Forum on Education

of the American Physical Society
Fall 2004

Thoughts from the Editor

Thomas D. Rossing

Looking back through past issues of our newsletter, I realized that I have now served as an editor for 10 years. During that time, we have seen a number of changes in the Forum on Education and also in the newsletter.

One thing that hasn't changed is the purpose of the Forum: to serve as an arena for the interchange of ideas concerning physics education. The newsletter has changed its format from a 12-page printed newsletter mailed to Forum members to being posted online. Hopefully, it is still being read and serving as a forum for exchange of ideas. Some issues have had a theme, some have not. On a couple of occasions, we have had a guest editor.

We always welcome contributions from FEd members and other readers. We are especially grateful for Letters to the Editor that address important issues and present the contributor's opinion about physics education. After all that is what a forum is all about.

This issue includes brief reports on physics education in four Asian countries. APS is a global society, and its members are concerned in the health of physics education in other countries. Over the years I have been fortunate to participate in meetings of physics teachers on five continents, and I have found physics teachers to be enthusiastic about physics education in every corner of the World. At the AAPT meeting in August, there were several sessions on international education.

This issue has three thoughtful letters to the editor. Ted Hodapp, the new APS director of education and outreach brings greetings, and his usual smile, to newsletter readers. We have also reprinted an editorial by Jim Nelson, AAPT president, from the *AAPT Announcer.* Finally, we have news about the Council on Undergraduate, activity based faculty institutes, and two fellowships, and a book review reprinted from *Physics in Perspective*. Happy reading!

IN THIS ISSUE

Letters to the Editor

Comments on "Words Matter"

I enjoyed the summer 2004 FEd newsletter article "Words Matter" by Art Hobson, and I share many of his concerns. I offer some comments on these issues.

In our calculus-based intro textbook "Matter & Interactions" (www4.ncsu.edu/~rwchabay/mi) Ruth Chabay and I consistently use the term "thermal energy transfer" and do not use the word "heat". We condition the name by saying this is "energy transfer associated with a temperature difference". Alas, we find experimentally in the classroom that there are serious problems with this, too! The students parse the phrase as "the transfer of thermal energy" rather than as "the thermal transfer of energy". As a result they continue to confuse Q with the change in thermal energy.

Chabay has started using the phrase "thermal transfer of energy" in her teaching, which is surely better and may fix the problem. Another possibility is to call Q "microscopic work." This is particularly appropriate in our curriculum, where we deliberately integrate mechanics and thermal physics as one integrated subject rather than as two isolated subjects, and where we emphasize the atomic nature of matter and continually make macro/micro connections (see R. Chabay and B. Sherwood, "Bringing atoms into first-year physics," *American Journal of Physics* **67**(12), 1045-1050, Dec. 1999 and R. Chabay and B. Sherwood, "Modern Mechanics," *American Journal of Physics* **72**(4), 439-445, April 2004). The term "microscopic work" is also physically correct and descriptive, in that the energy flow is associated with collisions of (on average) higher-speed molecules with (on average) lower-speed molecules, with interatomic forces acting through distances.

Another approach I've tried is to couch early exercises in terms of situations where there were both W and Q, not just Q. If Q = 50 J flows into water, raising the internal energy of the water by 50 J, the numerical equivalence encourages students to consider these two very different concepts to be the same thing. But if Q = 50 J and there is also W = 20 J of mechanical work done (say by stirring the water very vigorously), then the thermal energy rise is 70 J and is not numerically equal to Q. This seems to help quite a bit.

Using the naming conventions of Fred Reif, we call Newton's second law "the momentum principle" and instead of the third law we speak of the "reciprocity" of gravitational and electric forces, including electric interatomic forces.

We introduce Newton's second law in the relativistically correct form $d\vec{p}/dt = \vec{F}_{net}$. As for the third law, we downgrade it from the rank of a law since it is not true for magnetic interactions (consider two protons, one at the origin moving in the +x direction and the other on the x axis moving in the +y direction; you'll find that the magnetic forces are not equal and opposite, and the sum of the particle momenta changes with time, with corresponding change in the field momentum). Rather we focus on the form of the force law and point out the "reciprocity" inherent in the gravitional force law (interchange m1 and m2) and the electric force law (interchange q1 and q2). This change of emphasis helps understand why the (interatomic, electric) forces exerted by the small car on the big truck are just as big as those exerted by the big truck on the small car.

I don't agree that chemical energy is a kind of potential energy, because the molecular energy levels include kinetic energy as well as potential energy. Similarly with nuclear energy, where one can speak of a nuclear potential energy, but the energy levels also involve kinetic energy as well as potential energy. I do agree that "potential energy" is not a very good name. In our course we often speak rather of "pair-wise interaction energy".

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Energy

I enjoyed reading Art Hobson's article[1] in the Summer 2004 Newsletter and wish to comment on two points dealing with energy.

1. Hobson favors the term “thermal energy transfer” but in the next sentence notes that this should not be confused with “thermal energy.” Unfortunately, I think this is confusing. Let’s consider a different kind of example to clarify the issue. Suppose that two systems A and B interact (in isolation) and we observe that system B has gained charge. The correct conclusion is that system A lost charge and that there was a charge transfer from A to B. Now take this example and substitute “thermal energy” everywhere that the word “charge” occurs. Our correct conclusion is now manifestly wrong (unless we restrict ourselves to calorimetry experiments!). As Art correctly points out, I can change thermal energy by, say, doing work.

In my mind, this is exactly why we should use a term based on “heat” and not on “thermal energy transfer.” I don’t want students to confuse the end result (change in thermal energy of an object) with the process (heat, work, particle transfer, radiative transfer, etc).

Incidentally, I think there’s also a big problem with simply turning heat into the verb “heating.” In common textbook parlance, "heating/cooling" refers to any temperature or phase change, even if done by work. Other slight changes in wording such as "does heating" and "heats" don't fully resolve this issue. Some educators attempt to impute a distinct meaning to "warming" as a solution, but students generally don't appreciate such fine shades of meaning.

2. Hobson proposes dropping the term "potential energy" but fails to address the issue of conservative forces. It is because the adjectives "potential" and "conservative" are so closely related that an umbrella term is desired for these forms of energy.

Instead Art suggests using "more descriptive terms" such as elastic energy. But consider, say, a set of iron atoms joined together with metallic bonds to make a small helical spiral. Should we call the interaction energy between these atoms elastic energy, chemical energy, or electrostatic energy? As others have noted[2], many of these descriptions of "forms" of energy are not well differentiated. In particular, I myself am not clear about the meaning of 3 out of the 5 "common" forms of potential energy listed by Hobson. What exactly is "electromagnetic energy"? If chemical is "microscopic electromagnetic," why list it separately from "electromagnetic"? As for "nuclear," does that include rest energy? the electromagnetic repulsion between protons in a nucleus? strong and weak force interactions? only the energy released in fusion/fission reactions?

Energy is a central concept in our introductory courses and clarifying the terminology here is especially important. So I applaud Art's efforts but am not sure we should start changing the textbook treatments of thermal and potential energy just yet.

1. A. Hobson, "Words matter," APS Forum on Education Summer 2004 Newsletter, pp. 2-4.

2. E. McIldowie, "A trial of two energies," *Phys. Educ.* **39**, 212-214 (Mar. 2004). Also see G. Falk, G. Herrmann, and G. B. Schmid, "Energy forms or energy carriers?" *Am. J. Phys.* **51**, 1074-1077 (Dec. 1983).

