

FORUM ON EDUCATION

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From the Chair

Andrea P. T. Palounek

Now that it is my turn to serve a year as chair of the Forum on Education, I'd like to use this space to issue a challenge to all members of the Forum. We have one of the biggest memberships within the APS - 4,221 members. That means 9.8% of the total membership of the APS is concerned about education and outreach, questions such as:

How do we best serve K-12 teachers as resources of physics knowledge? Teachers at all levels need help implementing the new curricula and keeping up-to-date on physics content. K-12 teachers are experts in presenting material in effective ways; they know how students learn and can manage a classroom. We, on the other hand, understand physics deeply and have innovative ideas on how to present key concepts. Together, we can support excellent physics instruction and present science as exploration and inquiry instead of a catalog of facts to memorize.

How do we explain the importance of physics to the general public? How do we motivate students at all levels to develop important skills, acquire literacy in science, and pursue scientific interests? In addition to supporting specialized museums and individual exhibits, Forum members must work in partnership with media such as television, radio, newspapers, magazines and newsletters. Since not all of us can produce successful materials and museum exhibits, the Forum on Education must identify and sponsor ways of forming partnerships with experts in these areas. Together, we can find excellent materials to distribute to local markets.

How do we relate favorably to policy makers and other public servants? How do we increase their understanding of and appreciation for physics and other sciences? What are the problems we can help them solve on their own turf?

From The Editor

Sam Bowen

This summer issue basks not only in the summer sunshine, but also in the aftermath of the Centennial APS meeting in Atlanta. All of those who worked so hard to organize sessions on education should be congratulated. The sessions were uniformly well attended and even crowded.

Two major talks at the meeting are here excerpted for consideration. Sheila Tobias presents a cogent argument that exogenous factors outside the classroom may be as important as reforms inside, and urges the physics community to consider a list of action items. Kenneth Heller contributes a comprehensive article on the foundations of learning theory and their application to physics classrooms. He gives a very thorough review of resources available for improving physics classrooms.

Three letters to the editor raise issues with articles from the spring edition: whether computers will ever fulfill their promise in education, whether faculty at Ph.D. granting institutions have time to be involved in K-12 education, and whether teaching some incorrect things is useful.

There is an article about the Centennial meeting and a short article from the Division of Undergraduate Education at NSF on new programs.

A short report on the ERIC database, one of the major education electronic repositories, which notes that most of the Physics Education Research has not been included, is presented along with possible solutions for filling in this void from the past.

We have a short report on the PERC98 meeting at the University of Nebraska and the availability of the proceedings of this important meeting.

Cont'd on pg. 2

How do we identify and promote the wide variety of 21st century careers available to those with a physics background? Physicists can bring valuable expertise, perspective, and capabilities to traditional and new interdisciplinary or cross-cutting fields. How do we evolve physics education at both the graduate and undergraduate level so it serves the needs of students emerging into a changing research and economic climate? How do we adapt programs so they provide experiences and training applicable to the broad range of careers our students enter? How do we propel our workplaces to greater involvement in education and outreach at all levels?

How do we promote diversity not only within our subject areas, but within our ranks? Women and minorities continue to make up a far smaller share of physicists and physics students than the general population would imply. How can we identify the educational and societal impediments to a reasonable representation and begin to remove them?

How do we learn from one another and from sister societies as we further our efforts in education and outreach?

None of these are simple questions that can be answered quickly. They will not be served by simplistic, hasty fixes. However, working together, and using the Forum to kindle, foster, and promote successful initiatives, we can address these issues and others. I urge you to consider where you want to contribute. Let us use the Forum as a catalyst for genuine changes.

Andrea P. T. Palounek is the current chair of the Forum on Education. She works at Los Alamos National Laboratory.

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Bowen, cont'd from pg. 1

A list of the current Ph.D. programs in the US which focus on Physics Education Research is also included with webpages and email addresses. As a first step in a long process, your editor has invited one of the newer of these programs to describe what they are doing. You can read about Iowa State's recent entry into this area.

The National Science Teachers Association has recently surveyed practicing science teachers about reform and the results of the Third International Math and Science Study (TIMSS). A summary of these results are reproduced here. A very interesting report from the European Physics Society on efforts to improve science teaching and increase numbers of physics students has been contributed by Gunnar Tibell from Sweden. Tom Rossing has again contributed his "Browsing the Journals".

Letters to the Editor

Unappealing Future Vision of Computer Assisted Education

To the Editor:

That was an interesting juxtaposition, on pages 4 and 5 of the Spring 1999 FOE Newsletter: Don Holcomb's "Computer Assisted Education: What to do about this 600-lb. gorilla?", and Jack Wilson's vision of what that gorilla might look like in the near future. Wilson finds it an appealing vision and asks the reader "Do you?" This reader's answer is "I am not sure, but probably no." In spite of thirty years of massive investment by physics teachers in computer assisted instruction, Holcomb is left with the sense that "we know remarkably little about whether student learning is significantly enhanced by the presence of the computer." Blessed indeed must a project be, which continues to get massive support with such seemingly modest results to show even after thirty years ...

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Teaching Versus Research: Why We Don't Reach Out

To the Editor:

David Haase's good article (Spring 1999, pages 8-9) asks "Why don't the academic science departments put more coordinated interdisciplinary effort into K-12 outreach?" He only hints at the real answer, when he states that "an active research faculty member usually has neither the time nor the expertise to make a lasting impact on K-12 education...."

