Of course there is no numerical answer to that question without many caveats. Some programs are more accessible to younger children than others. Programs with more lively demonstrations may hold the attention and interest of children who may not follow some of the explanations. Also some 12-year-olds may not be able to sit still for an hour-long program wheres some 6-year-olds do have a sufficient attention span.

I also have asked questioned people who bring their children about the appropriate minimum age, and I come up with an age of around 8 when quite a few children start to enjoy these programs.

I have a belief that is not confirmed by any studies that I know of—but still a belief of mine. When people come into a lecture room (for either a class or a program) their receptivity for what they are about to hear is influenced by what they see in the room. I believe that interesting-looking objects, arranged with some care and attention to how they are displayed on the lecture bench or wall, can bring an expectancy to the audience, that influences how they listen and how much they appreciate what they see and hear. So, before a person gives his or her program, I have them think about what the lecture bench will display. I think that this expectancy effect is important enough to justify having things present that are not necessary for the presentation, but which can be referred to in passing and add visual interest to the lecture table.

Increase the Expectancy of the Audience with an Interesting Display on the Lecture Table and Walls.

I realize that some of these suggestions apply both to the children and the adults in the audience. With the (perhaps arguable) assumption that children have shorter attention spans than adults, it is important to use those techniques to retain their attention and interest in a program that is designed to (also) interest the adults.

As an offshoot of our Science Bag program, we have produced videotape versions of selected programs and are preparing to offer these programs on DVD, in addition to their current availability on VHS tape. More information about these programs may be seen at www.blueskyassociates.com.

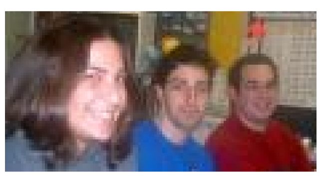
Robert Greenler is Professor Emeritus at the University of Wisconsin-Milwaukee. He is well known for his popular lectures on physics, especially optical phenomena, and he served as president of the Optical Society of America. His present address is 6225 Mineral Point Rd., Apt. 17, Madison, WI 53705.

Physics in Motion: A course for non-majors at Vassar College

Cindy Schwarz

Video analysis technology has been available for about two decades. I have incorporated in my introductory courses since 1995, initially with analog film and finally moving to digital video in the past five years. Since then, many innovative physics teachers have integrated video analysis into their introductory courses. This has been done to varying degrees, both at the high school and college level, in small liberal arts schools, community colleges and large universities. All of these uses were for courses where the majority of the students were representative of the usual population (pre-med, engineers, science majors, physics majors). Three years ago, I submitted a proposal to the National Science Foundation Course Curriculum and Laboratory Improvement (CCLI) Program. I wanted to develop and teach a course using the technique of video analysis, for a different student population and outside of the confines of the expected curriculum of an introductory physics course. The course, “Physics in Motion” is designed for freshmen in their first semester or for upper level students NOT majoring in the sciences. Taking video analysis outside of the standard curriculum has provided much more freedom in the topics covered and the order in which they are covered. Students have been “figuring out the physics” from the digital video with a little help and guidance from me.

During the first six or seven weeks of the course, they worked on projects (in groups of 2–4 students) investigating the concepts of velocity, acceleration, forces (including friction) and energy. For the first assignment, they filmed something (of their choice) that was slowing down. They predicted graphs of position, velocity and acceleration. After making the predictions, they analyzed their video on the computer using VideoPoint™ and compared their predictions to the actual results. More important than correct predictions was their understanding of the differences between their predictions and the actual results. Students then worked in groups, sharing their videos and finding commonality. Whether the movie was of a ball thrown up or a teddy bear sliding on the dorm floor, the students were able to identify similarities and differences. Many of the activities in the first half of the course were in this form: look around for something that moves in a certain way, make predictions about its motion, film it, analyze it, compare and contrast, reconcile differences, share with others, make a movie or presentation to share with the whole class. Investigations included answering questions such as “ Does the coefficient of friction between two surfaces depend on the mass of the sliding object?” “How much smaller is the coefficient of friction on an air hockey table with the air on than with the air off?” and “Does the mass of an object affects how far it will slide before stopping on a surface with friction?”

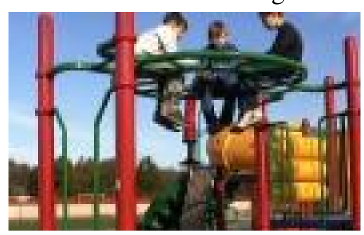


In many of the presentations, I heard physics discussed in ways that I have never heard before in my “standard” introductory courses. The students seemed to get a much deeper understanding of the physics involved and were able to apply it to new situations with success.

The second half of the course was primarily devoted to the design, implementation and creation of a multimedia project for K-12 students. I could not have imagined all of the ideas that the groups (nine so far) thought of. DVD’s were created on playground physics, videogame physics, roller coasters, swimming and diving to name a few. They were presented in classrooms and auditoriums to students in 5^{th}, 6^{th}, 7^{th} and 12^{th} grades.

The Playground Physics project was created by three freshmen, all of whom had some physics background from high school but no multimedia experience. They went to the school and interacted with seven fifth graders chosen by the teachers to participate in the project. They interviewed the children and videotaped them on the playground. They asked the kids how fast they thought they could run, 1 mile an hour, 5 miles an hour or 10 miles an hour. Most of them said they could run about 1 mile an hour. They then taped the children running and analyzed the video to find that the average running speed was about 11 mph. Boy were they surprised! The project was then put together on DVD and presented in the auditorium of the elementary school for about 100 fifth graders, their teachers and the principal. The students stopped the DVD between sections and interacted with the kids, asking questions and elaborating on the concepts, which included gravity and free fall, running speeds and friction. After the presentation, the fifth graders were asked if they would like to study more about physics in the future. Eighty three percent said they would definitely be interested in learning more about physics!

Another excellent project was The Physics of Videogames done by three seniors in the course. They were majoring in Film, American Culture and English. They went to a local middle school



and showed videogame clips to a sixth grade class. They interacted with the class, asking questions and having the students attempt some “videogame moves”. They came back three weeks later and presented the final DVD to the class. The main focus was on what is and isn’t realistic in a videogame. For example, in many videogames, the characters on the screen move one way in the air and then just turn around and go the other way. That violates the laws of physics! The point of the presentation was not to show that video games were bad, but to instill in the students the ability to discern what wouldn’t happen in reality. But that was okay because some of the games wouldn’t be nearly as fun if they stuck to all the laws of physics. Some students concluded they would love to study physics in the future because “its all about videogames”. Not true, of course, but if that’s the hook to get them to take physics in high school, who am I to argue. The teacher for this class had read about the projects from the prior semester in the local newspaper and had called me to see if we would come to her class. Afterward, she praised the presentations (interesting, relevant and fun), the interactions of the Vassar students with her students and the new insights she received about topics she teaches in her science class. She can’t wait for us to come back again!