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Voodoo Science

For three years I've taught the second semester of algebra-based introductory physics at Emory University. Late in the semester I have them read Chapter 7 from the book *Voodoo Science* by Robert Park (Oxford University Press, 2000). The chapter discusses the controversy surrounding whether or not electric power lines cause cancer. The chapter includes many of the scientific (and non-scientific) studies done, and makes the emphatic point that all the evidence shows there is no link, that electric power lines do not cause cancer. Furthermore, it discusses in detail much of the bad science and bad journalism surrounding the issue. The reading blends two topics: electric power lines, related to the physics they're learning, and health issues. The class is predominantly pre-medical students, and they find the article quite interesting. After the students have done the reading as homework, I lead a class discussion. I try hard to only ask questions and make very few statements myself -- in general, the reading has already done an excellent job defending the views I personally hold. The students always enthusiastically participate in the discussion; in groups of up to 50, over half of them offer a comment at least once during the discussion. Usually the article gets them quite excited, in fact; many of the students are passionate about the health issues the reading raises. One year, the class included more than two hundred students, so I broke them up into separate smaller groups over two days, which resulted in reasonable discussions despite the large class size. Later, as a homework assignment, the students write a two paragraph essay responding to the reading, either on one of the questions I suggest, or on a topic of their own. These essays are mostly quite good. Student feedback, both informal and on the anonymous end-of-semester evaluations, indicates that they really enjoy the reading. I have also taught the calculus-based introductory class, and assigned supplemental readings, covering topics such as nanotechnology, general relativity, and pseudoscience. Related homework assignments included a brief essay response to the reading, or locating a current article about the topic and explaining it in their own words. The essays again are very good and students indicate they enjoy the assignment, and the break from the traditional physics curriculum. The *Voodoo Science* reading seems to be the favorite, though, for both the algebra-based and calculus-based classes. You can get permission to distribute copies of Chapter 7 from *Voodoo Science* from www.copyright.com for a fee. Alternatively, your campus bookstore may be able to handle this for you by letting you distribute a coursepack with the copies, with the copyright fee as part of the price. Interested teachers can contact me by email for a list of discussion questions I've used with the *Voodoo Science* reading. Don't worry, using email won't cause cancer either!

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Greetings!

Ted Hodapp
APS Director of Education and Outreach

Earlier this year, Fred Stein announced his retirement as Director of Education and Outreach Programs at the APS. I was happily concluding a 2-year stint at the National Science Foundation as a Program Officer in the Division of Undergraduate Education and looking forward to returning to the classroom and my lab at Hamline University in St. Paul, MN. Upon hearing about and then contemplating this job, it seemed at first a bit daunting given the number of extensive projects already in motion. It also seemed like it would be an interesting challenge, so, with a few conversations back in Minnesota to put my academic position on hold for a few more years, I decided to jump in.

The biggest effort by far is to continue the NSF and Department of Education funded PhysTEC project (www.phystec.org) started several years ago by a cooperative effort between the APS, AIP, and AAPT. Further expansion of this project is now continuing through funds raised by the APS.

The project is up and running at 8 institutions across the country and we are learning a great deal about the challenges of bridging the gap between physics departments and schools of education. The active learning methods being implemented at these institutions are producing appropriately modeled instruction for future teachers of all grade levels as well as introducing education research-tested techniques to help excite and engage students of introductory physics. We will continue to build upon the successes already in place and we are actively working to provide convincing evidence of the effectiveness of this model. The challenge ahead is to build, through combined efforts of the three sponsoring organizations, a national coalition to help share and build upon best practices and innovative ideas that effectively prepare future teachers. You will be hearing more about this coalition in coming months.

Beyond PhysTEC, I will be working on and with a number of projects in education at all levels including the National Task Force on Undergraduate Physics, the task force on graduate education, minority scholarships, and others. One of my goals will be to continue to build bridges between the APS and the AAPT to make best use of the talents and strengths of both our societies.

I look forward to continuing to work with the Forum on Education and welcome your input and ideas as the American Physical Society moves forward with its education programs.

Theodore Hodapp is the APS Director of Education and Outreach. He can be reached at:
hodapp@aps.org *or 301-209-3263.*

Where are the "Science Candidates"?

Jim Nelson (reprinted from the AAPT Announcer *with permission)*

A national election is fast approaching and I notice a lack of candidates speaking to issues on interest to the scientific community let alone the physics community. During the recent AAPT meeting in Sacramento, I was waiting at the airport to pick up participants for the AAPT/PTRA Summer Institute, when I struck up a conversion with a local police officer. Eventually he asked why I was visiting Sacramento, and I indicted that I was attending a meeting of the American Association of Physics Teachers. The next words out of his month were, "I hated physics! I hated it the first day!!" I wondered, how could that happen on the first day? Perhaps it was not the first day, but that was the officer's impression. I asked him if he disliked school in general or just physics, and the answer was, "I was not very good at mathematics and they are the same." I could tell immediately the officer was able to speak articulately, so I spend a few minutes trying to make an argument that physics is not the same as mathematics. Physics is the innate human need to make sense of the natural world, and that a great deal of understanding about the natural world can be expressed using verbal descriptions as well as mathematical descriptions. Alas, I made no headway in this brief exchange.

I have not done a survey, but I fear there are far more people than necessary with this officer's attitude about the subject we love. I wonder aloud what is the source of such attitudes? Then the difficult realization sets in - as Pogo suggests, "We have met the enemy and it is us." Or as Randall Knight points out in his recent book, *Five Easy Lessons*, " Physics! that was my worst subject. You must be so smart to understand it! Perhaps an ego booster the first couple of dozen times you hear this, but it slowly dawned on me that this remark was saying something significant - and disagreeable! - about the subject I love."

No wonder there is little discussion of the issues important to the physics community - there is really no political capital in this. At a time when we need the support and understanding of political decision makers, we are not getting much attention. Too often we convince others that physics is only for the special few and we do not need them. Perhaps it is naive on my part to believe that having more citizens understanding physics will turn more attention to the physics communities needs when they are most pressing, but I suggest we give it a try. When teaching our students we need to remember that we will likely need these student's understanding and support in the future. We ignore this to not only our peril, but also the peril of our nation.

We need more policy makers in Washington who understand the long-term consequences of our present energy policy, more policy makers in Washington who understand the contribution of emigrants to our scientific knowledge and thus our national defense. At present university physics departments in the United States are having a very difficult time attracting foreign students and even professionals from other counties in part due to the impact of homeland security infrastructure. I predict that this present difficulty of admitting students from other nations and cultures to our universities and the present attitude toward emigrants will have disastrous impact on not only our national defense but also on our "good guy" on the block image. An image that is reinforced every time we tell a potential student he or she is welcome at our universities and in our nation.

I am only one teacher, but I have recently set a goal for myself when working with high school students and with fellow teachers during AAPT/PTRA workshops, "...to do no harm." Much like a doctor's patients, my students should leave my classroom better than when they entered, with an improved understanding of science, with a belief that they can do and understand physics if they chose to do so, and a realization of the importance of science to our nation's economy and defense. It is the most patriotic thing I can think to do daily. I know that I have failed in this regard in the past, but I am determined not to do so again. I am not suggesting that physics is easy or that grades should be inflated. To master any topic requires dedicated effort, but I am suggesting that we can do better job of making physics interesting and exciting for both the future physicist and the future citizen regardless of the nation that student calls home.

Perhaps our efforts will produce a more scientific literate public and more citizens who understand that our national economy and defense are tightly tied to the strength of our scientific community. I hope we will all meet fewer police officers who believe that physics and physicists are unpleasant.

Jim Nelson is President of AAPT. He has been a physics teacher in Florida and Pennsylvania since 1961. He received the AAPT Award for Excellence in Pre-College Physics Teaching in 2000, and Presidential Award for Excellence in Science Teaching in 1985. He served as director of the PTRA program.