Essentially every tenured faculty member at the nation's nearly 200 PhD-granting physics departments is a researcher. They would cut their own throat by taking on a K-12 project or any other educational project, because hiring, pay, promotions, and tenure are all based nearly exclusively on research as measured by publications, grants, etc. Most of these departments are eager to hire and to tenure promising researchers, even if they have only minimal teaching skills. But most would not hire an

outstanding teacher who does not have great promise in "pure physics" research, and would not grant such a person tenure despite evidence of significant creative work in course development, text materials, mentoring, K-12 outreach, etc.

It is arguable that the PhD-granting departments are the primary drivers of college-level physics education in America. Their policy imbalance between teaching and research has implications also for K-12 education (because we do not properly educate future teachers and we do little K-12 outreach), and for congressional and public attitudes toward science (because we pay so little attention to science literacy). Thus, many of the much-lamented problems of the physics profession, and of physics education, can be traced back to unbalanced hiring and promotion policies at the PhD-granting institutions.

But significant new research results require great concentration, time, and effort. Good researchers cannot be expected to devote a large fraction of their time or energy to teaching, because they would then generally lose out in the race for new research results. Except for a gifted and

Finally, your editor has been truly amazed by the number of faculty at large and small schools who are carrying out projects to assess student misconceptions, needs, and learning effectiveness. The current newsletter was originally scheduled to highlight some of the projects, but ran out of space. In particular, I would note that Doug Franklin and Mark Boley at Western Illinois University have begun extensive interviewing of students on the impact of physics demonstrations. Many other physicists at smaller universities and colleges are carrying out similar studies; some of which can be found in the AAPT Announcer. I hope you find reading this issue stimulating and useful. The editors welcome articles, letters, complaints and suggestions. A copy of the newsletter can be read on the web with all URL's at <http://webs.csu.edu/~bisb2/>.

tireless few, the truly balanced "researcher-teacher" doesn't really exist.

With these principles in mind, I suggest that the physics community move toward a balanced policy at research institutions by splitting the teaching and research efforts between different faculty members. Only about half of a research department's new faculty members should be hired primarily for research. These should of course be at least adequate teachers, but the main criteria for hiring and advancement should be, as is now the case for all faculty members, research results. The other half should be hired primarily for teaching and related creative activities such as new course development, text materials, undergraduate research, K-12 outreach, and mentoring. They should be valued, evaluated, paid, and tenured in parallel with the research faculty, but with a different job description.

The danger in this is that departments will bifurcate into sub-departments for teaching and for research. To the extent that this happens, we will get our present problems back again. Healthy departments, and a healthy profession, will recognize that the teaching side is at least as important to long-term prosperity as is the research side, and thus prevent this bifurcation.

Whatever dangers such a policy holds, they are not as dangerous as the present reality of a physics profession that produces the world's finest research but leaves its public schools, its school teachers, and its citizenry scientifically illiterate.

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Choosing "Things That are Incorrect" to Teach

To the Editor:

S.LHaan's article advocating teaching "things that are incorrect" made a good point, but tended to conflate useful incorrectness with less constructive teaching shortcuts. Certainly teaching Keplerian orbits raises no problems, since all but the densest students understand that those orbits will be perturbed by other planets, etc. Good old $F=ma$ physics is also tremendously useful, both as an actual way of making real-world calculations and as an opening to physical thinking. Within that coherent classical framework, students can learn how to apply multiple general principles to diverse problems. However, including the Bohr atom as a similar useful model is highly misleading. Almost nothing can be calculated from it, so it's not useful in the vulgar sense. Worse, there is no coherent set of principles in it. While historians of science can appreciate Bohr's heroism in provisionally working with numerology to show that the new quantum ideas were somehow connected with atomic structure, that does not account for the appeal of the model to undergraduates. That appeal comes from its vivid, pictorial images, which come at the expense not only of specific facts (selection rules, effects of multiple electrons, existence of superpositions, etc.) but of the whole consistency of approach that we try to convey. Teaching it is "enabling behavior" toward the students' tendency to see physics as a bunch of disconnected statements whose domains of applicability are assigned by the instructor. That may be popular, but it's not a step forward.

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From Innovation to Change: Forging A Physics Education Reform Agenda for the 21st Century

Sheila Tobias

(Excerpts from Talk given as part of an Education Symposium held on the occasion of the American Physical Society's Centennial Meeting, Atlanta Georgia, March 24, 1999)

Until now, physics education reform has focused largely on classroom based innovation rather than on the more political and institutional change required for long-lasting reform. There is a presumption that innovation is the mother of change. But what if it isn't? What if exogenous variables that set the boundary conditions are out of our control? Ought we not pay some attention to these exogeneous entities as well?

Setting an Agenda for the Next Wave of Reform

For starters, I will list and analyze an assortment of such entities.

Agenda item 1: Revisiting AP Physics Courses in High Schools: Is AP a pump or a filter?

Advanced placement was not an invention of the physics community, but initiated rather by the Ford Foundation in 1954 in collaboration with certain high school teachers who wished to accelerate some but not all college-bound students by giving them college-level material while still in high school.

In the 1950s and 1960s, the physics education community was moving in a different direction, trying to promote "PSSC" for the advanced student and later (for the more average student) Project Physics with its emphasis on concepts and context, presenting physics as a "humanistic endeavor."

But for 40 years, AP courses have flourished (among certain socio-economic populations) at the expense of broader, more conceptual courses for pre-college students. Michael Neuschatz, a statistician working for the American Institute of Physics calculates that the availability of AP physics (in only 15% of the nation's high schools) strongly correlates with social class. Thus the best and brightest (and wealthiest) are encouraged to skip the first-year course in college and university physics which might be a more appropriate introduction for students of their caliber.