When I originally designed the course I had assumed that the majority of the students enrolled would NOT have had high school physics. In the first class of sixteen freshmen, all but 4 had taken high school physics. This presented an immediate challenge in the course, and an adjustment in the material covered. Despite their high school physics background, the majority of the students learned more especially in the category of real world physics. The feedback from the

Vassar students indicates that this is a useful and interesting addition to our curriculum. More important in my opinion is the interaction it has afforded myself and Vassar students with the local students and their teachers. In the first year alone, we gave physics presentations to over 300 students, 13 teachers, 2 principals and 2 district math/science directors. All of the feedback questionnaires given to both students and professionals indicate that the program was successful.

There of course have been many challenges and adjustments in the first year of teaching and developing this course. I love technology and computers when they work, but getting the students familiar with the computers, cameras and software was a major, time intensive challenge. It seemed like someone always had a problem right in the middle of my also trying to go over the physics. I highly recommend that others do this type of course but make sure that you have institutional support and a good student assistant!

Cindy Schwarz is an Associate Professor of Physics at Vassar College. She is the author of several books for the general public - A Tour of the Subatomic Zoo and Tales from the Subatomic Zoo. (http://faculty.vassar.edu/schwarz/)

Energy - a Basic Concept and a Social Value

John L. Roeder

Thirty years ago I began teaching at The Calhoun School in New York City. Soon after I arrived, the Arab Oil Embargo meant that the availability of gasoline at the corner service station could no longer be taken for granted, and before year's end I would pay in excess of a dollar for a gallon of it for the first time. The term "energy crisis" entered our vocabulary, and at Calhoun we decided to start a seminar about it.

That seminar later led to more organized and systematic teaching about energy, first in a course on "Critical Social Issues" and later in a physical science course called "Energy for the Future." I got involved with the educational work of the National Energy Foundation, then headquartered in New York City, spent two summers working on NSTA's "Project for an Energy Enriched Curriculum," and became a Resource Agent for the New York Energy Education Project.

Although my energy-focused physical science course gave way to *Conceptual Physics* and later *Active Physics*, after Paul Hewitt convinced me in 1989 that physics could and should be taught to ninth graders, only last year did I return to my earlier "life" as an energy educator and develop an Active Physics-formatted chapter on energy issues, in which the challenge was the same as the final exam of my former course: for students to plan their energy future without fossil fuels.[1]

It is the Second Law of Thermodynamics that makes energy an important concept in society. If we had only the First Law to worry about, we wouldn't have to worry: energy might not be created, but it isn't destroyed either. All the energy in the world today would continue to be available to us.

But for energy to meet our needs, it must be transformed -- e.g., we need to increase the thermal energy in our homes in winter, and we need a lot of energy brought to our appliances by electrons in electric current if they are to operate. The Second Law of Thermodynamics tells us that when energy is transformed, some of it gets transformed to a form that is less useful (the most typical example of this is "waste heat"). Energy "sources" are more useful forms of energy that can be transformed to meet our needs. When we "produce" energy, what we are really doing is to transform useful energy from these energy "sources" to a form that meets our needs. When we "use" these energy "sources," energy in a form that met our needs is transformed to a less useful form. When we "conserve" energy, we "use" the smallest amount of an energy "source" to accomplish a particular task.

An important plan for any energy future is to "conserve" as much as we can, but "conserve" as much as it might, an industrial society still needs to "use" new "sources" of energy – to heat and cool its buildings, to run its appliances, to move its people, and to manufacture its goods. Because of their convenience, the "sources" of choice for more than a hundred years have been fossil fuels, the fuels I ask my students to plan their future without.

Why? Not just because a shortage of fossil fuels got us into trouble in 1973 – and again in 1979. Not just because burning fossil fuels produces carbon dioxide which leads to global warming. More fundamentally, we're eventually going to run out of them. Their continued use to support an ever-increasing population is not "sustainable" -- in the sense that our use of them denies future generations the benefits of their use (and as a manufacturing material as well as an energy "source").

Twenty years after the 1973 Arab Oil Embargo I took a retrospective look at what our actions showed we had learned from it. I learned that US total energy "use" had declined the years immediately following the energy crises of 1973 and 1979, that US energy use through 1990 had fallen below a host of predictions, but that most of the reduction was due to the industrial sector. But little had been done to wean us from our diet of fossil fuels.

The Solar Energy Research Institute was charged at its founding in 1977 to meet 20% of US energy needs from renewable sources by 2000. It was renamed the National Renewable Energy Laboratory (NREL) in 1991. I thought that this 30-year anniversary of the Arab Oil Embargo might be a good time to find out whether this goal had been met.

Data for US fossil fuel and total energy use are plotted on Figures 1 and 3. Both graphs show a decline following the energy crisis years of 1973 and 1979 and that both fossil fuel and total energy use had climbed back to their peak 1979 values a decade later and continue to climb. But, while fossil fuel use doubled from 1949 to 1968, it has not increased even 50% more than the 1968 usage since then. And not until 2000 did petroleum use climb back to its 1979 peak.

But the fact that we have put the brakes on increasing our petroleum use more than for other fossil fuels since the energy crises of the 1970s is no overt cause for rejoicing. For while imports still comprise only a small fraction of the coal (1.5%) and natural gas (20%) that we use, the fraction of petroleum imported passed 50% in 1990. M. King Hubbert, whose ability to forecast future fossil fuel production in terms of past data was legendary, wrote in the September 1971 *Scientific American*[2] that "In the case of oil the period of peak production appears to be the present," and he was right.

We've decreased the rate at which our use of energy in general and fossil fuels in particular has increased, but these uses are still increasing. Moreover, the time since the energy crises of the 1970s have seen a decline of US production of petroleum and continually increasing imports.

How're we doing on renewables? Did NREL achieve the goal of 20% of US energy from renewable sources by 2000? Fig. 2 plots energy from conventional hydroelectricity, biomass, geothermal, and solar, and only since 1988 has solar gotten up off the t-axis on the graph. Most of our renewable energy continues to come from the two sources that have played the leading role even before renewable energy was fashionable: hydroelectricity and biomass. Geothermal has also started to make a more significant contribution since the energy crisis years, although it, too, had been around for a long time (see Fall 2002 issue). The total US energy use in Fig. 3 shows an increasing gap between total energy use and fossil fuel use. Although no new nuclear reactors have been erected since Three Mile Island in 1979, nuclear electricity continues to play an increasing role, and this has increased to be just a little greater than renewables.