The Council on Undergraduate Research: Enhancing the Undergraduate Research Experience at Your Institution

Beth Cunningham and Terry Oswalt

Maybe you are a new faculty member at a primarily undergraduate institution starting to build your own research program. Or maybe you have been teaching for a number of years and have some experience with undergraduates in your lab but you are interested in enhancing their experience. Maybe you want to involve undergraduates in your research program but wonder if you can offer rewarding projects for an undergraduate student. In all of these cases, the Council on Undergraduate Research (CUR) can provide valuable resources.

The mission of CUR is to support and promote high-quality undergraduate student-faculty collaborative research and scholarship. CUR currently has 3,000 members representing over 870 institutions in eight academic divisions. Even though CUR's primary advocacy is in support of faculty and students at predominantly undergraduate institutions, faculty and administrators at comprehensive and research institutions are very welcome and can benefit from the services that CUR provides.

CUR was established twenty five years ago. The first project initiated was the publication of a directory on Undergraduate Research in Chemistry at Undergraduate Institutions (Private Liberal Arts Colleges) in 1979. Over the years, CUR divisions have expanded to include other natural sciences, first adding Physics/Astronomy and Biology followed by Geology, Mathematics and Computer Science, Psychology, and Engineering. Four years ago the Social Sciences division was added in recognition that undergraduate research goes beyond the natural sciences. CUR also includes an At-Large Division for grant administrators and undergraduate research program directors.

The common belief of CUR councilors and members is that research is one of the best forms of experiential teaching. To this end, CUR provides faculty development programs and helps administrators nurture, improve, and assess the research environments of their institutions. For example, CUR publishes a quarterly newsletter as well as a series of "How To" books. These are designed to share successful models and strategies for establishing and institutionalizing undergraduate research programs. CUR also provides services in support of its mission. These services include discipline-specific consultancy for departmental and institutional reviews, new faculty mentoring, and an active list-serve (CURLS) designed for members to post queries on issues related to undergraduate research, job notices, etc.

CUR serves the undergraduate research community many other ways. For example, it organizes and hosts "Posters on the Hill," an annual poster presentation on research findings by undergraduates on Capitol Hill. It administers a competitive program of summer fellowships for undergraduate students engaged in research. The CUR Fellows Awards recognizes leaders in undergraduate research. It also sponsors frequent CUR Institutes on proposal writing, institutionalizing undergraduate research, and developing programs that maintain faculty vitality post tenure.

CUR is active in the science policy-making arena. The national headquarters are located in Washington, D.C., giving CUR a strong presence on Capital Hill. CUR continues to forge new linkages between the undergraduate research community, the federal government, and industry. CUR maintains direct communication with federal and private funding agencies and hosts the "April Dialogues," an event that provides access to program officers at a variety of funding agencies. CUR directly reminds Congress of the importance of undergraduate by hosting the annual "Posters on the Hill." CUR prepares position papers, participates in formal hearings, and cooperates with sister societies on various initiatives. Finally, CUR keeps its individual and institutional members abreast of the many developments and trends in science policy and funding that occurs each year.

CUR sponsors biennial national meetings. The 11th CUR National Conference will be hosted by DePauw University, June 24-27, 2006. During the national meetings, faculty actively engaging undergraduates in research and administrators who provide support present their "best practice" methods. Additionally, representatives from federal and private funding agencies are available to discuss new and existing funding opportunities. Finally, the national meeting provides informal settings to learn more about undergraduate research and share the dialog with conference participants.

Perhaps you have heard about NCUR (the National Conference on Undergraduate Research) and wonder how NCUR and CUR differ. NCUR and CUR are two separate organizations. NCUR organizes an annual conference of student presentations each spring. Students from all academic disciplines and all institutions of higher education showcase their scholarship in the form of poster presentations. The next NCUR meeting will be held at Virginia Military Institute and Washington and Lee University on April 20-22, 2005. If you are looking for a venue for your undergraduate students to present their work, this is a great way for them to make a formal presentation as well as see what other undergraduate students across the US are doing.

CUR is a grassroots organization whose principal support comes from its dues-paying individual and institutional members. The active members, with support from the national office, provide the base through which CUR activities and programs are made possible. The Physics and Astronomy Division is one of the most active divisions. Four of CUR's 16 past presidents have been Physics/Astronomy Councilors. Current projects being undertaken by the division include developing a smaller scale directory of undergraduate research in departments across the US and examining ways to assess the effect of undergraduate research in a more rigorous manner. Any of the Physics/Astronomy CUR councilors would be more than happy to provide helpful information to you.

We encourage you to explore the CUR website (http://www.cur.org) to learn more about our active and growing organization.

Beth Cunningham is professor of physics and associate dean of the faculty at Bucknell University. She is a member of the FEd Executive Committee, Chair of the APS Committee on Education, and a Councilor in the Physics/Astronomy division of CUR.

Terry Oswalt is professor of physics and space sicences and associate dean at Florida Institute of Technology. He is also a Councilor in the Physics/Astronomy division of CUR.

Physics Education in Nepal

Choodamani Khanal and Simon George

Nepal is a landlocked and independent democratic country with constitutional monarchy, forming an important part of the Himalayan region of South-east Asia. The population of Nepal, as per 2001 census, is 23.2 million while it was 18.5 million, as per the 1991 census. Around 80% of the total population resides in the rural areas.

Scientific and technological development in Nepal has moved at a slow pace and agriculture remains the most critical sector in the economy, contributing almost half of the nation's GDP (gross domestic product) and the national economy has been characterized by heavy dependence on agriculture. The growth rate of the agricultural sector is declining, and contribution of the non-agricultural sector towards the GDP is increasing. The real growth rate of the GDP has remained at almost 3-4% for the last few decades, putting it at par with the population growth rate.

Industrialization in Nepal started in the year 1936. The early years of Nepal's industrial history were plagued with infrastructural problems and lack of any concrete policies on the part of HMG/N. As a result, many industries had to close down. The first governmental effort to give a boost to the industrialization process started in the year 1956, when the first industrial policy for the country was formulated.

The bulk of the population stays in rural areas and is engaged in agriculture and allied activities. There is a small upper class of society, residing mainly in Kathmandu and few other district headquarters, whose living standards are comparable to those of the Western economies. The rest of the population has very modest living standards.

Nepal is one of the least developed country (LDC) having $240 per capita income. This clearly indicates current backwardness of scientific innovation and the further importance of proper scientific policy for the country's development.

Primary and Secondary Education

Primary level is from kindergarten up to grade five; lower secondary level is up to grade eight; secondary level - grade nine and ten, and higher secondary level up to class twelve. The basics of English language used to be taught, beginning only from grade 4 in public schools. Nepal has two types of schools: Public schools which are completely financed by His Majesty's government and the private schools operating on independent resources.

The school curriculum is common with respect to Science in all Public and Private schools throughout the country. Prescribed standard science textbooks are used in all the schools. 40% of science contains physics and 30% each for Chemistry and Biology each. Final School examinations are conducted by the central School Leaving Certificate (S.L.C.) Examination Board, HMG for both Public and Private Schools Students on the successful completion of school education.

Secondary education in Nepal has been characterized by rapid growth and continuous change. During the year 1951-1997, the number of secondary schools in the country increased from 11 to 3322, the number of teachers increased from 120 to 16494 and student enrollment increased from 1680 to 344034.

The rapid growth of secondary education in the country over the past decades has adversely affected the quality of performance, particularly in secondary school science. During the year 1987-1997, while student enrollment figures in Secondary School increased by over 100%, quality (measured by passing percentage in the S.L.C examination) remained low.