Why might AP not be the best introduction to physics? Says long-time physics educator Stefan Machlup: "Most AP physics instruction is unimaginative, treating Halliday and Resnick as if it were some sort of a bible and Classical Mechanics as though it were Genesis." And Arnold Arons remembers that when, in the early days of AP, he and Eric Rogers tried to introduce conceptual questions into the AP exam, they were roundly defeated. AP Physics like AP mathematics (until recently) represents old rather than new pedagogy and content.

Indeed, AP physics may be contributing (in a perverse way) to the rather static enrollments in undergraduate physics. While in recent years, the number of high school students taking physics increased from a 1987 low of 20% to a 1997 high of 28% (possibly due to the increase of girls taking physics), during the same period, the number of college students graduating with a physics major has remained the same at around 3,800 annually. This means that, proportionately, physics is losing even more students than before. For most of the about 70,000 AP students go into engineering and their AP course is their terminal course in physics. Is Physics losing because so many students do not have the putative advantages of AP physics? Or because they do?

Agenda Item 2: Attention to exams, grading practices and standardized testing in equal measure to curriculum and pedagogical reform.

It is a oft-spoken truism that "Exams drive student behavior." Limited in the time they have to study, savvy students try to figure out what is going to be "on the exam". But in physics (and some of the

other sciences), it is not just the students whose behavior is driven by exams - but the teachers' and the curriculum itself.

Consider this: The designers of the physics portion of the MCAT (and not the physics education community) determine in large measure what kinds of physics medical-school bound non-majors have to know and, given economies of scale, the curriculum for algebra-based physics overall. Physicists should be talking to those who design the MCAT physics section if they want to make the curricular and pedagogical changes they are talking about.

Harvard's "Chem-Phys" course is one example among many. In 1991, two Harvard professors, one a Nobelist in chemistry, the other an astrophysicist set about to design a course that would link certain topics in introductory chemistry and introductory physics so as to prepare pre-medical students for the advanced chemistry and biochemistry courses they would have to take later.¹ Despite careful planning and a positive pilot, the students targeted for "Chem-Phys," namely the pre-meds, declined to enroll. Why? Because without a "standard" physics course, they feared they would be under-prepared for the physics section of the MCAT. (In this case, they reasoned, "less" would be less.)

Standard in-class examinations also constrain innovation. Whatever we say or do in terms of curriculum and pedagogical improvement, it is the content and nature of their in-class examinations that tell students — whether we intend this or not — what the subject is about and whether they are or can ever expect to be any good at it.

Agenda Item 3: Assessment and ranking of the quality of physics teaching in colleges and universities around the country.

The physics community has been understandably reluctant to "assess" and "rank" college and university physics departments on the basis of quality of physics teaching and its appropriateness to the range of students who might be attracted to the subject. To be sure, assessment could be abused. Therefore, measures would have to be carefully drawn, but might include:

- Recruitment and retention of majors (including but not limited to women, minorities, and first-generation college students);
- Comments by "client" departments;
- Popularity of non-majors offerings;
- General reputation within the institution; and
- Willingness to follow some kind of "guidelines" promulgated by APS/AAPT and to engage in continuous self-improvement.

The number of majors alone will never tell the whole story because physics remains a "hard" and demanding subject, compared to others. But those numbers (particularly the slope of the curve if they are changing) do reflect an aggregate judgment by a student body as to whether physics is perceived as not just training for research in physics but as a "liberal art."

Agenda Item 4: Adding some high school physics course to standard requirements for college and university admissions and adding some substantive science questions to the SAT and ACT exams.

If students want to know "will this be on the exam" before studying for a course, surely they are influenced by what is covered in the most widely used College admissions criteria and standardized SAT and ACT tests. Yet, questions about science that require substantive knowledge of either physics, chemistry, or biology, are notoriously absent from these standardized exams. (They appear only among the subject-specific elective exams.) This sends out a powerful signal to the effect that, unlike reading comprehension, writing and mathematical skills, vocabulary, and reasoning, science is neither required nor recommended for college admission.

However much we may speak of "science for all", college entrance criteria convey just the opposite: Science is but an option for some.

At the AAAS 1998 meeting, Gerald Holton reported that only 30% of all U.S. colleges and universities require even a single course in science or mathematics for graduation and that even many of the "elite colleges" require at most a mere 6% of the college courses taken be in the sciences or mathematics.

Agenda Item 5: Negotiating with biology and engineering communities for continued support for in-department physics offerings. Seeking other majors (computer science, nursing, business) for which general physics or tailor-made physics courses could be required.

The Engineering and Biology communities whose students account for some 80% of the physics FTE's in the nation's colleges and universities play a vital role in populating introductory college and university physics courses. Recently, the Accrediting Board for Engineering and Technology (ABET) moved to threaten that monopoly. Beginning in 1998, "Engineering 2000" is being phased in which places greater emphasis on "measurable evidence of student learning," rather than specific courses taken. But more ominous yet for the physics community is that in place of a one-year physics course taught in a physics department, ABET will now expect a year of combined college-level mathematics and basic science — a requirement that could be met by integrated math/science courses taught by engineers. Even laboratory experience is to be cut back, required only when it is "appropriate to the discipline. See these criteria at (<http://www.abet.ba.md.us/EAC/>)"

Another "customer base" for physics are biology majors, particularly those intending to go to medical school. If Departments of Life Sciences which are today enjoying a boom in enrollments were to offer their own "physics for life science majors," or "pre-medical physics," another large segment of the Introductory Physics population who count as physics FTEs would disappear. That exogenous variables, such as these, work in favor of physics — at the present time — is well understood. The fragility of these arrangements is, however, rarely acknowledged.