In 1979 the Ford Foundation-sponsored study, *Energy: The Next Twenty Years*, opened with the following statement:

> More than half a decade has passed since the oil crisis of 1973-1974 signaled a new era in U.S. and world history. The effort to develop a satisfactory policy response to what was once characterized as the "moral equivalent of war" has stretched out so long that weariness rather than vigor characterizes the national debate. . . . energy and environmental objectives seem irreconcilable; . . . a national consensus that solar energy is a good thing has yet to result in significant resource commitments, while support for nuclear energy, yesterday's hope for tomorrow, is eroding; and coal is marking time. Meanwhile, the slow, steady increase in the number of barrels of oil imported . . . provide[s] reminders that much needs to be done.[3]

I don't think it would stretch the imagination to replace "more than half a decade" in this statement with "three decades." In that time we have not learned the lessons of the energy crises, nor have we met the well-intentioned goal of 20% of our energy from renewable sources by 2000. In fact, at the World Summit on Sustainable Development in Johannesburg last year the leaders of the world could not agree to increase the percentage of the world's energy use from renewables to 15% by 2010. Last fall when I presented my ninth graders the challenge of the new Active Physics-formatted chapter I wrote on energy issues, I told them that I was asking them to do what the leaders of the world were unwilling to commit to: plan their energy future *without* fossil fuels.

In the year 2010 those ninth graders will be graduating from college and begin to take their place in the world. If the leaders of the world, more preoccupied with the politics of the present when they should be framing a forward-looking vision of the future, haven't figured out how to produce 15% of the world's energy by renewable means by then, I hope that the next generation will be better trained to deal with this problem.

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(*Note*: The preceding article was excerpted from the author's talk of the same title at the American Association of Physics Teachers meeting in Madison, WI, 4 Aug 2003.)

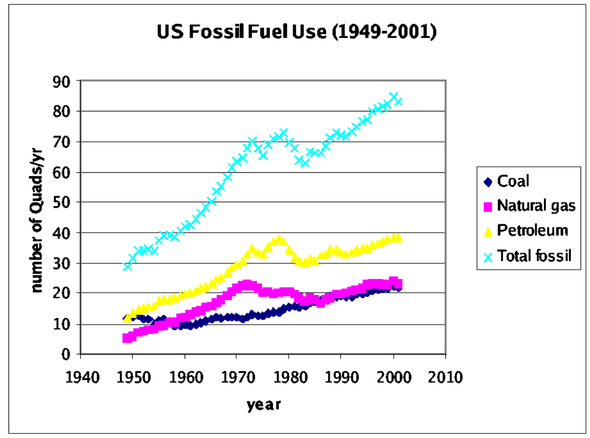

Figure 1

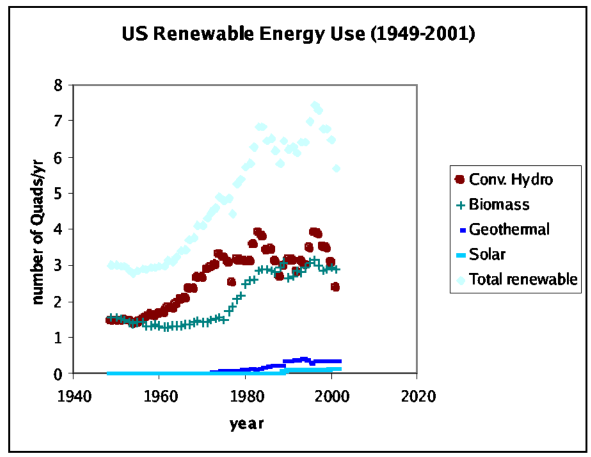

Figure 2

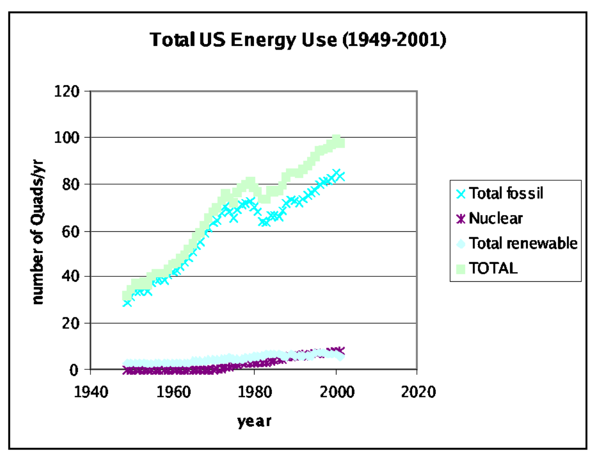

Figure 3

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Web-Delivered Interactive Lecture Demonstrations: Creating an active learning environment over the Internet

Ronald Thornton

In this article we describe a project whose purpose is to extend a pedagogical procedure, *Interactive Lecture Demonstrations* (*ILDs*)[1,2], that already works well in a proven difficult learning environment, the physics lecture hall or classroom, to what is probably an even more difficult environment, the internet. Educators often compare student learning as a result of web-delivery of learning materials to traditional science courses, where research shows few students learn. To conclude from such a comparison that web-delivery is better, may not serve education. If we compare web-delivery learning results to classroom and laboratory techniques that actually result in most students understanding the materials, we are then using an authentic standard We have preliminary evidence the extension of the *Interactive Lecture Demonstrations* to internet delivery (Web*ILD*s) results in student conceptual learning that is many times better than standard instruction and comparable to in-class delivery of *ILD*s.

Most in-class *Interactive Lecture Demonstrations* (*ILDs)* make use of real-time data collection and display or MBL (in our case Logger*Pro* with a Lab*Pro* interface from Vernier). Each individual demonstration in a sequence of 6-8 demonstrations follows an eight-step procedure. Students are given two sheets with the demo's described--a "prediction sheet" which they hand in and a "results" sheet which they may keep.

Interactive Lecture Demonstration Procedure

1. Describe the demonstration and do it for the class without MBL measurements.
2. Ask students to record individual predictions.
3. Have the class engage in small group discussions with nearest neighbors.
4. Ask each student to record final prediction on handout sheet (which will be collected).
5. Elicit predictions & reasoning from students.
6. Carry out the demonstration with MBL measurements displayed.
7. Ask a few students to describe the result. Then discuss results in the context of the demonstration. Ask students to fill out "results sheet" (which they keep).
8. Discuss analogous physical situations with different "surface" features. (That is, a different physical situation that is based on the same concept.)