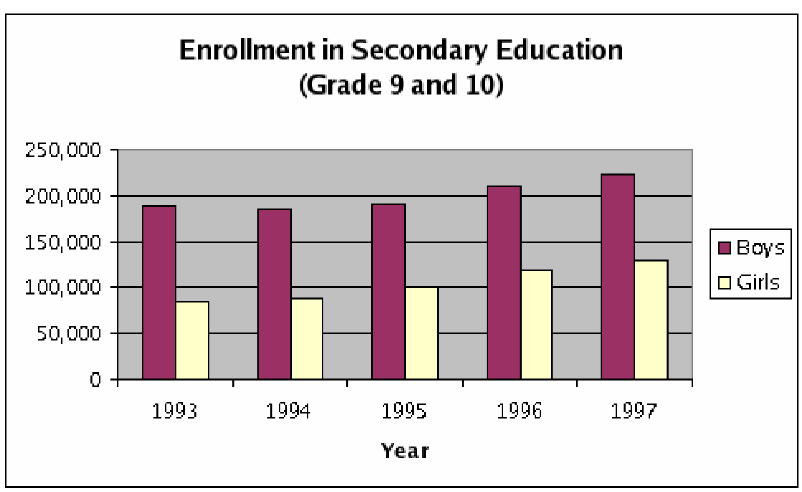
The basic objective of secondary education is to develop scientific skills in the students and the ability to look for the scientific reasons behind the natural phenomena, taking place in their daily lives and also to lay in them a foundation for advanced courses in science. More students regard compulsory science as one of the more difficult S.L.C subject, which is also evidenced by the low passing percentage in S.L.C sciences. The average marks in science in the S.L.C Only a very few teachers enjoy teaching science as an interesting and relevant part of daily life. There should be provision to make science a lively and enjoyable subject for the average students and general population.

A look back at the secondary school education in Nepal shows that with the recommendation of Nepal National Education Planning Commission (NNEPC) in 1956 and that of all-round National Education Committee (ARNEC) in 1961, secondary Education became more organized. The introduction of the National Education System Plan (NEPS) made it more need-based and application-oriented. Science was introduced as a separate subject and secondary curriculum being home science and public knowledge.

Higher Education

In Nepal science (Physics at higher level) is taught in two ways. One kind of syllabus is provided by Tribhuvan University as two-year intermediate level, I.Sc. (higher level study after SLC), and the other is provided by the higher secondary education board as 10+2. Two parallel levels of studying Physics exist in Nepal having almost the same courses of study. The main text book is *Advanced Level Physics* (fifth edition) by Nelkon-Parker. The basic difference in these two levels is the distribution of the courses and nature of questions attributed. For example long questions like "Derive an expression for a time period of a second pendulum" is asked and numerical problems like "A uniform steel wire of length m and area of cross section 3x10-6m2 is extended 1mm. Calculate the energy stored in a wire (Young modulus =2.0x10"Nm-2)". But in 10+2 level, short answer questions like "Why does the moon have no atmosphere?" are asked but the numerical problems are of the same kind as previously mentioned.

Apart from the theoretical implication, different practical experiments are performed at the laboratory to meet the concepts and visualize the things, which is taught in theories. Most of the practical experiments are done from current electricity and magnetism, optics, sound waves, heat and mechanics. Students will test and verify important physical laws by themselves. For example, studying heat they measure the specific



heat of water; the latent heat of fusion of ice etc. In electricity, conversion of ammeter into a voltmeter, the relationship between current, voltage and resistance in series and parallel circuits etc are the basic experiments.

At present the main emphasis is given to a scientific concept of problems. For this, different teaching methods have been followed. Modern method of teaching by overhead projector, audiovisual, talk programs and seminars have been exercised at private colleges and little is done in public colleges.

The standard of syllabus at these levels is similar to that in American colleges with an exposition of the concepts of physics together with the applications and quantitative manipulations. Mechanics, Thermodynamics, Optics, Electricity and Magnetism, Sound Waves, Atomic Physics (Nuclear Physics) are the major courses of this level.

One of the main reasons for the slow pace of science education is lack of proper funding. Being the one of the least developed countries, Nepal is facing inadequate funding in education in general and science, physics in particular. University Grants commission and Royal Nepal Academy of Science and Technology (RONAST) have been playing a significant role in financial sectors. RONAST helps in the research based programs. The financial support has been provided by the academy for different types of research in science and technology. The professors are highly qualified in their respective disciplines and provide the best education.

Internal capacity of the Physics department for the master's program is for 60 students per year. Student's pressure extended additional 60 students from 2003. Students have raised their voices to admit at least one third of the total applicants. Their voice has been temporarily accepted. There are hardly any jobs in the field of physics besides teaching. Less than 10% of the physics graduates get the government jobs inside or outside Physics field, about 50% choose teaching profession while rest 40% of them try to go abroad for further studies. Amongst those who seek greener pastures, more than 90% come to the land of opportunity, USA. The students with a degree in physics have a better opportunity to go abroad for further studies. This is one of the reasons why students want to go for Physics. The political instability of the country is another major contributing factor.

Conclusion

This article sketches the overall picture of the state of education, particularly Physics education in Nepal. In the rapidly growing scientific world, it is the education that determines the level of prosperity, welfare and security. This article has revealed the true state of Physics education in Nepal. Let us hope that future changes in science education will build a new Nepal with less poverty and more prosperity: a new Nepal with a stable social and political order and equal opportunity for all.

Kingdom of Nepal in a Nutshell

Capital:	Kathmandu
Total Area:	54,363.18 mi^2 140,800.00 km^2 (slightly larger than Arkansas)
Population:	25,284,463 (July 2001 est.)
Est. Pop. in 2050:	53,293,874
Languages:	Nepali (official; spoken by 90% of the population), about a dozen other languages and about 30 major dialects.
Literacy:	27.5% total, 40.9% male, 14% female (1995 est.)
Religions:	Hinduism 86.2%, Buddhism 7.8%, Islam 3.8%, other 2.2%
Life Expectancy:	58.65 male, 57.77 female (2001 est.)

We are thankful to Professor Lok Narayan Jha, Head of the Department of Physics, Tribhuvan University, Professor Shekhar Gurung, Principal of Tribhuvan University. We are also thankful to Bhuwan Khanal, Department of Journalism, Ratna Rajya Campus, Tribhuvan University, Nepal, without his support it would have not been completed.

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Physics Education in Korea

Junehee Yoo

Korea is located in the eastern section of the Asian continent. The total land area of south Korea is about 110,000 km^2 and the population is 48 million. Thus the population density is approximately 476 persons per 1 km^2 which is among highest in the world. As of 2002, per capita GNI of Korea was $10,013. Semi conductors, iron-steel, ship building, automobile and machinery are the main exports. Recently, IT industry has grown and the broadband internet is used widely.

Many people believe that education has been the major source of trained manpower in various fields, especially science and engineering up to now. But recently the decline in the numbers and falloff in quality of science and engineering major students are considered as big problems.

School Physics

Korea has a single track 6-3-3-4 system which maintains a single line of school levels. To ensure the standard quality of education, the national curriculum for each school level, criteria for development of textbooks and instructional materials are prescribed by law. The national curriculum has been revised on a periodic basis and the 7th curriculum had been revised in 1997 under the principles of enriching elementary and basic education, increasing self-directed ability and increasing autonomy at the level of local and school.

MBL at Chuncheon National University of Education

The 7th curriculum introduces ten basic common subjects, autonomous activities, and special activities that cover the ten years from the first year of elementary school through the first year of high school. As a result, all students take science lessons three times a week up to the 10th grade. Elective subjects are introduced for the final two years of high school and physics I/II, chemistry I/II, biology I/II, and earth science I/II are provided as elective subjects. Science and engineering track students enroll in two of them at least. Physics is not the most popular science subject as the Table 1 shows that 18 % of the whole student take it at Mock College Scholastic Ability Test in 2005.