Agenda Item 6: Revisiting class size by doing research, field work (site visits), collecting student exit interviews, and eventually meetings with faculty and deans, to determine where it is advisable and feasible to reduce class size.

Ten years ago, in seeking successful programs to study for my book, Revitalizing Undergraduate Science, a chemistry department chairman at Ft. Lewis College took me to see a large lecture classroom no longer in use. Based on student feedback and their own experience, the chemistry faculty at Ft. Lewis had imposed a maximum class size of 80 on themselves. Their 275 entering freshman chemistry students learned general chemistry in five separate sections. Ft. Lewis' decision flew in the face of widely touted "evidence" from the education establishment (albeit on early grade levels) that once a class exceeds 15, incremental increases do not make a difference. More devastating even to the efforts to reduce class size in order to encourage more interactive pedagogy, is the finding - again in the early schooling literature - that class size is an insignificant variable in student achievement.²

Recently, I visited a homogeneous introductory calculus-based physics course (meant for majors) at a large state university, with a class size of 73. Yes, the instructor "lectured," in the sense that he drove the class, worked the derivations, set the problems, and did the demonstrations. But, what a difference in style it was from the course for engineers taking place in the oversized lecture hall around the corner where 400 students struggled to learn the same material.

The instructor used the blackboard (no need for a transparency projector in that size room). He frequently stopped and asked not just for questions, but for comments. Students felt comfortable calling out from their seats that his yellow marker wasn't visible enough or that he had reversed a sign. He waited between topics. He seemed accessible. The spirit of the class was active and engaged. The point

is 73 is not 15, but neither is it 150, or 200 or 400, and with every additional increment of students, contact - real or imagined with the instructor - diminishes correspondingly.

Despite the successful efforts by physics education innovators such as Ron Thornton, David Sokoloff, and Eric Mazur, to turn the large class (by means of "guided inquiry" or "peer instruction") into a meaningful learning environment, absent the gifted and committed teacher, class size remains a barrier to improvement in college and university teaching.

Mathematics Departments as a rule have abandoned large introductory classes, substituting discussion sections for lectures, which proves that, if faculty can be persuaded that class size makes a difference, faculty find a way.

Agenda Item 7: Active participation in industry-university relations, development and accreditation of alternative post-baccalaureate degree programs.

Today, most physics majors who do not go on to graduate school, find jobs as "engineers" or "computer scientists."³ As Robert Ehrlich (previously cited for his survey of engineering deans, FED Summer Newsletter, 1998) explains it: "Few other disciplines, have the problem of graduating students whose main employment prospects [if they stop at the B.S. degree] lie in another discipline [engineering or computer science] that most universities offer." Thus, keeping them in physics requires that they be convinced physics will serve them better than the other majors not just in doing physics research but in a wide range of occupations.

The AIP is beginning to study current student and employer expectations, supporting web sites at which physics students can explore other options. But we must do more.

In my view, the physics community must not just monitor but actively create new opportunities for physics graduates, opportunities, that may involve altogether new professional tracks.⁴ If physics departments are to survive as centers for undergraduate studies, the major must be made as attractive to those with undecided career goals as to those headed determinedly for research.

Conclusion

Before you dismiss these agenda items as "visionary" and "impractical", think of them as I do, as the stuff of real revolution, without which, there may not be much to celebrate at the next APS centennial, 100 years hence.

Sheila Tobias is an author and education commentator, who has written several books about mathematics and science education. Her work can be viewed at her website (<http://www.sheila.tobias.net/>) and a more detailed version of this article with references can be seen at <http://webs.csu.edu/~bisb21/FEdnl/Tobias.htm>

¹ Sheila Tobias, Revitalizing Undergraduate Science: Why Some Things Work and Most Don't (Tucson, Ariz.: Research Corp., 1992), Ch. 2.

² One of the most widely quoted studies is based on a 1985 experiment in Tennessee classrooms that cost the state \$3 million, reported in Eric Hanushek, Making Schools Work, Brookings, 1994. Hanushek's was the finding that over and above 15, class size made no difference. The finding that smaller classes do not contribute to pupils' overall achievement is attributed to Gene V. Glass and Mary Lee Smith, "Meta-analysis of Research on Class Size and Achievement, Educational Evaluation and Policy Analysis 1(1), 1979, pp. 2-16. Together, these studies seem to have foreclosed further thinking and research on the issue, at least as regards k-12.

³ See John S. Rigden, "Find the Hidden Physicist," The Industrial Physicist, 3, 52-53 (1997).

⁴ See Sheila Tobias and Frans Birrer, "The Science-Trained Professional: A New Breed for the New Century," Industry and Higher Education (U.K.: August 1998).

NSF Educational Support Opportunities of Interest to the Physics Community

Norman L. Fortenberry, Karen L. Johnston, Robert F. Watson

Note: The opinions expressed herein are those of the authors and do not necessarily reflect those of NSF.

Over the past several years, the National Science Foundation's education support programming has made an extended recovery from its nadir of the early 1980s. This year the budget request that Congress is considering for NSF's Directorate for Education and Human Resources (EHR) is \$711 million, which includes programming for projects to strengthen any or all levels of formal education including pre-K through secondary, undergraduate, and graduate, and also informal education.

This paper focuses principally on undergraduate education programs in DUE, but physicists are reminded that other parts of EHR, as well as the disciplinary directorates may also have programs relevant to individual interests.

EHR support possibilities include but are not limited to: Course, curriculum, and instructional materials and technologies development at both pre-college and undergraduate levels, laboratory and instrumentation improvements at the undergraduate level, teacher and faculty professional development, teacher and faculty preparation, technical experiences for students, or combinations of these. The greatest fraction of EHR funds goes to support K-12 teacher enhancement projects. At the undergraduate level, K-12 teacher preparation and preparation of technicians are two very high priorities. All programs give emphasis to improving educational opportunities for minorities and disadvantaged students.