To deliver *ILDs* over the internet we needed to development web-aware software that 1) can present in proper order the many short video sequences that replace the actual presentation of demonstrations in a classroom; 2) is able to present and replay results as graphs and data synchronously with video sequences; 3) is able to present questions and collect student responses to a data base; 4) provides mechanisms to facilitate real-time internet textual discussions of predictions and results by small groups composed of students in different physical locations; 5) allows students to draw graphs and share them with others in the group; 6) provides administrative functions for monitoring students, collecting data for evaluation, and allows *ILDs* to be constructed. We have created such software and tested it with students at Tufts and the University of Oregon.

Student Testing and Learning Results (Academic Year 2002-2003)

We began testing with the software prototype with students in the introductory non-calculus physics class at Tufts University and the University of Oregon in September 2002.

At Tufts students were assigned the Third Law Sequence Web*ILD* as homework. The other three *ILD* sequences in *Motion, Force, and Energy* series were delivered in class. These *ILD* sequences teach concepts in kinematics, Newton's Laws and Energy. To do the Web*ILD* the students had to find at least one partner to collaborate with who could be on the Web at the same time (not the same place). Tufts servers delivered the *ILD* and collected the results using the prototype software. Learning results are shown in Figure 1.

We are using questions from the *Force and Motion Conceptual Evaluation (FMCE)*[3] to evaluate student learning. Figure 1 shows typical learning gains of approximately 10% in a traditional well-taught university classroom[4]. For in-class ILDs in a previous year at Tufts, the average gain for both categories was 89%. The average gain for Third Law Sequence Web*ILDs* was 72% using our first prototype software. This is better than expected with Web*ILDs* producing about 81% of the learning that in-class *ILD*s produce and about 7 times better than standard instruction.

At the University of Oregon, we divided the students in the introductory algebra-based physics course into two groups where one group received Motion, Force and Energy *ILD*s in-class and one group received Motion, Force and Energy Web*ILDs*. (The short introductory *ILD* sequence on the kinematics of walking was given in-class to both groups since we did not have a Web version). All other instruction was the same for two groups. The groups scored similarly on the pre-test using the *FMCE*. The students taking the Web*ILDs* were scheduled for a class period so they could be supervised. The only communication with students in the groups they formed was over the Web. They were not allowed to talk to one another. The Web*ILDs* were delivered from a Tufts server.

The results of this extended test are shown in Figure 2. Again the results were more than gratifying in that the Web results are 125% better than in-class delivery and about 4.6 times better than standard instruction. However the in-class delivery showed a normalized gain of only 45% while in previous years it has been closer to 80%. The *ILD*s were delivered by the same professor in the same way. We have no explanation for the drop. The students may be changing.

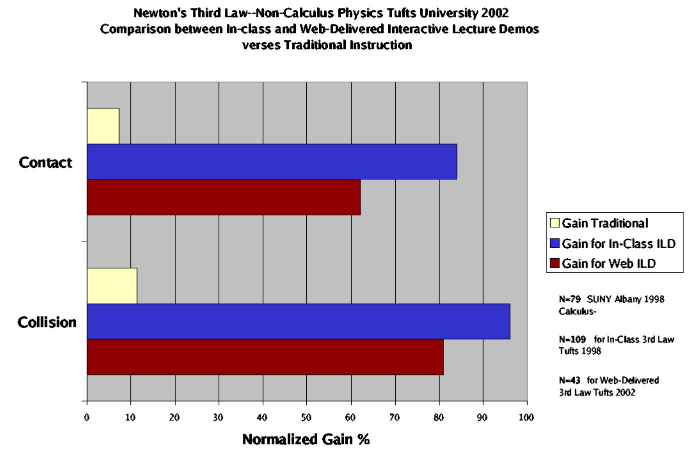

Figure 1: Normalized gain of students on Third Law questions (divided into collisions and contact forces) from the Force and Motion Conceptual Evaluation (FMCE). Normalized gain is the % of students who don't know a concept that learn it. The first bars show gains in a traditional Calculus-based physics course at SUNY Albany. (Gains of 10% are typical in well taught traditional courses.) The second bars show results at Tufts in a previous year for in-class delivered 3rd Law *ILDs*. The final bars show the result for 3rd Law Web*ILDs*.

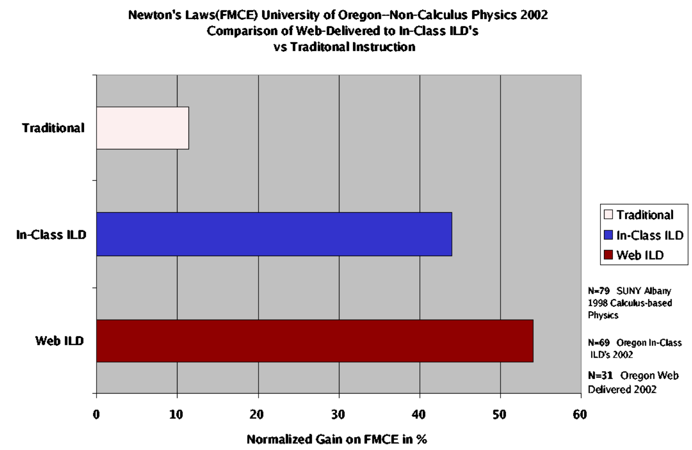

Figure 2: Normalized gain of students on the Force and Motion Conceptual Evaluation (FMCE). Normalized gain is the % of students who don't know a concept that learn it. The first bars show gains in a traditional Calculus-based physics course at SUNY Albany. (Gains of 10% are typical in well taught traditional courses.) The second bars show results at the University of Oregon for in-class delivered Force, Motion, and Energy *ILD* sequences. The final bars show the result for students who experienced the Force, Motion, and Energy Web*ILDs*.

We would expect an even better result for the Web*ILDs* if the students had been allowed an appropriate amount of time. They were scheduled for a 50-minute period. This is enough time for an in-class *ILD* sequence but we estimate that students require 60 to 70 minutes when they are Web-delivered due to typing and figuring out what to do. Consequently not all students finished.

Current and Future Plans

We have revised the student interface and are testing again at Tufts and Oregon. In the next few months there will be an opportunity to try the Web*ILDs* on-line. A link will be established at the web-site of the *Center for Science and Math Teaching*. (ase.tufts.edu/csmt/) There will be opportunities for testing for those who are interested.

Credits

This has been funded by FIPSE of the U.S. Department of Education. Ronald Thornton of Tufts University is the Project Director and David Sokoloff of the University of Oregon is a Principle Investigator. Academic Technology at

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The Berkeley Lab's Intensive Research Institute 2003: A model for scientists in working with preservice teachers

Peggy McMahan

During the summer of 2003, Lawrence Berkeley National Laboratory hosted upwards of 80 undergraduate student interns for ten-week research experiences through Department of Energy sponsored programs such as SULI (Science Undergraduate Laboratory Internships), CCI (Community College Initiative) and PST (Preservice Science Teachers). This year for the first time, the PST program was well attended, primarily through a partnership with the Center for Mathematics and Science Education, a NSF-funded program run by the Education Department at Cal State University at Fresno (FSU). This state university, located in California's Central Valley, serves a large Hispanic population and provides many of the teachers for that part of the state.