Table 1. Physics I and II taking Mock College Scholastic Ability Test 2005

Population subject level	Percentage of the total examinees			
	Physics	Chemistry	Biology	Earth science
I	18	30	29	17
II	4	13	11	3

According to the TIMSS-R and PISA studies, the average achievement of Korea seems like to be good. But internally several problems, such as low percentage and low score of upper 5 % group, the biggest gender difference, and low score of affective domains are found.

Recently, WISE (Women in Science and Engineering) has been launched to promote girls taking the science and engineering track. Large scale of promotions such as modernizing labs, improving physics textbook, and scientific culture events are taking place. Also some encouraging results in international competitions, such as Physics Olympiad and IYPT have occurred (Table 2). But on the other hands, industry is complaining about the falloff of manpower quality, and it is regarded as serious for the economy of the next generation.

Table 2. Rank of Korea at Physics Olympiad and IYPT

International Competition	2004	2003	2002	2001
International Physics Olympiad	2*/71**	1/54	2/66	15/65
International Young Physicists Tournament	Joint 3/24	Joint 1/23	14/19	-

New trends in Physics Education

Among many approaches to boost the number of students who take the science and engineering track and raise the quality of achievements in physics, two featured enterprises, physics education in cultural context and MBL will be described.

Physics Education in cultural context-scientific exploration at cultural sites--Scientific exploration at cultural site, such as old palace, world cup stadium, world cultural heritage, and museums have been developed and researched actively from the year of 1998, the 1st APEC Youth Science Festival was held. At that time, scientific exploration programs at Changdukgung palace, Celadon village, Korean folk village and Old printing museum were developed and evaluated as unique programs during the 1st APEC Youth Science Festival. After that, programs for various sites have been developed and many research have suggested that scientific exploration at cultural sites would give a chance for students to do a real science and settle the science, originated in the Western culture, in Korea.

Students discuss sundials at King Sejong's tomb

One example is the scientific exploration at National Folk Museum, located at downtown Seoul, which exhibits more than 7,000 collections about highlights of cultural heritages, things for everyday life. Because of it's huge amount of collections, students and teachers can choose some of favorite exhibitions among them according to their interests and needs. Thus differentiated approach for students' abilities and interests would be done as we expect during exploration as well as STS approach. Especially, at the National Folk Museum, many models and miniatures are exhibited to show the process of making metal arts, celadon and handcrafts. Also, the old instruments such as tread mill, snow shoes, sun dials, distilling pottery and so on, can show the way how the physical principles can be applied directly while modern instrument looks like black boxes. But most of the exhibitions are untouchable, so activities at the museum are restricted within estimation and observation. Also for the new generation the collections are so unacquainted that they might be uninterested in the collections and feel difficulties in elaborating their own inquiry problems.

A group of physics educators, led by Emeritus Professor Sungjae Pak at Seoul National University, has been developing the guidebooks for students and science teachers and doing researches. Through the research results and discussions, a primitive teaching model has been developed as a proper approach to the scientific exploration at cultural sites.

Middle school students are doing experiments using MBL equipments.

The Korean government and opinion leaders are voicing their concerns about the falloff in science and engineering major students from 2001. Especially physicists are worrying about the radical falloff in physics major students. One of the ways to boost the number of science and engineering major students is improve school science education and modernizing the school science and physics lab is getting to be a big issues. Microcomputer-based-labs (MBL) is one of the keywords and many pre-service and in service teacher training courses have adapted MBL experiments. Especially, sound related experiments are getting popular with MBL. Some active teachers are introducing MBL in their own lab gradually. The Korea Science Foundation has held a nation wide competition for middle school students and high school students, in which participants perform scientific inquiry experiments using computers.

Dr Yoo explains the lengths of pipe and pitches at National Folk Museum

Junehee Yoo is an assistant professor at Department of Physics Education, Seoul National University, Korea.

Physics Education in Malaysian Schools

Fathaiyah Abdullah and A Rahman Omar

In Malaysia, the teaching of physics as a subject begins at the upper secondary level known as form four or year 10 of the school system. Prior to that, physics is taught as part of the science subject.

The level of physics taught at upper secondary level (form four and five) is that of the 'O'- levels of the British System. Through the mid seventies, the medium of instruction was English, and the textbooks used were those used in the British Commonwealth such as *Physics* by Abbot. For the 'A'-levels the standard text was that of Nelkon and Parker.

From the mid-seventies until recently, the medium of instruction has been Malay. Subsequently textbooks were written in Malay and some English books were translated. Over the years, the curriculum has changed in order to be at par with 'O'-level. One thing that remained relatively unchanged was the laboratory. Same experiments using same set of apparatus were carried out over the past thirty years. To illustrate a few, ticker tapes were still used to analyze motion; wooden trolleys (the wheels of which have friction) were used to verify conservation of momentum; and rubber bands, trolleys and inclined plane were used to verify Newton's laws of motion.

Until recently, a practical examination, in which students carried out assigned experiments, was part of the examination. The experiments were not made known until the day of the exam. Students have to be prepared with the skill and knowledge of the experiment. This kind of evaluation was replaced by giving grades to experiments carried out by students at a point where the students are proficient. Teachers were somehow pressured to give good grades to their students. Good marks from the practical somehow diluted the quality of achievement of the students. We strongly believe that this was the case because of the skills the students attained when they enter the university were declining. There are talks about reinstating the practical examination.

In 2002, the Government of Malaysia took two major decisions: English was to be used as medium of instruction for science and mathematics and ICT-based education is to be implemented. The process of reverting to English as medium of instruction would be done in stages, starting in 2003, and by 2008 it will be in full swing. All 9,533 government schools will be provided with laptops, LCD projectors, screens, trolleys and printers. New computer labs were to be constructed too.

Since for more than two decades sciences have been taught in Malay, there is a need for retraining of science teachers. Few programs were carried out. District English language coordinators were appointed, and they are responsible for the improvement of command of English among teachers. Every science and mathematics teacher was given a notebook so that ICT-based education can be implemented.

In 1996 a brainstorming session at the Ministry of Education resulted in the conception of Smart School Initiatives. Parts of the objectives of establishing such schools were to democratize education so as to provide every child with equal access to learning and to produce workforce that is ICT literate. Initially few schools were chosen. Telekom Smart School (TSS), a private entity, was chosen to spearhead the initiatives. TSS and partners have developed courseware for the smart schools. With the policy change on medium of instruction, TSS has to redo the courseware in English. The efforts have paid dividend since many countries will adopt curriculum developed by TSS. What was developed in the courseware has been the subject matter. No laboratory activities were developed as yet. We have presented to TSS the need for an active-learning environment using microcomputer-based laboratories (MBL) and interactive lecture demonstrations (ILD). The next stage of implementation of Smart School Initiative could be the deployment of MBL and ILD. Recently our prime minister has decided that all schools in Malaysia are to be made Smart Schools.

In response to the need of teacher to be proficient in English, Universiti Pendidikan Sultan Idris (UPSI) has decided that all science and mathematics subjects at the university are to be taught in English. The effort has started since academic calendar 2003/2004.

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Physics Education in Pakistan

Aziz Fatima Hasnain

The Islamic Republic of Pakistan is situated in the northwest of South Asia. About 180 million people live on a land of 796,000 sq. km having US $450 per capita income. Pakistan's economy is based on agriculture and agricultural products. The port of Karachi also plays a major role in supporting its economy. In Pakistan one may find Islamic values finely mixed with 5000 years of cultural heritage.