Three Major New Activities for 1999

Computer Science, Engineering, and Mathematics Scholarship Program: NSF recently announced this program which will this year fund about 100 2- and 4-year colleges and universities to provide a total of 8000 scholarships. First closing date is August 30, 1999 (request NSF 99-121).

NSF Graduate Teaching Fellows in K-12 Education: This new program (first closing date was May 5, 1999) will support graduate and undergraduate students to serve in K-12 schools.

Interagency Educational Research Initiative: This new cooperative venture with the Department of Education and the National Institutes of Health will strengthen our knowledge base on how students can better learn science and mathematics (closing date this year was May 14, 1999).

The physics and other disciplinary communities are demonstrating increasing awareness of the need to revitalize undergraduate education. Much of the dialog is in response to the EHR Advisory Committee study, that produced the report, *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology* (NSF 97-37). Opportunities are expanding for the physics community to enhance ongoing efforts to revitalize undergraduate curricula and instruction.

Due's Advanced Technological Education Program (ATE) focuses on the future high tech workforce, principally those students whose entry level jobs require two years of science and technology preparation beyond the high school level. This program, which enjoys strong Congressional interest, supports projects that typically involve collaboration among community colleges, universities, high schools, and industry.

Due's NSF Collaboratives for Excellence in Teacher Preparation encourages institution-wide, or even region-wide systemic reform in the preparation of future elementary and secondary science and mathematics teachers. Projects include faculty from across the scientific disciplines working jointly with faculty from colleges of education toward a future teacher workforce that is well prepared both in content and in pedagogy.

Due's Course, Curriculum, and Laboratory Improvement Program (CCLI) is NSF's broadest support activity for "outcomes" based undergraduate projects. CCLI supports

a. Development of new educational materials for broad national dissemination (e.g., books, CDs, etc.) and associated faculty development at pilot and beta testing sites.

b. Adaptation and implementation of proven educational materials and practices (e.g., courses, labs, curricula, and teaching strategies) and associated faculty development).

c. Large scale national dissemination and faculty development through workshops for faculty across the disciplines).

CCLI themes include teacher preparation, diversity, faculty development, and integration of technology into education. All efforts aim to result in stronger local student learning experiences, and many strive also for outcomes of wider regional and national impact. Some programs are able to support comprehensive regional or national projects. Many faculty, however, may wish to seek support for more focused projects, such as a new piece of scientific instrumentation, time to develop some new laboratory experiments, or a new or revised course in collaboration with a few colleagues. These proposals are less time consuming to prepare, requiring fewer participating individuals and groups, and because they are less expensive, usually in the 25 to 100,000 dollar ranges, NSF can support many more of them.

In addition to direct funding, faculty may also find opportunities and benefit from activities such as: Collaborative projects with other institutions; use of materials and curricula developed in national impact projects, national faculty development projects (e.g. the Chautauqua Program and Project Kaleidoscope), through opportunities in professional organizations such as APS and AAPT, and a variety of NSF-supported conferences and workshops. Often these may be good starter activities for less experienced individuals.

DUE administers most, though not all (cf. undergraduate research support in the "research" directorates), NSF undergraduate education support programs. However, Physics educators should also become familiar with the other EHR programs, which can be accessed as described below. For example, faculty from one or more of the scientific disciplines led many if not most projects at the elementary or secondary level.

The best way to begin planning a proposal to any EHR program is to read carefully the relevant EHR divisional Program Announcement and Guidelines booklet, which describes in detail the programs, and provides information on writing and submitting proposals. It also describes ways to access the staff, and to find out about other NSF opportunities. For DUE, you may obtain the Guide by calling 703.306.1666, email-undergrad@nsf.gov, or by accessing the DUE Web site, <http://www.ehr.nsf.gov/EHR/DUE/start.htm>.

The DUE Web site is a rich resource of information on programs, projects, publications, reports, and many other items related to undergraduate SMETE. It also allows further access to the hundreds of DUE-supported projects that have their own Web sites. Most individuals contemplating a proposal for undergraduate SMETE whether to seek NSF funding or not will find the DUE Web site an indispensable tool for background study.

You can also begin with the NSF Web site, <http://www.nsf.gov> to obtain information about other program areas and projects throughout the foundation.

Norman L. Fortenberry is Division Director of the Division of Undergraduate Education (DUE), NSF, Karen L. Johnston is the DUE Program Director (on leave from the Physics Department, North Carolina State University.), and Robert F. Watson is the recently retired DUE Division Director.

ERIC databases do not contain Physics Education Research References over the last many years.

For several years the US Department of Education has been funding the ERIC database as an internet source of articles and research on education. It is common for education students and scholars to begin serious searches on educational developments with the ERIC database. The general feeling among educators is that ERIC is fairly complete and covers the important developments in education affairs.

For that reason, it was very surprising recently that a search for the Force Concept Inventory picked up no references. Upon contacting the ERIC Clearinghouse for Science, Mathematics, & Environmental Education, it was learned that the subscriptions to American Journal of Physics and The Physics Teacher had lapsed several years ago and that there was no cataloging of these two journals going on at the present time. This means that most of the Physics Education Research literature is essentially missing from the nation's major electronic database on education.

For future articles (after May 1, 1999) this situation has been remedied by the AAPT generously providing a complimentary subscription for both of these journals to the Clearinghouse. In the future, articles that appear in these journals will be logged into The "Current Index to Journals in Education" (CIJE) and will appear in the database.