Providing research experiences for such a widely diverse group of students has its challenges. Placing a student with a research group for the summer is easy – if that student is an undergraduate physics major from a top-ranked research university. Working with future teachers who have little course work in the physical sciences requires a special kind of science mentor with a willingness to teach subject matter as well as direct research. With this in mind, the staff at Berkeley Lab's Center for Science and Engineering Education, headed by Rollie Otto, devised the Intensive Research Institute.

Four of the six number participants in this pilot program were math majors planning to teach mathematics. These students had only a few introductory courses in science and it would have been difficult to find a meaningful 10 week mentored research experience. Two of the participants were science majors who expressed broad interests in their preference for a summer research experience. A local high school teacher, Mr. Tom Knight, who had experience working at the Berkeley Lab joined the group as a content advisor to the students and methods advisor for the Berkeley Lab scientists leading the two week institutes. The stated goals were to provide:

- A deeper understanding of scientific research,
- Direct experience with modern scientific instruments, and
- To update and enhance students' knowledge of the scientific concepts, principles and theories behind the experiments.

Four scientists were asked to present successive two-week workshops designed to provide the students with:

- First hand experience with scientific instruments and research methods,
- Subject matter knowledge of the underlying science concepts, principles and theories related to the workshop activities, and
- An opportunity to relate their newly acquired knowledge and skills to high school and middle school mathematics and science standards.

The four workshops presented in the 2003 Institute were:

- *Nuclear Science and Neutron Activation Analysis*
- *Natural Terrestrial Radioactivity*
- *Cosmic Ray Detection*
- *Fingerprint Analysis at the Infrared Beam Line*

In *Nuclear Science and Neutron Activation Analysis* (presented by Rick Norman), the students learned basic concepts of atomic and nuclear structure, radioactive decay, how to use Geiger counters, NaI and germanium detectors to measure radiation. They then took samples to a nuclear reactor for irradiation and analyzed them using neutron activation analysis.

Natural Terrestrial Radioactivity (presented by Al Smith) utilized the Low Background Counting Facility to familiarize students with the ubiquity of natural radioactivity and the significance to human health and explored applications to Homeland Security.

In *Cosmic Ray Detection* (presented by Peggy McMahan) students explored cosmic rays: what they are, how they can be detected, and what they can tell us about the origin of the elements in the universe. The use of accelerators to mimic the cosmic ray environment of space was discussed and the students observed a radiation biology experiment at the 88" Cyclotron. They built a cosmic ray detector and designed classroom activities around it. The first three workshops together made a nice package focused on nuclear science topics and the three presenters worked closely to integrate the material they presented.

Fingerprint Analysis at the Infrared Beam Line (presented by Mike Martin) focused on electromagnetic radiation, utilizing the infrared beam line at the Advanced Light Source. As part of an ongoing project using IR spectroscopy to obtain chemical information from latent human fingerprints, the students learned to collect infrared data on fingerprints, and analyze and interpret the spectra.

As one of the participating scientists, I can attest that my two week experience working with these students was very intense but at the same time highly rewarding. The students came in as almost a blank slate and left with some basic knowledge, an appreciation for scientific research, some familiarity with using basic laboratory equipment and – most importantly - an enthusiasm to bring what they learned to whatever subject they end up teaching. Enrique Lopez, one of the student participants, was quoted in an article in the Fresno Bee about the LBNL/FSU partnership: "Man, I think my work changed my teaching enormously. A lot of high school teachers can't say they had real laboratory experience. I got hands-on work with the latest technology that real scientists are using. When we go into the classroom, we will relate what we did." A critical factor in the success of the program was the close interaction between the scientists and the experienced high school teacher assigned to the program. His practical knowledge of what works and doesn't work in a classroom was essential and he worked daily with the students to turn what they were learning into classroom activities.

The materials and activities used in all four workshops would be of equal value to inservice teachers as well as preservice and could serve as a model for other government and university laboratories. The subjects chosen also have the advantage of being applicable over several major classroom subject areas and grade levels, such as Earth Science, Chemistry, Physics and some math subjects. A shortened half-day version of the cosmic ray workshop will be presented at the Northern California AAPT/APS meeting in November 2003. More detailed information including material about any of these workshops can be obtained from the author at p_mcmahan@lbl.gov.

Faculty and Student Intern Partnerships

S. Narasinga Rao

The R&D Intern Partnerships program funds faculty and student internship programs at colleges and universities in Oklahoma. Students and faculty from these institutions of higher education are paired with 48 Oklahoma firms and farms that benefit from the interns' efforts.

The R& D Intern Partnerships program has (1) increased the pool of scientists and engineers available to Oklahoma industry, (2) encouraged students to be scientists and engineers and (3) enhanced a faculty member's background to provide a better teaching environment.

The projects have five common features.

(1) An Oklahoma business, Oklahoma college or Oklahoma university must be the fiscal agent.

(2) An equal match of the OCAST funds from nonstate appropriated funds is required.

(3) The research must be performed in an applied research facility - located at a firm, a non-profit research institute, or an institution of higher education. The mentor is from industry or an academic with documented success record of applied research.

(4) An Oklahoma firm or farm must benefit.

(5) A majority of the project reviewers are from outside of Oklahoma and have a background in industry, academia, and government research.

The award may be for one or two years. Most of the programs have interns working in an Oklahoma industrial laboratory on an applied research project with an industry mentor. The firm provides half of the intern's salary and fringe benefits as the required match and OCAST provides half of the intern's salary and fringe benefits. Other programs have been approved. The reviewers have shown a preference for the programs in which at least 75% of the total funds (OCAST plus Match) go directly to the interns as salary and fringe benefits. The remaining support is most often Principal Investigator salary and fringe benefits as well as supplies to run the program.

Three students from our university who participated in this program have already been absorbed by the industries in which they worked after internships and graduation

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A Good Question?

Fred Hartline

Everyone does it. It's entirely natural, and almost everyone enjoys both the giving and the receiving if it's consensual rather than coercive. Some professors even have a reputation for being very good at it. What is it? *Asking and answering questions!*

Besides the fun, *questioning* can be a powerful educational tool in classes from 5 to 500, especially if it is used to spark interest, and engage the learner to grapple with and think out unfamiliar concepts or problems. I once asked a physics teacher colleague of mine to enumerate his reasons for asking questions in class. Months later, he brought me a list some 30 distinct purposes for the questions he asked!

