FORUM on EDUCATION

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Seeking New Models for Education Programs at APS Meetings

Ken Krane

When I was a graduate student in the 1960s, I regularly attended the annual general meeting of the APS, which was held jointly with the AAPT. Many APS members *also* attended their divisional meetings, but the general meeting was an annual event that provided a focus for the national physics community. I recall that preparation of papers for the general meeting engendered a great sense of urgency throughout my department as the deadline approached.

Along with many of my fellow graduate students, I often spent time at the AAPT part of the meeting. Listening to talks about physics education or browsing through displays of textbooks and instructional equipment enhanced my desire to become an academic physicist, and the lesson I gleaned from the joint APS/AAPT meeting was that teaching and research should demand equal emphasis in an academic career.

Sadly, we now have neither a general annual meeting nor a joint annual meeting with AAPT. Graduate students and postdocs who attend APS meetings have thus lost the opportunities to learn about physics teaching by attending AAPT sessions at joint meetings. Similar opportunities for new or experienced faculty to hone their teaching skills have also been lost. AAPT meetings offer a rich array of invited and contributed sessions on topics that are of great usefulness to college and university instructors. However, of the approximately 5000 physics faculty members at U.S. research universities, only about 10% are AAPT members. Thus few research university faculty have the opportunity to enhance their teaching or share teaching ideas with others by attending sessions at AAPT meetings.

One of the missions of the Forum on Education is to sponsor education sessions at APS meetings. At the present time the Forum is allocated two sessions of invited papers at the March meeting and four sessions of invited papers at the April meeting. Often these sessions are co-sponsored with other units, which allows us to extend the number of sessions in which we participate. (According to the rules for allocating sessions at meetings, if we co-sponsor a session with another unit we are "charged" only one-half session against our allocation.) In recent years these sessions have spanned a wide array of topics: for example, preparing future university faculty, teaching thermal and statistical physics, finding and holding a faculty job, improving physics graduate programs, communicating physics to the general public, and enhancing the preparation of K-12 teachers. These programs have generally been lively and well attended. Unfortunately, these sessions are not available to physicists who attend divisional meetings other than the March and April meetings.

The Executive Committee seeks the advice of Forum members on the question of how we can enhance our efforts to provide sessions on physics education at APS meetings. Should we endeavor to include invited sessions on education topics at other divisional meetings? At present the six education sessions at the March and April meetings are organized by the FEd Program Chair (who is the chair-elect of our Executive Committee) with the help of members of the Executive Committee who may take responsibility for individual sessions. Clearly a significantly greater role in arranging sessions will require additional organizers and thus an expanded Program Committee that goes beyond the Executive Committee membership.

What should be the relationship between the Forum and the education committees of the various APS divisions? Should the FEd continue to take responsibility for organizing education sessions at divisional meetings, or should we instead provide suggestions and session templates for the divisional education committees? Should these programs take the form of parallel sessions or pre-meeting workshops? Similar questions arise with respect to education sessions at sectional meetings.

In the past six years more than 300 recently hired physics and astronomy faculty have attended the New Faculty Workshops, currently sponsored jointly by AAPT, APS, and AAS. Participants have

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offered enthusiastic testimony about the positive impacts the Workshops have had on their teaching. How should we spread these lessons to the several hundred new faculty hires each year, most of whom will not have the opportunity to attend one of these workshops? Again, what is the proper role of the APS divisions and sections in developing targeted teaching enhancement programs for new faculty (as well as for graduate students and postdocs who are contemplating faculty careers)?

I would like to encourage FEd members to respond to me with their views on these questions. I will share your comments with the members of the Executive Committee before we begin planning our annual programs at our fall meeting.

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Letter to the Editor

To the Editor of the FEd Newsletter:

Raymond Hall's article (Spring 2002, pp. 7-11) presented four excellent student activities for promoting critical thinking. Hall mentions quite a few pseudoscientific beliefs that are professed by many Americans: astrology, psychic contact, extra sensory perception, ancient astronauts, big-foot, out of body experiences, etc. To this depressing list, I would like to add one item that should be in every list of significant pseudosciences.

Creationism, the belief that the Bible's Old Testament can be read literally and that Earth and the main biological types (especially humans) were created separately just a few thousand years ago, is arguably America's most important pseudoscientific belief because it is held so dogmatically by so many people, its base lies in mainstream religion, and it cripples science education in the public schools. Especially when disguised as "creation science" or "intelligent design," creationism fits perfectly the standard definition of pseudoscience as "any claim that is presented so that it appears scientific even though it lacks supporting evidence and credibility." Its negative effect extends explicitly to all the sciences, including physics. For example, creationists in 1999 in Kansas removed from the state science standards all mention of the big bang, radioactive dating, continental drift, the age of Earth, global warming, and biological evolution. Although this rule was rescinded in 2001, similar laws and rules exist in many states. Polls consistently show that roughly 50% of all Americans believe that "God created man pretty much in his present form at one time within the last ten thousand years."[1]

Creationist nonsense remains endemic because we scientists have failed to teach good science to all students. All of us should follow Raymond Hall's suggestion by teaching critical thinking in our general science courses. In addition, there are at least four specific opportunities to introduce evolution-related topics into physics courses: First, teach radioactive dating as an application of nuclear physics, and present the main geological ages along with supporting radioactive and non-radioactive evidence. Second, discuss the consistency between the second law of thermodynamics and increased organization in open systems such as a growing leaf, and counter the fallacious creationist argument that evolution contradicts the second law. Third, present big bang cosmology and the supporting evidence: the expanding universe, the three-degree microwave background radiation, "ripples" in this radiation, and quantitative agreement between big-bang isotope-formation predictions and observed isotope ratios in our galaxy's oldest stars. Fourth, discuss (perhaps in the context of possible life elsewhere in the universe) the hypothesis of the chemical origin of life on Earth and supporting experimental and fossil evidence.