Many of the economic development programs cannot achieve their goals because of the 2.9% annual population growth. Education and health sectors are the ones badly affected by this growth rate.

Education in Pakistan

The Ministry of Education is responsible for formal and informal education in Pakistan. Education departments in the provinces control the administration of primary to college level education, while the Higher Education Commission takes up matters related to higher education at the universities. Universities have their own curricula and examination system. For technical education there are separate district offices and boards of examination in the provinces.

To bring its society into consonance with the changes taking place in the world, the Pakistani Government has initiated many development programs to enhance scientific and technological capabilities in every field. Computer education has been introduced at the grass roots level. Computer labs with Internet connectivity have been set up in schools and colleges to make the computer technology accessible to each and every student. With the development of IT in Pakistan, demand for expenditure on higher education and research has increased.

There are about 32 universities and 9 degree awarding institutes in the public sector, and 18 universities and 9 degree awarding institutes in the private sector. There are about 475,000 students in the universities. Most of the private universities offer business or computer education to students. Out of five medical universities there are three private universities, and one out of four engineering universities belong to the private sector.

A student starts learning science in the primary schools, including introductory knowledge of concepts from biology, chemistry, and physics. Science is compulsory up to class eight. After class eight, students have the option to continue education in four major groups: 1) science group; 2) general science or humanities group; 3) home economics group; 4) computer science group. A student, after completing 10 years of secondary education in any of the groups at the age of 15, may continue a 2-year course of higher secondary education in the same group. At this stage, another option, a commerce group, is offered to students. After passing the higher secondary examination, students join professional colleges or universities.

Physics education

Physics as a subject is introduced in class 9 and 10, and it is compulsory for science students. Physics is taught every year up through class 18 (masters level). A rather traditional style of teaching is followed at all levels. It is a common practice to concentrate the teaching/learning process around the prescribed syllabus. Teachers avoid demonstration of physical concepts because of the nonavailability of equipment. There are certain constraints in the system, which do not let the teacher develop her/his skills of teaching. Teaching based on textbooks and examination is the major source of inhibiting the individual's capabilities. Very little attention is paid to developing problem solving skills and concept building among students. There are teachier training programs for school and college teachers, but these program do not play an effective role in changing the teaching/learning pattern.

Research in physics

Quaid-e-Azam University has contributed a lot in producing PhDs in Pakistan. So far it has produced near about 100 PhDs in physics. QAU has laboratories facilitated with sophisticated equipment for research. The statistics about PhDs produced from other universities is significantly low. The reason for small number of students opting research for higher degree is that universities abroad attract them.

Apart from universities, there are research institutes in Pakistan where students perform research. The Pakistan Atomic Energy Commission and its affiliated institutions, the Centre for Solid-state Physics, and the A.Q Khan research Laboratories are the premier research institutes.

Recently, the Higher Education Commission has established a list of supervisors who are involved in research activity and offer PhD program for students. The website is *hec.gov.pk* at this website one may also find updated list of students who are involved in research program especially the website of Quaid-e-Azam University.

Strategies for development

The Higher Education Commission has now become a controlling authority for tertiary education. The first task of HEC is to implement a "Model University Plan." In its model university plan, HEC has given a new dimension to administrative and academic structure of state universities as well as to private universities. HEC has formulated advisory groups at the national level for the promotion of basic sciences. An advisory group for physics, which consists of physicists from universities and research organizations, has been constituted. The function of this group is to bring forth problems related to physics and prepare proposals for the improvement of physics education in Pakistan. A four year BSc course, proposed and designed by National Centre for Physics has been submitted to HEC. A research program in nano-physics, submitted by an advisory group, was approved by HEC. Presently three groups are involved in nano-physics project according to available facilities in the institutions. Two groups are working at QAU and PAEC at Islamabad and the third group is working at Karachi University.

Obstacles

The major obstacle is that our authorities are not yet convinced that good physics education plays an important role in the development of country. It is hard to expect good physics education from least motivated and nonqualified teachers of physics at secondary schools. Poorly managed teaching laboratories at colleges and universities have affected the performance of students.

Centre for physics education

Under the patronship of Dr. Abdus Salam, some dedicated physics teachers belonging to university, colleges and schools established a Centre for Physics Education, Karachi in 1991 to promote conceptual understanding of physics at all level and to serve it as a resource centre for physics teachers where they could upgrade their knowledge of physics. Ever since these teachers organized their first workshop on teaching of physics in 1985, they have become the pioneers of setting new trends in teaching of physics. These teachers have been successful in developing CPE into a resource center for physics in which one may find books, periodicals and other instructional material including many costly software programs of physics. CPE is proud of establishing Computer Based Physics Laboratory at APWA Govt College in 1995.

The Centre for Physics Education is very well recognized at international forum of physics education, especially in Asian region. From the CPE platform we have organized workshops, seminars and training programs at local as well as international level. Recently in 2003, 2nd International Conference on Physics Teaching was successfully organized, in collaboration with the Physics Department, University of Karachi. In that conference we had speakers from Italy, Malaysia, Nepal, Philippine, Sudan and USA. This activity was sponsored by UNESCO Jakarta, Abdus Salam Centre for Theoretical Physics Italy, Phillip Industries of Pakistan and the National Centre for Physics, Quaid-e-Azam University, Islamabad.

Aziz Fatima Hasnain is Secretary General of the Centre for Physics Education in Karachi. Her email address is afhasnain@hotmail.com.

Activity Based Physics Faculty Institutes

Priscilla Laws

Are you interested in increasing your students' understanding of the physical world? 2-year college, 4-year college and university faculty are invited to attend one of the NSF-sponsored Activity Based Physics Faculty Institutes to be held at the University of Oregon in summer 2005 and at Dickinson College in Central Pennsylvania in summer 2006. These one-week Institutes will encourage faculty to use active learning strategies and teaching methods based on physics education research by 1) giving them hands-on experience with the materials in the Activity Based Physics Suite, 2) assisting them with modifying those materials for use in their own courses, and 3) providing continued follow-up support for the five years of this project. The institutes will be taught by Priscilla Laws (Dickinson College), David Sokoloff (University of Oregon), Ronald Thornton (Tufts University) and Patrick Cooney (Millersville University). Please visit our web site: http://darkwing.uoregon.edu/~sokoloff/abpi.htm for more information and an application.

University of Oregon 2005 Sessions: June 20 - June 24 or June 27 - July 1 (attend either)

Dickinson College 2006 Sessions: June 19 - 23 or June 26 - June 30 (attend either)

APS Congressional Science Fellowship

The American Physical Society is currently accepting applications for the Congressional Science Fellowship Program. Fellows serve one year on the staff of a senator, representative, or congressional committee. They are afforded an opportunity to learn the legislative process and explore science policy issues from the lawmakers' perspective. In turn, Fellows have the opportunity to lend scientific and technical expertise to public policy issues.

Qualifications include a PhD or equivalent in physics or a closely related field, a strong interest in science and technology policy and, ideally, some experience in applying scientific knowledge toward the solution of societal problems. Fellows are required to be US citizens and members of the APS.

Term of appointment is one year, beginning in September of 2005 with participation in a two-week orientation sponsored by AAAS. Fellows have considerable choice in congressional assignments. A stipend of $50,000 is offered in addition to allowances for relocation, in-service travel, and health insurance premiums.

Application should consist of a letter of intent of approximately 2 pages, a list of key publications, a 2-page resume and three letters of reference. Please see the APS website *http://www.aps.org/public_affairs/fellow/index.cfm* for detailed information on materials required for applying and other information on the program.