All teachers use questions to check students' recall of previously dispensed information or problem solving techniques. Fewer teachers appreciate and fully take advantage of in-class questioning to motivate learning and build a cooperative, intellectually exciting learning environment, while at the same time receiving invaluable feedback about what and how well the students are learning. Most likely you already have a style of in-class questioning that you find comfortable and useful for you and your students, but just possibly there are a few tricks that you haven't tried which might add some sparkle to your teaching.

As one of the co-developers of the Classtalk® classroom response system, used for interactive questioning at more than 70 high schools, colleges and universities in its heyday, I have had the good fortune to sit in on quite a spectrum of physics lectures and classes over the past decade. What I report here isn't careful research, but rather an assemblage of tips, tricks and generalizations that are based on my own experiences and field observations.

What is an "effective" question?

Everyone has slightly different criteria, but here are a few that I think are particularly important. A good question sparks student interest, and makes them think. It leads them to confront their preconceptions, starts productive discussions or debates among peers, helps refine understanding, boosts familiarity and confidence, and generates even more questions in the students' minds. Open-ended questions, and questions with more than one correct answer can be very stimulating, since real-world situations often have more than one workable solution, although such questions may be a bit more difficult to use in large classes.

What makes questioning particularly effective?

Here are a few thoughts to consider:

Get every student to answer-- no "fence sitting" allowed

At the races, who gets the most involved-- someone who has placed a bet on a horse, or a passive observer with nothing invested in the outcome? In class, you want EVERY student to commit to an answer or answers, before the "truth" is unequivocally established. When only one student is called upon to answer, everyone else can play "wait-and-see." Students are great at *ex post facto* rationalization-- if you allow them to sit on the fence they'll think "I knew that" when the answer(s) emerge, and continue to believe "I know that" until a similar question on the next exam proves that they don't. In contrast, if they've actually "voted" on a choice, say by holding up a card, they'll remember their vote and whether or not they "got it right."

Preserve apparent anonymity-- no public humiliation

Students are very sensitive about appearing too dumb or too smart to their peers. If you want them to participate freely and voluntarily, take steps to make sure that their responses are at least *quasi* anonymous. It's OK to have a few students help count an ocean of responses, but you will get much better participation and a spirit of cooperation if you're careful not to expose individual answers. When only one person gets it wrong, he/she knows it without your pointing it out, and will try very hard not to be "the only one" in the future.

Give credit for any answer-- a bit more for getting it right

Sometimes you may have a class for which "credit" doesn't seem to matter, but for many students, credit means "it's worth doing." You want them ALL to answer, and to really think things through. It doesn't take much credit to motivate healthy participation, but without it you may have 10-20% of the class riding along with minimal commitment and effort.

Use intriguing questions and humorous scenarios

If a question seems important, interesting, funny, or even wacky, students are much more likely to relate to it. Work these ingredients into your questions-- hot topics, campus intrigue, fictional scenarios featuring classmates or people they know. Get beyond the bare facts of the question with entertaining unessential spice. Most young folks go for sugar frosted cereal in bright boxes!

Make the questions neither too hard nor too easy, ~40-60% of your students should get it

This isn't a hard and fast rule. On occasion you'll want to stun them with a question that everyone gets wrong, or reward them with one that everyone gets right. But to start a good discussion in class and move all students forward in their understanding, it's best that the question be a bit of a stretch for most of them, but not so difficult that only a few are successful (or lucky) enough to answer it correctly. See below for the value of splitting the class!

Split the class? Should there be at least two popula answers?

There are great lessons in near unanimity, right wrong, but people are naturally captivated by controversy and close race. Which of the following is more likely to spark a livel in-class discussion and airing of student preconceptions: 1) question that produces an undeniable dichotomy of opinion, or 2 a question with an overwhelming majority? *What do you think?*

Experiment with small group collaboration prior t answering

We discovered the benefits of small grour serendipitously, when we couldn't afford enough response uni for every student. It's marvelous for esprit. Despite occasiona dysfunctional groups, most students really enjoy and learn fro hashing out their options in a small group. Let them vo individually if they can't agree. The whole atmosphere of th classroom/lecture hall changes when the students get accustome to brainstorming in small groups.

Use questions often enough that it's familiar and comfortabl for the students

Two or three thought-provoking questions in a 4 minute period is plenty. In contrast if you only ask questions o Fridays, you may miss the near magical transformation of you class.

Never give away the answer before they've figured it out fo themselves!

These days students are trained to memorize answer rather than think. You have a precious "teachable momen before they know the correct answer(s) for sure. Make the best o it. Once they know the accepted answers many will sto listening.

Inventing great questions is the supreme challenge. also helps if the students understand why you keep asking the instead of just lecturing. They'll really appreciate your Socrati forays when you show that you're listening by reteachin something they really didn't understand!

A few relevant references

Mazur, E. Peer Instruction: A User's Manual, Prentice Hal (1997).

Dufresne, R.J., W. J. Gerace, W. J. Leonard, J. P. Mestre, I Wenk "*Classtalk:* A Classroom Communication System fo Active Learning" J. Computing in Higher Education, 7, (1996)

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FEd sessions scheduled for the March and April APS meetings

March meeting

Monday, March 22: Research at Predominantly Undergraduate Institutions
(Brian Andreen, Peter Collings, Anne Silversmith, Enrique Galvez, John Brandenberger)
Tuesday, March 23 (joint with DCOMP) "Open Source Software in Physics Education and Research" (Paul (DuBois, Wolfgang Christian, Matthias Troyer, Wolfgang Bauer, Bruce Sherwood)

Wednesday, March 24 (joint with CSWP): "Keeping Women/Girls in Science"
(Elizabeth Simmons, Barbara Whitten, Mary Pavone, Liz Whitelegg, Gerhard Sonnert, Laurie McNeil,)
Panel discussion and reception will follow.

April meeting

Saturday, May 1 (joint with FGSA): "Alternative Careers"
(Benn Tannenbaum and others)

Saturday, May 1 (joint with CSWP): "Keeping Women and Girls in Science"
(Gerald Holton, Barbara Whitten, Tricia Rankin)
Panel discussion

Sunday, May 2 (joint with FPS): "Teaching Socially Relevant Physics"
(Al Bartlett, Kerry Browne, Art Hobson, Greg Mulder, Brian Jones)

Sunday, May 2: "Course Reform and PhysTEC"
(Ron Thornton, Ingrid Novodvorsky, Al Rosenthal, Gay Stewart, Carl Wieman)

Monday, May 3: "Textbooks"
(Greg Puskar, Paul Zitzewitz, Ray Serway, Mark Grayson)

Tuesday, May 4 (joint with DNP) "Undergraduate research"
(to be announced)

Possibly 3 more sessions.