It is valuable to have the results of the Physics Education Research community in this very comprehensive database. However, it is not quite clear what to do about the missing decade or so of articles.

At the moment there is no funded plan to get previous journal articles into the database. In the meantime, the following procedure will work. Each author should search the ERIC database for their articles: website (<http://eric.syr.edu/Eric/>). If the articles

are not referenced, then the ERIC clearinghouse staff is very willing to put the article into the database. If the journal holds the copyright, a copy of the journal article with the citation information can be sent to the address below and the article will be processed for the "Current Index to Journals in Education" (CIJE). Unrefereed articles on educational research can also be submitted to ERIC with what appears to be minimal editorial review by submitting two copies of the paper and signing a release form. Non-journal articles must be education related, must make a significant contribution to knowledge on a subject, be contemporary, timely, legible, and more than 5 pages.

Articles for inclusion in the ERIC database can be submitted (2 copies) to: Niqui Beckrum, Database Coordinator, ERIC Clearinghouse for Science, Mathematics, & Environmental Education, 1929 Kenny Road, Columbus, OH 43210-1080. For more information you can contact Niqui via email at beckrum.1@osu.edu. The ERIC staff appears extremely willing to help the Physics community fill in the gaps in their coverage.

The failure to process the Physics Education Research over the last several years appears to be an artifact of the level and priorities of funding support from the U.S. Department of Education. The processing functions of the Clearinghouse are funded, but more critical analysis and searching for non-traditional sources of education research were not very generously funded especially for non-traditional education journals and subject areas like physics. There should also be some effort to influence the Department of Education to provide more funding for functions of the ERIC Clearinghouse if it is to be a comprehensive source of education information for the nation.

APS Centennial Celebration The end of an era presents a new challenge to the Forum

Robert G. Fuller

The APS Centennial Celebration was accompanied by much hoopla. When was the last time a meeting of the APS got two pages, with color photos even, in the Chronicle of Higher Education? (Volume XLV, Number 30, pp. A22, A24)

For those of us who were able to join the other 11,000 physicists it was an inspiring occasion. Just think, all those people who knew what a Hamiltonian was in the same conference center?

The invited sessions and panel were held in large convention halls with plenty of people in attendance. The quality of the presentations was very high. But for those of us who can remember the old so-called New York January meetings of the APS/AAPT, it was the end of an era. This is the last joint meeting planned for the APS and the AAPT. Many of the divisions of the APS moved their meeting dates to coincide with the centennial celebration. No more plans for that are in the future, I think. The 100-year celebration of the APS marks an end of an era of physics in America. The APS is now a loose confederation of separate divisions with their own meetings and their own sections of the Physical Review. I am guessing that it was the last general meeting to be held by the APS in my lifetime.

As such it presents a real challenge to the Forum.

The invited sessions sponsored jointly by the Forum and

the AAPT were very well attended, standing room only. A majority of the people at those sessions seemed to be APS members not normally in attendance at AAPT meetings. After many of the papers there were lively questions and discussions about the topics that, while common at AAPT meetings, seemed new and exciting to many of the APS members in attendance.

How can the Forum continue to encourage such cross over of information between the AAPT and APS members in the future? The Research in Physics Education community is small and vigorous. It is increasing the body of sound research on improved pedagogy for learning physics.

Without joint meetings between the AAPT and the APS, how can the Forum bring knowledge about educational issues to the attention of APS members? What activities of the Forum are likely to help APS members to be aware of the growing body of knowledge in research in physics education and be able to use those research results in their own professional work?

Are there techniques available using the new electronic communication media that will enable the Forum to continue and expand its essential role in the APS?

Robert G. Fuller is a professor at the University of Nebraska - Lincoln and has been a leader in Physics Education Research.

Introductory Physics Reform in the Traditional Format: An Intellectual Framework

Kenneth J. Heller

Reform, a comprehensive restructuring of the introductory course at universities and colleges, has already been launched in Biology, Chemistry, and Calculus. Reform efforts build on research to take into account the nature of the discipline, the institutions providing instruction, the students, and the instructors. In Physics, an evolutionary process of change has been occurring based on research on learning and teaching. Physics educators are developing different approaches to changing the introductory physics course. Some of these changes make use of new technology, others reformulate the subject matter, while still others restructure the format in which all or part of the course is delivered. Some of these changes find certain niches in which they can thrive. Others can be integrated into the existing course structure. Still others will die out. All need investigation to determine their potential if the introductory physics course is to be more effective. The focus of this article is the pedagogical context for the most conservative of the changes to the introductory physics course, those that do not significantly change the course content and can be incorporated within its traditional framework of lectures, recitation sections and laboratories.

Understanding the necessity of having a pedagogical context comes from our experience. As productive physicists, we all operate in a physics context, a theoretical framework based on data that evolves toward a closer representation of reality. We need that framework to evaluate the significance of past work and formulate future efforts. Within physics we have many examples showing that a theory need not be correct to be fruitful. It is not even necessary that we completely understand a theory in order for it to be useful in guiding our work. It seems reasonable that a similar *modus operandi* is useful, and maybe necessary, to make continuous progress in our teaching. As an introduction to such a pedagogical context I will attempt a brief review of the development of the traditional structure of the introductory physics course and the research based learning theories that underlie some of the current reform efforts.