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Reference:

1. Michael Shermer, *Why People Believe Weird Things* (W. H. Freeman and Co. New York, 1997), p. 156.

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Exploring the Alternative of Professional Master's Programs

Hans Bozler

Like many faculty members in primarily Ph.D. oriented science departments, we became concerned by the diminished interest in physics graduate programs from U.S. trained undergraduates. While our graduate programs were filled by highly qualified students from abroad providing much needed diversity, there was also a message that we were not providing educational opportunities that were highly valued by students graduating from our own colleges and universities. The reasons for the flight of domestic graduate students are many and complex. They include better opportunities and more rapid access to professional careers in non-science graduate programs; higher salaries paid in professional careers including medicine (MD), law (LLD), and business administration (MBA), and, at least until recently, the attraction of careers in information technology.

Charged with the desire to attract more and better-qualified graduate students drawn primarily from colleges and universities within the U.S., we started looking at the issues that related to perceived values of graduate education. Supported by the Alfred P. Sloan Foundation, we initiated a series of experimental professional master's degree programs with the intention of providing a high value alternative to the traditional Ph.D.: the Professional Master's in Physics for Business Applications, Computational Biology, Computational Linguistics, and Environmental Risk Assessment. These programs are intended to be self-supporting, interdisciplinary alternatives to the Ph.D. All of the University of Southern California professional master's programs require substantially more coursework than traditional master's degrees in the sciences. In addition to the coursework, these programs include internships and participation from industry. All of these programs develop skills in the areas of computation, modeling, and problem solving.

The vision of our new programs is to provide an interdisciplinary education that in turn focuses on potential careers and provides a fast track to those careers. Many other universities have also started professional master's degree programs. A more complete description of the vision for professional master's degrees and information about universities that have initiated these programs is available on the web site www.sciencemasters.com.

Initiating new graduate programs involves a variety of challenges. They include challenges from getting the right students to motivating employers. Additional challenges come from university administrations, competing schools within the university, and from our own colleagues. Some of these are due to the culture and traditions of academics and employers – the very thing we would seek to change. Below, I will focus on our experiences with the physics program.

In our planning process for the Physics for Business Applications program, we proceeded to ask two constituencies about physics graduate programs. The first involved a lengthy questionnaire to our alumni (at all levels). This questionnaire drew a high level of response and the message was pretty clear. There was a lot of interest and enthusiasm for programs that combined physics skills with aspects of business and other professional but non-traditional skills. In fact, many of our alumni had already gone that route in an *ad hoc* fashion in order to enhance their own careers by going back to school in one or more professional areas.

The second constituency has been a group of industry contacts. There the message has been less clear. Their focus was more on industries' need for immediate job skills, rather than on enhancing the careers of the students. In fact one research division head in a large technology corporation referred to his employee's promotion to a management position as "going over to the dark side." Although it seemed surprising at first, there is a natural tension between academics whose primary interest should be the successful careers of their graduates, and traditional industry employers whose success does not particularly depend on enhancing the career of their employees, but rather their skills and productivity in doing their current job.

The program design for the USC Professional Master's in Physics for Business Applications called for a rigorous basic training in physics plus training in our business school (the Marshal School of Business) as well as an internship with the requirement of having the students write and defend a report based on the internship. Likewise, the other USC programs emphasize combinations of disciplinary training and practical skills. For the Sloan funded programs at USC, the total number of professional master's students taken in the last three years is close to 60, with the Professional Master's in Computational Molecular Biology being the most successful in attracting students. It has averaged about 12 new students per year. The university mandates that the majority of students provide their own support and that they must be capable of competing with our Ph.D. students. These conditions greatly limit the number of students. In Physics for Business Applications we have taken seven students, from which three have graduated and four are in progress -- a smaller number than we anticipated, but nevertheless they provide quite a bit of insight on how such programs can operate.

Initiating a new type of degree program involves changing culture, perceptions and expectations both within the academic community and externally with future students and employers. The culture issues start with the rather checkered history of master's degree programs. Most science departments and their associated schools are not in general comfortable with these programs because they have primarily used master's degrees as a means of "out-placing" Ph.D. students who either cannot or do not wish to complete their degree. National ratings of graduate programs do not consider anything but the Ph.D. programs. Master's students are not major contributors to the research in their departments. Most importantly master's students do not become faculty at universities.

Potential employers need to be convinced that carefully trained professional master's students are excellent candidates for positions in business and industry. In many cases, traditional employers have been deluged with applications from Ph.D.'s even though their positions do not require the specific training that the Ph.D. program adds. We hear comments, roughly paraphrased, like: "The value of the Ph. D. is that we know that the candidate is smart." Several of our business and industry contacts pointed out that the greatest interest in graduates from professional master's programs would come from smaller, more entrepreneurial employers who expect their employees to perform a wide range of tasks. This prediction appears to be quite correct. In analogy to MBA's being partial to hiring more MBA's, a tradition of hiring professional master's students in the sciences

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needs to come from successful placements of those students – a long process.

Even in an academic setting, patience with new programs can run short. Administration goals can change more rapidly than programs. Old perceptions of master's programs linger, while there remain suspicions that master's programs detract from Ph.D. programs in some sort of "zero sum" manner. Financial aid for students who would otherwise be fully paid and receive full tuition support by going into a competing Ph.D. program, is a particularly difficult issue. In the physics community, students are frequently advised to start a Ph.D. program even though their academic record indicates a small chance for completion.

The physics departments should consider restructuring graduate programs to make them more reflective of the talents and job prospects of their students by:

- substantially reducing the number of students in Ph.D. programs;
- creating really high quality masters' programs;
- getting administrators to understand that by supporting high quality master's programs they can actually improve their Ph.D. programs;
- and finally, encouraging their undergraduate students to take a look at the new options.

Relevant web sites:
www.sciencemasters.com
http://physics.usc.edu
www.usc.edu/dept/sloanweb

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Physics First: Precursor to Science/Math Literacy for All?