All applications must be postmarked by January 17, 2005 and should be sent to the following address:

APS Congressional Science Fellowship Program
C/o Jackie Beamon-Kiene
APS Executive Office
One Physics Ellipse
College Park, MD 20740-3843

AIP State Department Science Fellowship

This Fellowship represents an opportunity for scientists to make a unique contribution to U.S. foreign policy. At least one Fellow annually will be chosen to spend a year working in a bureau of the State Department, providing scientific and technical expertise to the Department while becoming directly involved in the foreign policy process. Fellows are required to be U.S. citizens and members of at least one of the 10 AIP Member Societies at the time of application.

Qualifications include a PhD in physics or closely related field or, in outstanding cases, equivalent research experience. Applicants should possess interest or experience in scientific or technical aspects of foreign policy. Applications should consist of a letter of intent, a two-page resume, and three letters of reference. Please visit *http://www.aip.org/gov/sdf.html* for more details. All application materials must be postmarked by November 1, 2004 and sent to:

AIP State Department Science Fellowship
American Institute of Physics, Attn: Audrey Leath
One Physics Ellipse
College Park, MD 20740-3843.

Browsing the journals . . .

Thomas D. Rossing

•A thoughtful editorial by Paul Hewitt entitled "The three stages of learning" appears in the September issue of *Physics World*. He reminds us that Robert Karplus found learning effectiveness is maximized by a three-stage cycle consisting of *exploratory activity, concept development,* and *applications*. Stage 1 is based on students' experience (e.g., dunking objects into water before getting into Archimedes' principle). Explanations and definitions are treated in stage 2, which involves using textbooks and other conventional approaches to physics teaching. Stage 3 includes solving problems and doing lab experiments. Unfortunately, teachers are usually short of time and send students straight to stage 3 and then wonder why they struggle.

Hewitt suggests that more qualitative questions be included in exams. "If we give about 50% of marks to such questions then concept development would naturally become a key part of the courses. Textbooks should provide solutions to qualitative questions as well as to numerical problems. Our obligation as teachers is to help students learn the concepts that underlie the professions they choose. Mathematical skills and problem solving are important but should be secondary for students at an introductory level.

•"Research in problem solving" is the subject of a Resource Letter in the September issue of *American Journal of Physics*. Many instructors would like their students to learn to use physics principles and concepts to solve problems, but they know this is a difficult task. After even the most lucid lectures, only a fraction of the students are able to solve problems with the desired facility. To help more students become competent problem solvers, it is useful to study how people solve and learn to solve problems.

•Since publication of the AAAS report "Science for all Americans" (1989), commissions, panels, and working groups have agreed that reform in science education should be founded on "scientific teaching" in which teaching is approached with the same rigor as science at its best. According to an article on "Scientific Teaching" in the 23 April issue of *Science*, it is surprising that change has not progressed rapidly nor been driven by research universities. Universities need to provide venues for experienced instructors to share best practices and effective teaching strategies. Tenure, sabbaticals, awards, teaching responsibilities, and administrative support should be used to reinforce those who are teaching with tested and successful methods, learning new methods, or analyzing new assessment tools.

•"Formative assessment" is the subject of an article in the October issue of *The Physics Teacher.* By formative assessment, the authors mean assessment designed to enhance teaching and learning. Teachers and students seek information about the state of student learning and then use this information to adapt teaching and learning to meet student needs.

•The July/August issue of *J. College Science Teaching* has an article about "Powerful Ideas in Physical Science," a preservice curriculum for elementary education majors developed by AIP and AAPT with support from NSF. The teaching/learning approach in this curriculum was developed by a collaboration of college faculty members from universities around the United States, and the curriculum is currently available from AAPT. PIPS now consists of six modules: Light and Color, Electricity, Heat, Conservation of Energy and Nature of Matter, Force, and Motion. Each module requires about 20 hours of instruction time, so instructors can choose among the six modules to create a one-semester course. PIPS is thought to work best in small-class settings rather than the traditional format of large lecture with smaller laboratory sections.

•Many teachers have used compact discs (CDs) as reflection diffraction gratings. A note in the September issue of *Physics Education* discusses how a CD can be used as a chromatic lens which will bring diffracted light of a given wavelength to several foci located at certain distances that are determined by the allowed orders of diffraction. Transparent CDs can be obtained by removing the coating on CD-ROMs.

•An interview with Lindsay Nicholson, editor of *Good Housekeeping* magazine, who has a degree in physics and astronomy, appears in the September issue of *Physics World*. **Q**: Why did you originally choose to study physics? **A**: It was actually to annoy the nuns at my convent school. The usual pattern was for girls to do English, history, and French A-levels and become teachers. **Q**: How much did you enjoy the course? **A**: Well, of course, the joke was on me. I was pretty hopeless at the lab work-possibly because I'd been taught needlework rather than metalwork at school-but I loved cosmology, planetary astonomy and all the theoretical stuff. **Q**: Does your physics training influence how you work? **A**: Absolutely! It's so intellectually rigorous, it's made me a better writer and a better researcher.

•An application of Newton's second law to a snowboarder dropping off a vertical ledge shows that the average normal force during landing is determined by four factors: flexing of the legs, softness of the snow, the angle of the landing surface, and the forward motion of the snowboarder, according to an article in the July issue of *Physics Education*. A relatively simple model helps to explain why a snowboarder may jump from rather high ledges and land comfortably.

•The vacuum cannon that shoots ping-pong balls at high speeds is a spectacular classroom demonstration of the nature of air pressure. An analysis of the canon is given in a paper in the July issue of *American Journal of Physics*. The theoretical maximum speed is found to be the speed of sound divided by $\sqrt{\gamma}$ which can almost be reached with a cannon 2 meters in length. This is faster than the muzzle velocity of some handguns.

•A popular buzzword in U.S. education these days is discovering "what works," according to a note in the 11 June issue of *Science*. The Education Department even funds a "What Works Clearinghouse" on programs ranging from teaching math to reducing schoolyard violence. This heightened interest in assessment stems from the massive 2001 education reform bill, known as the No Child Left Behind Act, which requires school districts to offer programs shown to be effective through "scientifically based research." But, according to the note, there's a dirty little secret behind that requirement: No program has yet met the rigorous standard, because none has been scientifically evaluated and shown to be effective.

•"Reflections" is a regular column in *Syllabus*, magazine of technology for higher education. In the June issue, the manager of technology outreach at Princeton University talks about simulations and how they can or cannot serve in place of labs in which students "learn by doing" in a controlled environment. Labs, especially at the undergraduate level, have shortcomings, such as time limits, safety considerations (a student lab is a poor place to study thermonuclear reactions), or physical limitations. Well-designed simulations allow the student to explore dead ends as well as the proven, the true, the false, and the unexpected. As Einstein said, "Anyone who has never made a mistake has never tried anything new."

•Education initiatives at the National Academies of science are discussed in an article in the September issue of *Journal of College Science Teaching*. When government agencies need unbiased, independent analysis and understanding of complex and controversial issues in science and technology, they often turn to the National Academies. Educators who wish to incorporate these issues into their classes can do likewise. More than 150 reports focusing on education have been published by the National Academies during the past 10 years, many of which focus directly or indirectly on undergraduate education.

•The September 1 issue of *The Achiever* carries excerpts from remarks made by Rod Paige, U.S.Secretary of Education, at the 2004 National Urban League Conference in Detroit in July. He reminds us that the NCLB (no child left behind act) requires accountability, testing, and inclusiveness. It empowers parents with more information and more choices. It enables students in need to obtain tutoring and mentors. He cited considerable evidence that the law is working. Mathematics scores for fourth and eighth graders is rising. Students in the largest urban public school systems showed significant improvement in reading and math in the first year under NCLB.