There are many recent developments that have yielded sustainable improvements to some aspect of the introductory physics course. All are grounded in a research base encompassed by modern learning theory. Examples of these efforts that have been implemented within the traditional format (and those primarily associated with their development or implementation) are: Cooperative Group Problem Solving (Heller & Heller, University of Minnesota, <http://www.physics.umn.edu/groups/physed/>);

Interactive Demonstrations (Sokoloff & Thornton, Oregon State & Tufts Universities, <http://www.vernier.com/cmat/ild.html>); Overview Case Studies (van Heuvelen, Ohio State University, <http://www.physics.ohio-state.edu/~physedu/people/vanheu/index.html>); Peer Instruction (Mazur, Harvard University, <http://mazur-www.harvard.edu/Education/pi.html>); Socratic Dialog Inducing Laboratories (Hake, Indiana University, <http://carini.physics.indiana.edu/SDI/>); and Tutorials (McDermott, University of Washington, <http://www.phys.washington.edu/groups/peg/tut.html>). Other physics reform efforts that call for the restructuring the entire course format, such as Workshop Physics (Laws, Dickinson College, [http://Physics.Dickinson.edu/PhysicsPages/Workshop Physics/Workshop Physics Home.htm](http://Physics.Dickinson.edu/PhysicsPages/Workshop%20Physics/Workshop%20Physics%20Home.htm)) or reformulate the subject matter, such as a new Electricity and Magnetism text (Chabay & Sherwood, Carnegie-Mellon University, <http://cil.andrew.cmu.edu/emi.html>) also are guided by education research but will not be addressed here. An excellent introduction to these developments is the "The Changing Role of Physics Departments In Modern Universities", the 1996 Proceedings of the International Conference on Undergraduate Physics Education, AIP 399, especially the examples in volume 2.

To appreciate our current format of lectures, laboratories, and recitation sections, it is interesting to briefly trace its history. In the 18th century, higher education in the United States was for the elite, the leaders who would guide the society. Classes were based on the recitation section and the textbook. Students would study the text outside of class. The class would consist of an inquisition of each student by the instructor and perhaps by other students. Debates were encouraged. The instructor was usually someone who had just graduated and was awaiting a job, a graduate TA in today's terminology. By the 19th century, the participants in higher education had widened to society's upper class. It was now considered to be a "broadening" experience rather than a preparation for a specific leadership task. To accommodate the more diverse background and interests of the students, classes were made more entertaining and less challenging by the introduction of a new innovation in higher education, the lecture. Classes required less active involvement by the students. The lecturer was usually someone with experience in the field, a professor. The science professors introduced their best students to laboratory work in their research laboratories. In the 20th century, higher education became a more serious matter. It now became open to everyone who was qualified. It was a necessary preparation for a profession and an entry into the market for good jobs. The structure of the introductory physics class now had its traditional format of lecture, recitation section, and laboratory.

The 20th century also is the beginning of scientifically based learning theory. Over the century three theories emerged, behaviorism, developmentalism, and cognitive apprenticeship. All of these theories are based on data and posit specific mechanisms for learning. Because learning is a complex human activity, testing these theories has all of the ethical and statistical problems of testing theories of medical treatment. Nevertheless, this testing occurs and the results have influenced the evolution of learning theory. These theories so permeate our society that, by conscious design or not, almost all of our pedagogy is now based in some way on one of them. As usual with theories, the one with the most pervasive influence is the oldest, behaviorism. It corresponds most closely to our common sense and turns out to be the least applicable to learning complex skills and concepts of higher education. The following are brief descriptions that I hope gives some idea of the essence of these theories. They should be taken in the spirit of a cartoon rather than a mechanical drawing. As with any vital theory, each has developed many variations and nuances that this article ignores. For those interested in more details about learning theories, <http://www.gwu.edu/~tip/>, contains brief summaries and is a good place to get references.

Behaviorism emerged around 1910. Its most influential exponent was Edward Thorndike. It was the first scientific learning theory based on extensive experiments usually based on modifying animal behavior. At its core, behaviorism holds that the primary difference between experts and novices is the amount of knowledge they possess. This knowledge can be built in an incremental process, adding important skills and concepts piece by piece until understanding is achieved.

Pedagogy designed under the influence of this theory begins with an expert breaking down the subject to be taught into a set of simple, logical steps. The first simple step is explained to the student and then practiced by the student until mastered. At that point the second step is introduced, practiced, and mastered. When the student has mastered all of the steps they will have mastered the subject. To teach under this theory, an expert must first determine the logical construction of the subject matter. The teacher transcribes that knowledge structure incrementally into the student's conceptual framework by drill and practice, using simple steps to reproduce the expert's logic. Examples used in this practice are stripped down to

the essentials so as not to detract the student's attention from the underlying logic. In physics, examples thus take the form of the ubiquitous block sliding down a frictionless inclined plane. Pedagogy based on behaviorism is useful to teach most people simple repetitive tasks such as taking apart, cleaning, and reassembling a machine.

Unfortunately, behaviorist pedagogy is not useful to teach most students complex skills, such as problem solving, or physics concepts. Nevertheless, the behaviorist influence is evident in our physics textbooks, laboratory manuals, problems that contain several small subproblems, and the mostly abandoned attempt at teaching physics by programmed instruction (the Keller Plan). This theory is logical and implementable, but, as Poincaré said, "There is nothing sadder to see than a beautiful theory trampled by a brutal gang of facts."

The two more recent learning theories, developmental and cognitive apprenticeship, recognize that the learning process is more complex than envisioned by behaviorism. Both theories are based on data which show that individuals have different ways in which they acquire knowledge, and in which they connect bits of knowledge to form concepts. Learners construct knowledge under the influence of their existing framework of understanding.