Richard R. Hake

I. "Physics First"

The Lederman (1999; 2001a,b) "Physics First" brigade appears to be attracting recruits: e.g., two sessions on "Physics First" at the January 2002 AAPT meeting in Philadelphia; recent pro-"Physics First" editorials by AAPT leaders (Chiaverina 2002, Khoury 2001, Hubisz 2001a); a "Physics First" website (Livanis 2000); and "more than a hundred schools around the country. . . that have switched the sequence to the rational order" (Lederman 2001b). Lederman (1999) writes:

> **Our reform thrust, in military metaphor, is toward a weak section of the barriers to change that surround the school systems.** We have observed that 99 percent of our high schools teach biology in 9th (or 10th) grade, chemistry in 10th or 11th grade, and, for survivors, physics in 11th or 12th grade. This is alphabetically correct, but by any logical scientific or pedagogical criteria, the wrong order. A standards-based science curriculum must contain at least three years of science and three years of mathematics. And the coherent order begins with 9th grade physics**, taught conceptually** and exercising only the math of 8th and 9th grade; then chemistry, building on the knowledge of atomic structure to study molecules; then the crowning glory of modern, molecular-based biology. . . . We stress that this is a design for **ALL** students, work- bound, liberal arts-college-bound, or science-and-technology-bound. The schools that are "doing it right" report greatly expanded enrollments in fourth-year electives and Advanced Placement science courses**. Thus, a solid, core curriculum will enlarge rather than** . . . (diminish the pool of). . . **future scientists**. (My **emphasis**.)

II. Precursor to "Science/Math Literacy for All"?

But does K-12 education need "Physics First," or "Physics For All?" I agree with Hubisz (2001a) that *both* are desirable. However, considering the appallingly low level of science literacy among the general population, and society's need to solve the monumental science-intensive problems (economic, social, political, and environmental) that beset it (see, e.g., Lederman 1999, Hake 2000), I would rate "Physics For All" or, more generally, "Science/Math Literacy for All," as being by far the more important.

Viewed from that perspective, Lederman's "Physics First" reform thrust could be *an important **precursor** for more systemic reform* such as that envisaged by "Project 2061" (AAAS 1989, 1993, 1997, 2001, 2002), a long-range effort designed to achieve "Science/Math Literacy for All." As indicated in AAAS (1989, p. 11), Project 2061 "was started in 1985, a year when Comet Halley happened to be in the earth's vicinity. That coincidence prompted the project's name, for it was realized that the children who would live to see the return of the comet in 2061 would soon be starting their school years." But I would submit that "2061" could also designate the earliest year by which scientific literacy as defined in *Benchmarks for Science Literacy* (AAAS 1993) might characterize a *majority* of Americans (even despite the thorough and thoughtful efforts of Project 2061). My pessimism reflects the formidable roadblocks to education reform (Section III), and the monumental inertia of the U.S. educational system.

Considering only the *physics* aspects of "Science/Math Literacy for All," the cogent arguments of Hugh Haskell (2001) for "Physics for All," *starting in the very early grades* are worth pondering:

> I have been saying for years that physics can be taught earlier than the 12th grade, and it should be, but just dumping physics into the ninth grade isn't the solution either. . . . It isn't that we have to "dumb down" physics so that it can be taught as a terminal course to ninth graders; we need to teach the early concepts to kids starting as early as they can be expected to grasp them . . . They need to start learning to ask the question "How do we know that?" . . ..(Arons 1983). . . and they need to start learning some of the vocabulary of science. They can also start learning how to draw a graph, and how to collect things--how to choose what fits into a desired category, how to decide on cate-

> gories, in other words, how to look systematically at the world . . In this way, we can expect that the students will be able to do certain things when they get to the ninth grade, and even more by the time they get to the twelfth grade. **But we have put them on a ramp to understanding and not a cliff**. Keeping the cliff but just making it lower because the kids are starting in the ninth grade is no improvement**.** . . . it involves much more than just reversing the order of presentation . . . **it involves a major rethinking of the philosophy of science education in the pre-high school years**. (My **emphasis**.)

Haskell's arguments are in consonance with:

A. The AAAS Project 2061 as indicated above.
B. The *National Science Education Standards* (NRC 1996).
C. Mahajan & Hake (2000) and Hake (2002a,b).
D. The "Revolutions in the Goals and Methods of K-12 Science Education" (Lopez & Schultz 2001).

III. Systemic Roadblocks to Science/Math Literacy

Among important roadblocks to science/math literacy are, in my opinion, the following:

A. High-stakes state-mandated tests of reading and mathematics (see, e.g.; AAAS 1997e; Heubert & Hauser 1998). Will these crowd out K-8 science education?
B. State science standards that are antithetic to the National Science Standards (NRC 1996) and the AAAS (1993) "Benchmarks for Science Literacy." An outstanding example is the California science standards (Feder 1998, Woolf 1999).
C. An antiquated and dysfunctional K-12 science/math curriculum (AAAS 1997f,g)
D. Science textbooks that are overstuffed, uninformed by education research, and often riddled with scientific errors (see, e. g., AAAS 2001; Hubisz 2001b).

Attempts to overcome roadblocks "A" – "D" will require considerable educational redesign (Wilson & Daviss 1994) as well as grass-roots political effort. In my view those four roadblocks, challenging as they are, will be far easier to overcome than the fifth and most formidable:

E. The dearth of effective K-12 science/math teachers (APS 2001, AAPT 2000).

IV. Conclusions

The reports of the Glenn Commission (2000), Hart-Rudman Commission (2001), NSF (1996), AAAS (2002), AAPT (2000), and APS (2001), and the "No Child Left Behind Act" (U.S. Congress 2001), all testify to the current national interest in improving pre-college teaching and education. On the other hand, there exist very serious systemic *roadblocks* to improving K-12 science/math education that may take sixty years or so to overcome. In the meantime, Lederman's "Physics First" regime, while not the ideal *ramp* to science/math literacy, might – if vigorously supported – be adopted by thousands of U.S. school systems within the next decade. This would auger well for the eventual attainment of the goal of "Science/Math Literacy for All" by demanding that serious attention be paid to the several roadblocks that are common to both "Physics First" and "Science/Math Literacy for All," most importantly, *the dire shortage of effective science/math teachers.* In particular, physics departments might help to overcome this roadblock and at the same time enhance their numbers of physics majors and graduate students, through programs designed to provide a large corps of teachers capable of *effectively* teaching physics to vast numbers of students in the "Physics First" schools: ALL ninth-graders plus those taking twelfth-grade honors and AP physics courses. Then, too, once ninth graders have experienced the excitement of well-taught conceptually oriented physics they will doubtless flock to enroll in twelfth grade and undergraduate physics classes, many of them as physics majors.