Browsing Through the Journals

Thomas D. Rossing

•The most exciting science in the 21st century is likely to evolve among, not within traditional disciplines, according to a Policy Forum report in the 12 September issue of *Science*. Most research universities have softened disciplinary boundaries by creating multi-departmental graduate programs in biomedical science, for example. However, physical science and mathematics departments are not anxious to relinquish bright students to courses and laboratories in biomedical departments. Cultural barriers are at least a great as institutional barriers. A scientific language, approach, and training style are passed from mentor to student within disciplines like a tribal culture. In some programs, shared trainees are the catalysts bringing research groups together. Because trainees are funded from non-departmental sources, barriers for mentor participation are lower.

•A comment in the September issue of *Physics World* deals with “Effective teaching with the Web.” Websites designed to teach physics can be useful, but they must be far better before students no longer need to rely on the help of real teachers, it is argued. “Real” teachers involve students in situations that are designed to encourage learning, so when we use the Web to teach, we need to stimulate the mind of the user and offer a visual (and sometimes audible) environment to encourage learning. It is not enough to just present information. Computer-based teaching and learning systems would automatically adapt to the users’ needs so that each user will get individual attention. Students will still need to carry out experiments, but the time spent on these will be more effective if they properly prepare for them using pre-lab computer exercises.

•“Global study of the role of the laboratory in physics education” is the title of the 2002 Millikan Award Lecture by Simon George printed in the August issue of *American J. Physics*. Physics education in India, Malaysia, Singapore, Great Britain, etc. is compared to the United States. The author concludes that physics education at the high school level in the United States is more than satisfactory, but that the weak link is that a mere 25 percent of students choose to take high school physics courses. A large percentage of teachers in the K-8 levels are not comfortable in teaching science to their students. From these teachers, students learn long-lasting lessons about science. We need to help our K-8 teachers to feel more confident in teaching science.

•“Make Science the ‘Fourth R’” is the title of an editorial by NSTA President John E. Penick in the October/November issue of *NSTA Reports*. He points out that last year, for the first time, ACT set benchmark scores to determine college readiness in science and math. Only 26 percent of 2003 high school graduates who took the ACT test earned a score of 24, which would predict a high probability of completing a first-year college science course with a grade of C or better. Even worse is the fact that only 5 percent of African American test-takers, 10 percent of Mexican American students, and 14 percent of Hispanic and American Indian students scored at this level. He feels that this is due to the emphasis on reading and mathematics and growing neglect of K-12 science teaching in classrooms across the nation. This situation is exacerbated by the No Child Left Behind Act, which will begin testing for math and reading in 2005, while science will not be tested until 2007-08, thus encouraging schools to devote available resources and time only to math and reading. “Schools and districts must bolster their science education programs and insist that science be part of students’ daily life,” he urges.

•A director of network services at a large university discusses “Mobile Computing on Campus” in the October issue of *Syllabus*, a journal devoted to technology for higher education. Early projects involved research with robots, wearable computers, and integrating eyepieces. Wireless devices are replacing wired keypads in classrooms. Although laptops are still the most popular mobile devices in use, PDAs are coming up in numbers as are Tablet PCs. Changes in instructional technology that have resulted from mobile technology are discussed.

•Do planetarium shows, popular lectures, and other science communication activities get people interested in science is a question discussed in a comment entitled "How to get the message across" in the October issue of *Physics World*. Do these public events, which rely on individual physicists who have a passion for communication as well as physics, have any effect on people's attitudes toward physics? It is difficult to measure the success of such activities and even defining what makes an event successful is tricky. Successful science-communication events do require a good deal of organizational effort.

•Enrollment in distance education courses has nearly doubled since 1995, according to a report by the Department of Eduations's National Center for Education Statistics. More than half of the nation's colleges and universities offered such courses in 2000-01. Distance education courses were offered by 90 percent of public two-year institutions, 89 percent of public four-year institutions, and 40 percent of private four-year institutions. The report is available from <http://nces.ed.gov/surveys/peqis/publications/2003017>.

•The High School Teachers' summer program has grown from 9 teachers in 1998 to 40 teachers this past summer, according to an article in the October issue of *CERN Courier*.. In addition to teachers from CERN member states, teachers from non-member China, Mongolia, Slovenia and US took part during 2003. A "hands on" workgroup, in which participants built demonstration accelerator models for the classroom, was organized during this past summer. Another feature was the Alumni working group which brought participants from previous years back to CERN to conduct a survey among their colleagues on the usefulness of the program in teaching and related work.

•An editorial entitled "More or Less" in the October issue of *The Physics Teacher* discusses the popular call for "less is more" in physics instruction. We try to heed Arnold Arons' warning against rushing through our courses so fast that students are left only with "inert" (memorized) knowledge, but we generally accept some reduced level of student comprehension in order to cover the minimum number of topics we've chosen to teach. Every year, we have to make harder and harder choices about what topics to include in our freshman physics course.

•A list of websites that refute space-related humbug, such as crop circles, the "Roswell Incident" in which an alien spacecraft purportedly crashed in New Mexico in 1947 can be found at <www.astrosociety.org/education/resources/pseudobib.html>, according to a note in the 3 October issue of *Science*. Teachers can transmute pseudoscientific misconceptions into lessons on critical thinking and scientific methods—if they have the straight story behind purported paranormal events.

•Why do so many U. S. Students avoid science? Part of the answer could be a deep dislike for the subject by authors of the most popular children's books, according to an editorial note in the 10 October issue of *Science*. Author Sharon Creech loathed geometry, she told the *Washington Post* in an interview on the eve of the National Book Festival, while writer-illustrator Steven Kellogg told them that the thought of algebra "still causes me to lapse into a coma." Of the seven writers interviewed, four named math as their worst subject in school and two fingered chemistry.

•A university science course that integrates physics, education, and community outreach is described in an article entitled "Coordinating Physics and Education Instruction" in the September/October issue of Journal of Science Teaching. The course for undergraduates who have expressed an interest in teaching is composed of three elements: physics content, theories of teaching and learning physics; and practical experience teaching physics to K-12 students.

Executive Committee virtual meeting

On October 25 the Executive Committee held a teleconference meeting with 12 (of 18) members and one guest taking part. In order to save travel money the Executive Committee holds several meetings each year by teleconference plus a face-to-face meeting at the APS April meeting.

The Committee discussed the report of the Budget Subcommittee (Christian, Heller, Malamud, Rossing, and Zollman) on ways to use available FEd funds to further physics education. It was decided to support the registration fee for new fellows at the meeting at which they are presented their certificates, and to support teacher preparation workshops and/or special sessions at APS and joint APS/AAPT (regional) meetings. A Physics Education Award is also being considered.