Book review

Stephanie Pace Marshall, Judith A. Scheppler and Michael J. Palmisano, editors, *Science Literacy for the Twenty-First Century*, Amherst, New York: Prometheus Books, 2003, 321 pages. $29 (hard cover).

Art Hobson (reprinted from Physics in Perspective *with permission)*

This collection of 31 essays by eminent scientists and science educators commemorates the eightieth birthday of Leon Lederman, who has the unusual distinction of being at once a Nobel laureate and one of the nation's foremost science educators. Like most collections of essays by different authors, this collection is a mixed bag ranging from thought-provoking to pedestrian, and over a variety of topics. The editors have arranged the essays into six broad categories: Invitations to Scientific Study, Reframing Science Learning, Reframing Science Teaching, Scientific Stewardship, Demystifying Science for Public Policy, and The Lederman Legacy for Education.

Nearly all of the essays are about some aspect of science literacy for non-scientists. At least five general themes emerge: America's science education system is failing badly and in many ways both as regards science literacy and also as regards education for future scientists. Second, the nation desperately needs a scientifically literate populace, as suggested for example by the American Association of Science's report *Science for All Americans*; but the scientific community is far from answering this need and in fact many scientists see science literacy as a low priority that they prefer to ignore. Third, "inquiry" or "active engagement" pedagogical methods really work and are a key to improving science education. Fourth, it is at least as important to teach how science works as it is to teach the facts and theories of science. Fifth, there is a difference between doing science, which requires technical proficiency including mathematics, and understanding science, which requires hard but non-technical thinking.

All authors appear to have a common understanding of the meaning of science literacy. As James Trefil's essay puts it: A scientifically literate person can deal with scientific matters arising in public life with the same ease an educated person would exhibit in dealing with political, legal, or economic matters. Most essayists agree with Trefil that "this kind of literacy isn't a luxury—it's a necessity. Without it, our democratic system would degenerate into one in which decisions are made either by an intellectual elite or by demagogue-driven mobs."

It is in many ways a hopeful collection, because it recounts many science literacy successes: Fermilab's involvement in K-12 science education (see Marjorie Bardeen's essay); the Illinois Teachers Academy for Mathematics and Science, a center for retraining K-6 teachers (Lourdes Monteagudo's essay); the Illinois Math and Science Academy for scientifically talented high school students (Stephanie Pace Marshall); MIT's "open courseware" experiment to make its course materials available, free of charge, anywhere on Earth (Charles Vest); Rice University's Model Lab program to involve middle school teachers in science education via a year-long residency in an urban Houston middle school (Elnora Harcombe and Neal Lane); the fascinating story of "miracle worker" Annie Sulliven's interactive and inquiry-based teaching methods in the "impossible" educational triumph of guiding the deaf and blind Helen Keller toward an astonishing command of idiomatic English, and of Alexander Graham Bell's involvement in that triumph (Dudley Herschbach); people's innate interest in topics like black holes, warp drive, and time travel, and the implications for education (Lawrence Krauss); the ingrained, but sadly unrecognized, love of nature and science demonstrated in people's enthusiasms for fishing, horticulture, eco-tourism, hunting, automobile repair, dinosaurs, and gambling probabilities (Stephen Jay Gould); Lederman's efforts to reexamine the high school science curriculum and to encourage a more logical sequence putting physics first, chemistry second, and biology third (the editors' "Brief Biography").

But these essays also have their dark side. Ironically, this is most vividly illustrated by Leon Lederman, instigator of many of the hopeful programs recounted in these essays. Lederman begins the book's Epilogue with characteristic wit: "The wisdom contained in this book is awesome, the praise is fulsome, and my response task is gruesome. There is a common theme, the many failures of our education system?." His essay is devoted to listing the obstacles to attaining science literacy for all Americans. It is a daunting list: Science, technology, and invention are often confused. The nature of scientific inquiry is missed. Parents too often have little interest or time to pay attention to the quality of their children's schooling. Poverty, hunger, poor health, and the lack of nutrition, health care, dental care, and exercise, all make it difficult for children to learn. Children in our urban ghettos too often do not have the family support, encouragement, and help they need. Peer pressures are often negative. America's cultural diversity makes the task more complex. Poor schools fail to provide needed educational technology, and even some basic educational materials.

There's more: Estimation, statistical inference, and probability are rarely taught. Meaningful and coherent science curricula do not exist. Unfortunately, science is introduced via ninth-grade biology. High-stakes testing and the need for accountability has mushroomed to unreasonable proportions. There is insufficient appreciation of the importance of science to non-science students. The system continues to propagate the myth that women and some minority groups cannot do math and science. For far too many students, the motivation for learning, or even for staying in school after tenth grade, is missing. Student mobility and teacher turnover are too frequent and disruptive. There are problems in recruiting, training, and retaining good teachers. In particular, there is an endemic shortage of science and math teachers. Teachers are not given serious time to prepare, to develop professionally, to work with other teachers, or to mentor. Many universities do not require a serious science sequence; one would think that a two-year sequence of science with laboratory would be a minimum requirement for an educated college graduate, but the typical requirement is a single "rocks for jocks" course. Media coverage of science is dismal and does not convey the excitement, value, or significance of scientific developments. And finally: the greatest obstacle is the resistance to change.

Leon Lederman's evident sense of social responsibility is reflected in several essays. Many authors noted that general science literacy is essential for democracy in our science-dominated culture. I was struck by the number of times global warming was mentioned as an example of the socially relevant topics that we should be teaching. Sheila Tobias's article "Women and Physics" focuses on physics majors, but connects with science literacy through its opening quotation from Rachel Ivie and Katie Stowe's 2000 report *Women in Physics*: "There can be no science literacy in the population absent the full participation of women in all fields of science?" Mae Jemison suggests that funded research should always include a component for public education, perhaps to be used in a partnership with K-12 education.

Shirley Malcom, director of education for the American Association for the Advancement of Science, suggests that many physics teachers reject Lederman's recommendation to put physics first because physics would then have to be taught to all students and these physics teachers believe many people are incapable of learning physics. Malcom and all the other essayists clearly believe that physics literacy is feasible for all people. Bruce Alberts, president of the National Academy of Sciences and chair of the National Research Council, charges that scientists and engineers have been "completely disconnected" from pre-college science and math education, and that university science and math departments have failed to teach exciting inquiry-based introductory courses that are relevant to the world outside the university.

Melvin Schwartz, who shared the 1988 Nobel Prize in physics with Leon Lederman and Jack Steinberger for discovery of the muon neutrino, makes a telling observation. As chair of a Columbia University committee to revise the core undergraduate curriculum, he proposed that science should be treated like the humanities; every student should be required to take a two-year sequence covering the major discoveries in science and mathematics. But most of the other scientists on his committee were "completely opposed" to the idea, because teaching freshmen would detract from their research time. "Since their careers depended on the number of papers they could turn out, there was no incentive for participating in such a program." There could be no more telling indictment of the failure of our universities to provide science education for all students.

Among the small number of essays lying outside the realm of science literacy, the contributions of astrophysicists Edward "Rocky" Kolb and of Michael Turner on the "inner space / outer space connection" between quantum physics and cosmology are noteworthy. Lederman and David Schramm conceived the idea of an astrophysics group at Fermilab to exploit this connection (see the "Brief Biography" of Lederman), and recruited Kolb and Turner to head the project. This group recently published a wonderful survey for non-specialists, *Connecting Quarks with the Cosmos* (National Academies Press, 2003), on the major unsolved issues at the intersection between high energy physics and cosmology. Kolb's and Turner's essays are a reminder to science educators of the fascinating contemporary topics that we could, but mostly don't, teach.

It is a volume full of inspiring examples and ideas for obtaining a scientifically literate populace, and a gloomy recounting of the obstacles blocking that goal.

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