Richard Hake spent 40 years researching superconductivity and magnetism at the University of Illinois, North American Aviation, and Indiana University, together with 25 years teaching physics and researching physics education at the latter institution. He is now retired and living in California. He can be reached at <rrhake@earthlink.net>, < http://www.physics.indiana.edu/~hake >*, and* < http://www.physics.indiana.edu/~sdi >.

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† Submitted to the *APS Forum on Education Newsletter* on 31 May 2002. A more complete version of this paper titled "Physics First: The Opening Battle in the War on Science/Math Illiteracy" is online as reference 20 at
< http://www.physics.indiana.edu/~hake >.

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We Need Your Input!

The Editors of the FEd Newsletter invite your comments, contributions, and suggestions for this newsletter. If you have a new idea to share with others, let us know. If you know of an educational program or issue that deserves our attention, please contact one of the editors. And if you have comments about the format or content of the newsletter, we would appreciate hearing about that as well.

We specifically invite comments about the electronic version of this newsletter: do you find it easy to read? Do you take the time to read it? Do you print it out so it is available to read when you have the time? Your comments are solicited.

Approximate Best Fit Modeling of Physics Phenomena

Stewart E Brekke

Most upper grade and high school students can do "approximate best fit" modeling of physical and biological phenomena. In every lab in physics and chemistry that allowed simple modeling, I attempted to do a mathematical modeling. This modeling was done by using an "approximate best fit method" in which the student finds the "approximate best fit curve" and the "approximate best fit equation" to fit the curve. Thereby, students describe a physics phenomenon mathematically, as it should be, by finding its equation using only algebra and a calculator.

Many students were not used to this approach and often tried at first to simply describe verbally what happened in the lab experiment. But I pointed out to them that a worthy conclusion of a high school student who has done an experiment is to describe the physics event in mathematical terms. Most simple and direct experiments such as the relationship between the initial height of a tennis ball and its first bounce height can be modeled approximately by a simple equation such as $y = kx$, $y = k/x$, $y = kx^2$ or $y = kx^{1/2}$.

After I get the students started, they take the data and plot it on a rectangular coordinate system. Other coordinate systems can be used, however. I then put the curves of each of the above equations on the board: a generic line through the origin with a generic equation under it, $y = kx$; a generic hyperbola with $y = k/x$ under it; a generic parabola (usually half of one) with $y = kx^2$, and a generic square root curve, with the generic equation $y = k\sqrt{x}$ under it. The student then tries to identify the best curve that fits the data points approximately and sketches it on the graph approximating the points. This is called "approximate best fit modeling."

The student then picks a point on the sketched curve and solves for the constant k. After solving for the constant k, the equation is completed (such as $y = 0.45x$ or $y = 1.66/x$). The student then substitutes the variables used in his equation, such as y = H, initial height, and x =B, first bounce height. Then the equation describing the first bounce height of the tennis ball versus its initial height becomes, for example, $B = 0.45H$. Only a meter stick and a tennis ball are needed for this "approximate best fit" line modeling exercise. In the linear case a ruler can be used for help with the modeling, where the student puts the ruler at the origin of the graph and tries to put half of the data points above the line and half of the data points below the line. The student then draws in the line and picks a point on the line, then solving for the constant in the model $y = kx$ of a line through the origin.

At first the sketching of the "approximate best fit curve" is difficult for the students since they have never done this type of graphing, and I often have to help them. I also have to warn them that this type of graphing is only done in the physics class and the chemistry class since if they do an approximate best fit in a math class, they will probably not be doing their math graphing correctly. I ask the students why the curves fit so well in algebra class but not in physics or chemistry class. I explain to them that most often in math class we are dealing with ideal situations. I often refer to Plato's Theory of Ideas in which in a perfect world, an Ideal world, we make no errors in measurement. But when we take measurements in a real situation, we make errors in measuring and therefore all the points are not in a perfectly straight line, or in a perfect hyperbola. Therefore, we must make approximations in measuring and in our equations in physics class. I purposefully do not use the computer to model the data since the students can do it easily by hand and calculator.

By doing this type of modeling for all kinds of physics experiments the student can see how we get some of the formulas we do physics problem-solving with. One type of formula is made by modeling data such as the speed of sound formula $v = 331.45\text{ m/s} + 0.6T$, where T equals the temperature of the air. Even Ohm's Law was found in this manner, by modeling empirically.

Some of the formulas used in physics class are derived from deduction from other known formulas. For example, the relation $E = hf$ was found by using induction with best fit modeling. Combining it with the standard wave equation $v = c = f\lambda$, using deduction, gives us $E = hc/\lambda$. In this manner the students can see the different ways in which physics formulas that they use in class are obtained, some by inductive best fit modeling and some by deductive methods or by a combination of both.

These "approximate best fit modeling" experiments can be used for science fair projects. The science fair project I still have is by one young boy, a basketball player, who found the "approximate best fit" equation of a line predicting the initial height of a basketball versus its first bounce height on a regulation hardwood basketball floor as $B = 0.60\ H$ and won first place in our school science fair. Another modeling experiment that often works out very well is the curve and formula relatng the period of a simple pendulum to its length. The students can easily take data using a meter stick and stopwatch, and the curve is approximated by $y = k\sqrt{x}$ where $2\pi/\sqrt{g} = k$. Therefore, $T = 2.01\sqrt{L}$. The students can then find their percent error also.

Other modeling experiments are the relationship between the area of a flashlight projection and its distance from the bulb of the flashlight, the time of free rolling of a ball down an incline versus its height at the top of the incline, the relationship between the hand and the arm length, the height and the foot length, finding g, finding π, finding the number of turns of a wire on a long iron nail versus the number of paperclips it can pick up, and so on. The ability of high school students and even upper grade-school students to model using the "approximate best fit modeling" technique is well within the capability of every student in physics, chemistry, biology and earth science. Finally, even using the periodic table, especially the noble gases, for modeling specific heat, density, and ionization potential versus atomic number or mass number provides a non-experimental academic exercise in modeling. Other experimental curves from the periodic table and physics and chemistry texts can be modeled by hand and calculator if they are smooth or linear using the "approximate best fit method."