In addition to sessions planned for the March and April meetings (listed elsewhere in this newsletter), we plan to co-sponsor a session on "Physics of Beams and the Accelerators that Produce Them" at the AAPT national meeting in Sacramento next summer. DPM and AAPT have approved this session which will be organized by Ernie Malamud. It is hoped that this session will be a model for other APS divisions in future years.

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.org/units/fed/index.html

Book Review

By Art Hobson (reprinted from Physics In Perspective *with permission)*

George Gamow and Russell Stannard, The NEW World of Mr Tompkins. Cambridge, United Kingdom: Cambridge University Press, 1999, ix + 258 pages. $24.95 (cloth), $16.95 (paper).

This is a revised and updated version of Gamow's 1965 classic *Mr Tompkins in Paperback*, which is in turn a revised and updated version of Gamow's even more classic *Mr Tompkins in Wonderland* (1940) and *Mr Tompkins explores the Atom* (1945). Science popularizer Russell Stannard revised 14 of the 15 chapters in Gamow's original and added four entirely new chapters.

George Gamow (1904 to 1968) was an influential physicist and cosmologist, a founder of the big bang theory, and popular with the general public as a science writer and lecturer. The two earliest *Mr Tompkins* books were widely read by non-scientists and scientists as an entertaining and authoritative introduction to the remarkable ideas of recent physics, for example *c* as the universal speed limit, relativistic length contraction, curved space, the second law of thermodynamics and Maxwell's demon, the expanding universe, quantum uncertainty, atomic structure, and nuclear structure.

The *Mr Tompkins* books, including Stannard's version, are neither science fiction nor straightforward science popularization, but instead a mix of fantasy and science. Mr C. G. H. (the initials are purposeful, as we will see) Tompkins is a mild-mannered bank clerk with a short attention span and a vivid imagination. Having extra hours on his hands, he attends a public lecture on Einstein's theory of relativity. During the lecture by "the professor" (Gamow's stand-in), and frequently throughout the book, Tompkins nods off into a dreamworld where the marvels of physics are commonplace experiences. In these other worlds, the speed of light (*c*) is so slow, or the gravitational constant (*G*) is so large, or Planck's constant (*h*) is so large, that special relativistic, general relativistic, and quantum effects manifest themselves directly.

Stannard updates Gamow's physics. The 14 revised chapters are slightly updated, for instance by the brief introduction of dark matter and the theory of cosmic inflation into a chapter on spatial curvature. Gamow's explanations are slightly improved upon but largely unchanged. The four new chapters are devoted entirely to new results since 1965: Stellar and galactic black holes, the cosmic background radiation, the strangeness quantum number, SU(3) symmetry, the latest in particle accelerators, quarks, gluons, the standard model of particle physics, supersymmetry, string theory, and cosmic inflation, all in the spirit and style of Gamow's original. The entire revision was done with the approval of the Gamow family.

Stannard also updates Gamow's book linguistically and socially. "By Jove!" becomes "Ah!," "The Gay Tribe of Electrons" becomes "The Merry Tribe of Electrons," and so forth. Happily, the professor's daughter Maud is radically transformed. For Gamow, she is a "painting" student who seldom speaks up for herself when her "Daddy" is around. In a typical exchange in the 1965 edition, Maud pouts and says, "Daddy, if you are talking physics again, I think I will go and do some work." The professor replies, "All right, girlie, you run along." In Stannard's revision, Maud is a prominent professional artist who is deeply conversant with the entire range of modern physics, assertive, and frequently remonstrative with her "Dad" for being overly academic and out of touch with non-scientists such as Tompkins.

Notwithstanding the historical importance of the originals, and the faithfulness of Stannard's revision, I cannot recommend this book either for the general reader or for scientists. The problem lies not in Stannard's revision but in the original works, as viewed today. In the 1940s, the *Mr Tompkins* books were a welcome breakthrough in rendering modern physics interesting and understandable to the general public. But today they do not measure up to recent non-technical science writing, and they are stylistically dated. Stannard's revision is too close to the original to change this assessment.

Mr Tompkins alternates largely between the professor's lectures, and Tompkins' dreams. Thus, Tompkins falls asleep during the professor's lecture about special relativity, and dreams of a city in which the speed of light is 20 miles per hour. Special relativistic length contraction, time dilation, aging, and so forth, are described in an entertaining fashion, but without any discussion of the theory because it's Tompkins' dream, not the professor's. This is a neat idea, and it works fairly well.

The professor, in the lecture through which Tompkins snoozed, then explains the physics behind the dream. But many explanations are too compressed and technical for most non-scientists. For a typical example,

> The splitting of this four-dimensional spacetime continuum into a three-dimensional space and a one-dimensional time is purely arbitrary, and depends on the system from which the observations are made. Thus two events, separated in space by the distance l_1 and in time by the interval t_1 as observed in one system, will be separated by another distance l_2 and another time interval t_2 as seen from another system. It all depends on the particular cross-section one is taking through the four-dimensional reality, and that in its turn depends upon one's motion relative to the events in question.

This discussion is comprehensible to a physicist, but it is too compact, too devoid of examples, and too abstract for non-scientists. They will find it discouraging, especially in view of the importance the professor places on spacetime.

Stannard's book contains 20 equations that also appear in the original, most of them rather complex, including the Einstein field equations, with few of them explained for non-scientists. This will completely discourage most non-scientists. Nearly every physics popularizer these days manages to present good physics, and even good *quantitative* physics, without equations. The reason is that physics is fundamentally about observations and ideas, and both are describable in words, or perhaps proportionalities and graphs. Equations are required only if one wants to *do*, as contrasted with *understand*, physics.

Although the book is directed at adults, it has a storybook quality that ranges from the entertaining image of Tompkins waltzing around a human-sized atomic nucleus, to the silly "Cosmic Opera" in which the now-passe debate between the big bang and steady state cosmologies is set to music and poetry. This child-like quality might have been entertaining fifty years ago, but will probably not appeal to most readers today.

As readers of *Physics In Perspective* know, many non-scientists today are, like Tompkins, fascinated by modern physics. They attend sold-out performances of plays, such as Michael Frayn's *Copenhagen* and Tom Stoppard's *Arcadia,* with significant modern-physics themes. They enthusiastically read such books as Brian Greene's *The Elegant Universe,* Alan Guth's *The Inflationary Universe,* Paul Davies' *The Mind of God,* Leon Lederman's *The God Particle,* Steven Weinberg's *Dreams of a Final Theory,* and everything by Carl Sagan. Such works set a very high standard. The *Mr Tompkins* books were admirable pioneers in this worthy endeavor, but today's reader will find these recent entries more enlightening and engrossing than Gamow's originals or Stannard's rewriting of them.

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Executive Committee of the Forum on Education