Linear modeling can also be done by more motivated students using the standard statistical regression formula. I had a high school science fair winner, now an assistant principal in an elementary school, find the equation of the stretch of a rubber band versus the applied mass using a regression line determined by the method of least

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squares. This can be done easily with some time and effort using a cheap calculator by many students if they have the time and motivation. Calculators have made many time-consuming and error prone calculations much more accessible to even at risk students, although the young girl who did the equation for the stretch of a rubber band was above average in ability and motivation.

For many years, I have done these approximate best fit modeling techniques with regular chemistry and physics students, from the most at risk students to the most motivated honors students. I have had classes start out at the beginning of the year by modeling the first bounce height of a tennis ball versus its initial height to help learn the meter units as we always must. Even the stretch of a rubber band versus mass applied can be modeled mathematically to practice combining the use of meter units and kilogram units. The approximate best fit method of mathematically modeling physics and chemistry phenomena is simple and very useful in the high school physics class and can be used by all students, even those in the university freshman classes.

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Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP)

Ruth H. Howes

In 1999, APS, AAPT and AIP created an eleven-member National Task Force on Undergraduate Physics (NTFUP) to investigate the drop in the numbers of students graduating with bachelors degrees in physics that occurred during the 90s. The Task Force recognized that physics departments operate in a changing environment. Disciplines like computer science and neuroscience challenge physics' place in the center of the scientific universe. Much experimental physics is done by large groups at user facilities rather than in a basement laboratory, and computational physics has begun to rival experimental and theoretical physics. Industries focus increasingly on product development rather than basic research so physics graduates find themselves working as members of multidisciplinary teams and need the "soft" skills to do that. Today's high school graduates are more likely than ever before to have studied high school physics, and they bring enormous skills in using computers. However, they often lack training in algebra or calculus, and they are accustomed to learning from video rather than from books. They are increasingly ethnically and economically diverse.

Many physics departments, particularly those granting Ph.D.s, saw steep declines in the numbers of graduating majors. Other departments have adapted successfully to environmental changes and either have all the majors they want or are growing. From conferences and other contacts with the physics community, we know that the department is the engine of change in the university, that a physics major's experience depends on an entire physics program, not just a series of courses but also things like advising and a community of faculty and students, and that one size program will never fit the diverse institutions that educate undergraduate physicists.

In 2001, NTFUP received funding from the ExxonMobil Foundation for SPIN-UP in order to find out what these thriving departments were doing right. We looked for departments with plenty of majors where morale was high for both faculty and students and the majority of the faculty was involved in undergraduate education. These departments succeeded in placing their majors in both grad school and the workforce, attracted women and minorities, earned the respect of their administrations and other departments on campus, and paid attention to training K-12 teachers. We also looked for variety in types of institutions in size, in geography and in mission.

At the invitation of the department chair, teams of three physicists including a NTFUP member visited 23 departments that seemed to us to be thriving. The department agreed to produce a rather extensive report before the visit and to support local expenses for the team. About 70 physicists volunteered to conduct the site visits. Each team produced a report for NTFUP and the department chair. The confidential reports have been turned into public case studies describing successful programs and strategies. The reports are available in the Programs Section of the AAPT website under NTFUP.

There appear to be several keys to building a thriving physics department. They are modified locally, but they reappear in all or nearly all our thriving departments. First, all the programs we visited focused on high quality academic preparation of students. Many of them used flexible programs to accommodate the wide-ranging interests of their students, but in no case did "flexible" mean lowering standards in the physics courses being taught. Students might not take as many standard physics courses, but the physics they studied was rigorous. A number of departments had introduced several tracks through the physics major. Others used 3/2 programs (3 years undergraduate physics followed by 2 years in a professional school) both to attract students to physics and to recruit them as physics majors.

In all thriving departments, the faculty as a whole placed a high value on undergraduate education. If they did not participate directly in undergraduate education, faculty members regarded it as a critical undertaking for the department and supported those actively involved during promotion and tenure and salary debates. Each department worked to best serve those students actually enrolled in physics, not the students the faculty wish were there. They constantly interacted with students and modified the physics programs in response to what they learned. All departments worked to build a community of physicists including faculty, students and staff. Most departments, even those so small that they used the back of a lecture hall, set aside space for students.

The thriving departments had strong and sustained leaders who were able to build a vision of a physics program that fits the mission of the university and serves the need of students. Most thriving departments also had support from their universities. All thriving departments paid attention to advising students and to recruiting them, but these activities varied widely from campus to campus.

Each of the thriving departments took responsibility for the condition of their undergraduate programs. Faculty members did not blame poor student preparation or unresponsive administrators for the down turn most of them once experienced. They analyzed the situation and took action to correct it.

Finally, we worked with the AIP Group on Surveys and Special Studies to conduct a national survey of departments granting bachelor's degrees in physics. The survey achieved a 74% response rate, clearly indicating wide interest in undergraduate education throughout the physics community. The survey results are still being analyzed. However, we are able to present two preliminary findings. First, the courses and content comprising physics majors are remarkably uniform in almost all physics departments. This seems to indicate that the pedagogy in these courses and other aspects of an undergraduate physics program are critical to building a thriving department. Second, most departments report doing many of the things that seemed to be working for thriving departments. It is not clear whether some less successful departments have just started work on their programs or whether they need help in making these activities more effective in their local environments.

The Task Force is hard at work on a report on SPIN-UP due out later this fall. We are exploring ways to use these results to improve undergraduate physics programs. Under consideration are a series of regional conferences for teams of physicists from departments or a program of sending consultants to departments. We invite you to contact us to discuss SPIN-UP or your individual undergraduate program at NTFUP@aapt.org. This article was prepared with the help of the Task Force, particularly Ken Krane and Bob Hilborn.

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Strategic Programs for Innovations in Undergraduate Physics at Two Year Colleges (SPIN-UP/TYC)

Mary Beth Monroe

The American Association of Physics Teachers has received funding from the NSF Advanced Technological Education Program for a new project targeting physics programs at two year colleges (TYCs). Over the next eighteen months, Strategic Programs for Innovations in Undergraduate Physics at Two Year Colleges (SPIN-UP/TYC) will conduct ten site visits and a nation-wide survey of all TYC physics programs. The site visit reports and the report of the survey, prepared and administered by the American Institute of Physics, will identify and describe TYC physics programs that are shaping the future with initiatives that

- Encourage students to pursue degrees in physics or other Science, Technology, Engineering and Mathematics (STEM) areas;
- Encourage women and minorities to study physics;
- Encourage students to pursue teacher preparation programs in physics or related STEM areas;
- Successfully implement academic change at two year institutions.

Following a review of the site visit reports and AIP survey report, the project leadership will prepare a major report describing identified characteristics of outstanding TYC physics programs. Case studies of two year colleges will be prepared by the project leadership and these will be included in the report which will be disseminated to college physics departments nation-wide. This AAPT project parallels the SPIN-UP initiative of the National Task Force for Undergraduate Physics, funded by the ExxonMobil Foundation, that is compiling a report based on twenty-three site visits to successful physics departments of four year colleges and universities and a nation-wide survey of undergraduate physics departments at four year colleges and universities.

The Two Year College in the Twenty-First Century (TYC21), an AAPT project from 1995-1999 also funded by the NSF, produced a national network of more than 500 two year college physics faculty. James Palmer, Illinois State University, in his "Notes from the Editor" in the TYC21 monograph, *A Model for Reform*, explains the need for a strengthened two year college presence within the national community of college physics teachers: "Community colleges enroll just under half (46%) of all first-time college students in the United States. Among first-time students at public institutions, 54% attend two year colleges. For many Americans, especially for those who do not go on to become physicists, it is the community college that provides a window to the world of physics. And among those who teach at the college level, it is the community college professorate that has the greatest collective experience in introducing physics to the citizenry." Jay Norton, University of Southern Mississippi, wrote in the "Project Summary" of the monograph, "The educational diversity and opportunity in the two year colleges could be (and should be) exploited to aid in retaining students in the sciences, as well as prepare a science literate citizenry." The 1996 AIP Two Year College Physics Study reported that 31% of TYC physics students are women and that 15% of the students enrolled in physics at community colleges are underrepresented minorities. However, opportunities to increase these percentages are high since 58% of all two year college students are females and minorities constitute about 23%.

During the initial phase of SPIN-UP/TYC, the principal investigators (Tom O'Kuma, Lee College; Mary Beth Monroe, Southwest Texas Junior College; and Warren Hein, AAPT Executive Office) defined a set of Project Core Questions and Indicators of a Successful TYC Physics Program that will serve as guidelines for the site visits and national survey. The Core Questions, which appear below, reflect the diversity characteristic of TYC college missions, student populations, and programs of study:

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1. What type of classroom environments and course structures are effective in preparing two year college students for success
    a. at the two year college?
    b. in the workplace?
    c. for self improvement?

2. What institutional and faculty activities and practices are effective in promoting change
    a. in the classroom?
    b. in the physics program?

3. What institutional and faculty initiatives are effective in recruiting and retaining
    a. STEM majors?
    b. women and under representative populations?
    c. future K-12 teachers, especially STEM teachers?

4. What formal (articulation agreements, bridging program courses) and informal (professional interactions) mechanisms are most effective in insuring a seamless transition for students from the two year college
    a. to the four year institution?
    b. to the workplace?
    c. to both of these?

5. What institutional and faculty initiatives are effective in establishing cooperative activities
    a. with local schools (pre-college), private and public?
    b. with civic clubs and/or youth organizations (e.g. Boy Scouts of America)?
    c. with the general public?

The ten Indicators, mapped to the Core Questions, address the areas of (1) stable enrollment, (2) transfer success of students enrolled in STEM courses to four year institutions and/or the workplace, (3) morale among TYC physics faculty and students, (4) respect and collegiality among TYC faculty and administration, (5) cooperation among STEM faculty on the TYC campus and between institutions, (6) student diversity, (7) professional development, (8) learning styles and needs of TYC students, (9) contributions to the science preparation of future teachers, and (10) issues relating to institutional transfer of students.

Two year college faculty, for the most part, have little experience in conducting site visits to academic institutions for the purpose of identifying exemplary practices in physics classrooms and programs. In addition, little documentation exists concerning physics programs at two year colleges and unfortunately most physics faculty at four year colleges are not aware of the differences between their institutional structures and missions and those of the community colleges. Therefore in an effort to enhance the skills of the faculty who will conduct the TYC site visits over the next year and to refine the site visit tools prepared by the SPIN-UP/TYC project leadership, the project leaders organized a Training and Planning Conference hosted by Trinity University in San Antonio, Texas, July 25-27, 2002. Fifteen faculty from two year colleges, eight faculty from four year colleges and one industrial physicist attended the intense three day meeting.

Trial site visits and preparation of the site visit reports were the focal activities for the training workshop. Prior to the visits, site visit teams of three members each prepared sets of site visit protocol questions addressing the SPIN-UP/TYC Core Questions and Indicators of an Outstanding TYC Physics Program. Subsequently Jack Hehn, AIP Education Director, engaged the teams in group dialog to contemplate fictional, but typical, scenarios of TYC physics programs and to consider how the information in the scenarios related to the Indicators.

Four teams visited the multi-person physics department (three or more full time faculty) at San Antonio College and four teams visited Coastal Bend College in Beeville, Texas, which has a typical TYC physics department of two or less faculty. Each team then prepared a site visit report and an oral presentation concerning one aspect of their visitation. A panel consisting of Jack Hehn, Karen Johnston, Momentum Group, and Bernard Khoury, AAPT Executive Officer, through responsive commentary to the oral presentations, highlighted the nature of the information collected during the site visits and the relevance and completeness of the information as project data. During the concluding discussion, participants identified additional information teams should be provided with prior to actual site visits, additional college resource personnel the visiting teams might want to interview and a list of seventeen lessons learned while conducting the site visits. The project's external evaluator, Karen Johnston, in her initial evaluation of the training conference reported that the conference had successfully achieved its goals and objectives. In addition she noted that the faculty who will serve as site visitors "bring a wealth of talent, experience and credibility to the important and delicate tasks of visiting and reporting on physics programs at other institutions."

In late June, 2003, SPIN-UP/TYC will host a Writing and Planning Conference. During this conference the project leadership and invited participants will critically examine the case studies of TYC physics programs emanating from the TYC site visit reports and the AIP report of the TYC survey in anticipation of identifying essential elements of highly successful TYC physics programs. The TYC case studies and a description of the essential elements will be provided in the SPIN-UP/TYC report that will be available January 2004.

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The Transition from Industry to the Academy

R. Steven Turley

You may be considering leaving industrial or government employment for an academic job. If so, my experience and those of colleagues who have made similar transitions might prove helpful. I will specifically focus on three aspects of the process: preparing for the switch, marketing yourself, and adapting to the academic culture.

Preparing

The first step in preparing for an academic job is to make sure that is what you want to do. Some of my considerations were:

Salary: My academic salary is significantly lower than what I was getting in industry. This is generally true for others as well.
Colleagues: In my case, there is a stronger sense of collegiality in my academic department than I had with my industrial co-workers. Others have reported that their academic departments were more political than non-academic settings.
Research: I have less time and fewer resources for research than I did in industry. On the other hand, I have more independence in the projects I pursue and have fewer impediments in sharing the results of my research with others.
Students: My relationships with students, both in the classroom and in mentoring settings, bring me a fulfillment not readily available in industry. On the other hand, they exact a cost in both time and energy.
Culture: I found a richer intellectual environment in academia than industry. I am involved in broader discussions within and outside of physics than was usually the case in industry. Another significant difference is that academic policies are more often determined by faculty committees than by administrators. Corporate policies were generally specified by managers.
Complexity: My academic assignment has many more facets than my corporate position.

The two main criteria that will be used to evaluate you in the academic job market are your potential as a teacher and a scholar. There are a number of things you can do to accumulate evidence and experience that will impress faculty hiring committees.

There is no substitute for any teaching experience you can acquire. Be creative in looking for opportunities to teach in corporate training seminars, short courses at professional meetings, and adjunct opportunities at local colleges. Student and peer evaluations of your teaching will be particularly valuable. Become conversant with physics education literature and best teaching practices.

To the extent you can, direct your industrial research in areas of interest in the academic community. Academic hiring committees will be the most impressed by publications in general physics journals and with success in obtaining external funding for your research. Patents, internal reports, and contract reports are usually less valued. Even if you need to publish papers on your own time, it is well worth the investment.

Marketing

When you apply for an academic position, it helps to do some extra marketing to successfully compete with applicants from academic settings. It often helps to translate industrial experiences into equivalent academic ones. For instance, you could relate experience running training seminars to classroom teaching. Bringing copies of reports written for managers or clients provides additional evidence of scholarship.

It is wise to go out of your way to make personal and professional connections with academic colleagues. They can help you locate employment opportunities, serve as references, clue you in on what various departments are like, and let you know what different schools are looking for. Use your contacts to help you understand the culture in the various academic environments.

As is the case with looking for industrial positions, it is very helpful to know as much as you can about places you would like to teach. Be prepared to explain ways that you can make a unique contribution to help meet their departmental and institutional objectives.

Adapting

Once you get your first job, you will need to make some adjustments to adapt to an academic setting. These may include adding teaching to your professional responsibilities, changing the focus of what you are doing, balancing more complicated time commitments, adapting to cultural differences, and looking for different rewards for your efforts.

Look for mentors to help you master the complicated process of effective teaching. Team teaching a course with an experienced colleague can be particularly helpful. Stay current with physics education and become involved in institutional opportunities to learn about improving your teaching. The American Association of Physics Teachers and the APS Forum on Education both provide excellent opportunities at conferences, for instance.

Well-designed student and peer evaluations can also be valuable tools to improve your teaching. Your school probably has some sort of mechanism already in place. My favorite tool is the IDEAS survey available through Kansas State University. It provides specific constructive suggestions on research-based teaching techniques. Non-evaluative feedback from your own surveys may be the most useful instruments for you to use. You can ask "dangerous" questions without fear of repercussions, tailor the survey to meet your specific needs and objectives, and discover needed changes before it's too late to have an impact on the current course. I have also had good experiences with trained student observers from our campus faculty development center and getting informal feedback from students as I visit with them before and after class or in my office.

You may encounter a difference in focus between your academic assignments and those you had in industry. I had to make a shift from a product-centered to a student-centered focus. Generally, teaching should be a critical part of what you do rather than a distraction from your research. If you regard it as an opportunity rather than a "load" it will be more enjoyable and more fulfilling. Mentoring opportunities with students should be treated in the same say. Look for joy in your opportunity to assist students making the

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transition to professional physicists rather than being annoyed that they take time away from other things.

Another attitude that is usually more pervasive in academic than corporate cultures is an emphasis on making a difference in our local or global community. To fit into this culture, find something you are passionate about and look for ways to have a significant impact. Some ideas to consider are particular social and political issues, assisting involvement of traditionally under-involved groups, improving K-12 education, and being a role model in the community (for at-risk youth, for instance). Being involved in the community puts a human face on our discipline and shows them why what we do matters.

You will probably find yourself with more flexible time, but with a more complicated time commitment in academic assignments than industrial ones. For new faculty, there is often pressure to sacrifice time in other areas that are important to you (such as family, hobbies, or service) to meet school expectations. In the long run, these sacrifices usually lead to tension and unhappiness. I participated in a helpful exercise at a conference for department chairs in 2001 where we were each asked to write down an ordered list of the things that were most important to us. We then compared that list to where we spent our resources (time, energy, and money). Conflicts between what we value and what we do produce stress.

In dealing with the various time demands, it is helpful to keep in mind the relative importance of various time investments to your institution. For instance, at my school, excellent classroom teaching gets a lot more credit than the development of new courses (and is a lot less risky). Citizenship efforts that directly enhance the undergraduate experience are more highly valued than community outreach efforts. Experienced faculty, especially those involved in tenure and promotion committees, can clue you in on the focus that will bring the highest return at your school.

Having gone through the process of preparation for a change, successfully marketing yourself to get a position, and adapting to an academic environment you may find it helpful occasionally to remind yourself why you made the change. In my case, I made a conscious decision to sacrifice some financial remuneration for more independence in research, departmental collegiality, relationships with students, teaching opportunities, and the university culture. When things are tight financially, it is helpful to remind myself of why I made the trade-offs I did.

Summary

If you are considering the move to academia, now may be a good time to start getting ready. At my institution as well as others (see Denise K Magner, "The Imminent Surge in Retirements", *The Chronicle of Higher Education*, March 17, 2000; Rachel Ivie, Katie Stowe, Roman Czujko, "2000 Physics Academic Workforce Report," AIP Pub. Number R-392.4, March 2001) faculty retirements are increasing while PhD enrollments are decreasing. With good preparation, marketing, and adaptation this could be an opportune time to make this transition.

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Browsing Through the Journals

Thomas D. Rossing

•Like the Millennium Dome in London, a network of science centers built as part of the millennium celebration in Britain are in financial trouble, according to a news item in the 13 June issue of *Nature*. A dozen or so science centers, intended to boost the public understanding of science, educate children, and help to revitalize depressed urban areas, were financed largely with $360 million from Britain's national lottery. But with no lottery money available to maintain them, many of them, such as the Glasgow Science Centre, are in financial difficulty. "Without support from government, the future of science centers that do not have income streams other than visitors spending is bleak," the CEO of a science center in Newcastle is quoted as saying. Observers fear that many centers will be forced to replace educational activities with more commercial alternatives.

•A conference called **Physics on Stage 2** brought 420 teachers and educational experts from 24 European countries to Noordwijk April 2-6, according to a report in the June issue of *Physics World.* The conference, held at the European Space Agency's Space and Technology Center, included performances, presentations, and workshops. Most of the countries reported a common problem: a shortage of physics teachers. A third conference, **Physics on Stage 3**, will be held at CERN in Geneva, in November 2003. Information is available at www.physicsonstage.net.

•A thoughtful editorial "Science for Citizens" by the editor, Lester Paldy, appears in the May issue of *Journal of College Science Teaching*. "It's remarkable," Paldy comments, "that nearly 50 years after the post-Sputnik reforms in pre-college and undergraduate science education and after the expenditure of many billions by NSF and other federal agencies, we're still struggling to figure out how we should approach the problem of science education for citizens." He suggests that local school boards would do well to hire science teachers who can share with their students at least one scientific hobby. Most schools would never hire music or art teachers who did not practice some aspect of those subjects. Why should science be different?

•A call for more physics education research in the United Kingdom is the theme of an editorial "Looking at how we teach physics" in the May issue of *Physics World*. Although the UK is one of Europe's most active centers for developmental work in university physics teaching, more research on physics education is needed, the author argues. He cites groups at the Universities of Washington and Maryland in the US as examples.

•A resource letter on risk analysis in the May issue of *American Journal of Physics* is intended to provide an introduction to the literature on risk analysis. It includes a discussion of how risks are calculated with roughly decreasing reliability: from historical data; new risks calculated by an understanding of engineering processes; and new risks calculated by analogies with other processes. Like all resource letters in the series, it lists books and journal articles useful in teaching about the subject, risk analysis.

•The May 3rd issue of *Physics Education* includes two special features: Physics for Citizenship, which includes papers on "Citizenship and science" and "A citizenship dimension to physics education." The other special feature is on Teaching Quantum Physics, which includes four papers on various aspects of the subject. It is interesting to note that the March issue of *American Journal of Physics* also had a special focus on teaching quantum mechanics.

•"Concern continues over K-12 Math, Science education despite R&D reforms" is the title of an article in the May/June issue of NSTA Reports. The article discusses *Science and Engineering Indicators 2002*, a report from the National Science Board released in April. America's high school students continue to fall behind in international achievement measures in science and mathematics. Though more students are taking advanced academic courses in high school, many students need remedial work in college. A persistent issue in science and mathematics education is the size and adequacy of the teaching force, the report said. Teacher pay scales in the United States tend to be lower than those in a number of other countries, including Germany, Japan, South Korea, and the Netherlands. In addition, teachers in American schools tend to work longer hours. The full text of the report can be read at www.nsf.gov/sbe/srs/seind02/start.htm.

•Politicians understand the kind of stories that journalists are looking for. If more scientists did, too, they would be better equipped to get their message across, argues an editorial in the April 4 issue of *Nature*. Many scientists are quick to attack the media when they believe they have been misrepresented, whereas politicians realize that attacking journalists is short-sighted strategy. Instead they have become experts in rebutting inaccurate stories and imparting their own message. Some grant-awarding bodies now promote media training for scientists. Britain's Engineering and Physical Sciences Research Council, for example, announced plans to include $720 for media training in each grant it awards.

•A strategy to tackle the declining popularity of the physical sciences in Ireland has been unveiled in a report by a government task force, according to a story in the June issue of *Physics World.* The strategy includes plans to upgrade undergraduate laboratories and the creation of "access" courses that can ease students' transition from school to university. Other recommendations include the creation of the post of chief science adviser, the setting up of a national science-awareness program, and the construction of a national hands-on science center.

•"Improving Science Education for All Children" is the title of a guest editorial in the April issue of *The Physics Teacher* by Representative Vernon Ehlers (R. Mich). Dr. Ehlers, who is one of two physicists in Congress, reminds us that during the trying times last fall, Congress passed the President's education reform bill. This new law requires science testing for the first time in 2007-2008, giving states time to set the standards and prepare the tests. While these reforms will do much to improve our nation's schools, there is more to be done. Clearly the traditional "Three R's" of childhood education no longer offer sufficient preparation for an age where virtually every job requires basic problem-solving skills and technical competence. He urges the physics education community to participate in science education reform efforts by impressing upon local, state, and federal educators and policy-makers the need for such reform and the numerous contributions that science and technology make toward knowledge and our way of life.

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