Although modern developmental theory began in the 1920's with the work of the psychologist Jean Piaget, it achieved broad acceptance in the 70's. The early empirical basis of this theory was investigations of the similarities in the reasoning errors of children as a function of age. In developmental theory, the difference between a novice and an expert is not simply the amount of knowledge, but in qualitative differences in their modes of reasoning. This difference has its roots in biological development in that children are not capable of certain modes of reasoning, such as conservation or proportional reasoning, until a certain age. Even after being biologically capable of a mode of reasoning, a person cannot attain it without going through the previous stages of intellectual development. Pedagogy must cause the learner to recapitulate missed stages of intellectual development; they can not achieve a new stage incrementally by building up a logical set of simpler ideas. In some sense, modes of reasoning are like quantized atomic levels. Only by applying enough energy, can the transition be made.

A pedagogy based on developmental theory requires research in three areas: how learners think incorrectly about a subject; what sorts of experiences will cause them to identify and lose confidence in those incorrect modes of thought; and the types of experiences learners need to construct new patterns of thought. Pedagogy based on this theory takes students through a carefully constructed sequence of artificial situations, called a "learning" cycle. The developmental learning cycle comprises: experiences that cause students to probe their own ideas about the topic; challenging experiences that directly conflict with their own predictions based on incorrect ideas; experiences which help rebuild their conceptual framework based on correct ideas, and finally repeated, successful experiences applying their reconstructed ideas in different contexts to help them integrate their reconstructed ideas with other related ideas. While pedagogy based on behaviorism concentrates on knowledge acquisition, that based on the developmental theory depends first on knowledge destruction, followed by knowledge acquisition.

Within the traditional format, Interactive Demonstrations, Peer Instruction, and Tutorials are examples of changes in introductory physics pedagogy that are heavily based on a developmental learning theory. All make use of the research on student difficulties in learning specific concepts and apply strategies to encourage students to unearth and confront their misconceptions. Interactive Demonstrations accomplish this by using lecture demonstrations, designed to confront student misconceptions, with graphic feedback using computer assisted data acquisition. Before the demonstration is performed, students are required to predict the outcome. Peer Instruction also operates in the lecture. It uses the time honored technique of interrupting the lecture at regular intervals to ask students

questions and allowing them to discuss their answers in small groups. In this case, the questions are designed to help students confront their misconceptions. After students indicate their answer, the lecturer discusses it if necessary. Tutorials, on the other hand, have been used to replace recitation sections although they could equally well replace the traditional laboratory. The tutorials are typically a carefully designed set of concrete activities designed to take students through the entire cycle prescribed by developmental learning theory. The activities are closely based on student misconceptions uncovered by research. Students work in small groups that are guided by instructors who circulate through the groups.

Cognitive apprenticeship is the most recent of the modern learning theories articulated in the 1990's by Allan Collins, John Brown, and Susan Newman. The theory is motivated by noting the effectiveness of traditional apprenticeships in teaching complex skills. This apprenticeship system is how physics graduate students become physicists. The empirical basis of this theory is the research detailing the contrasts between expert and novice knowledge structures in adults as well as children. This learning theory agrees with developmental theory that novice knowledge is qualitatively different than that of experts. An important element of this theory is that learners' concepts and skills are closely interlinked with their past experiences. As with the developmental theory, the student must reconstruct their knowledge framework to become more expert-like in their thinking. However, since each learner has a different set of experiences as well as concepts and skills, only they can determine which knowledge links need to be built, destroyed, or modified. This means that to be effectively learned, material should be presented in contexts that have some chance of overlapping the learner's experiential framework. Within this theory, concepts cannot be effectively learned in isolation from applications familiar to the learner.

To apply the cognitive apprenticeship theory to pedagogy requires three actions: modeling (showing how it looks), coaching (doing it with guidance), and fading (slowly withdrawing structure). In the modeling phase, the teacher explicitly demonstrates the entire action that the student is expected to learn in a context that is complete from the student's point of view. For most students this requires not only familiar objects, such as a skateboard going down a ramp instead of a block sliding down an inclined plane, but also some motivation for determining an outcome. Whether the teacher wishes to model a skill or the construction of a concept, it is presented in detail in several different contexts that might be meaningful to the student. The act of modeling is efficiently done in a lecture format. Textbooks can also provide effective models.

Although necessary for learning, modeling is not sufficient. Next the student must be coached while applying whatever is to be learned. Again, several applications should be used which might be meaningful to the student. Attempting to apply the previously presented model forces each student to examine any ideas impeding that application. The students provide a significant amount of coaching when they work together in small groups on an activity that is complex and rich enough to connect with their individual experiences. Additional coaching by the instructor is also needed, although less frequently than peer coaching, to move the students toward a more expert-like approach. Items that provide a structured guide, such as worksheets outlining a problem solving strategy or computer tutorials, can also be useful tools for coaching. Finally, students must have the opportunity to practice applying the skills or concepts alone, without coaching, in order to finish the integration into their own knowledge framework. Once students have become familiar with a procedure, the tools that support that procedure are withdrawn. In contrast to developmental approaches, cognitive apprenticeship concentrates on knowledge application as the mode of acquisition.

Cooperative Group Problem Solving and Overview Case Study are primarily based on cognitive apprenticeship. Both make use of the research that contrasts the thought processes of experts in physics with those of novices. Cooperative Group Problem Solving uses the very traditional approach of teaching

physics concepts through problem solving and is the most complete example of cognitive apprenticeship. The lectures are used to model an expert-like problem solving strategy and an explicit concept development in realistic contexts. These lectures are occasionally paused so students can answer questions, using informal groups to provide some peer coaching. Recitation sections and laboratories provide the bulk of the coaching. In recitation sections, students work on context-rich problems in cooperative groups of three to provide peer coaching. A graduate student TA functions as a coach by intervening in a group when necessary. Laboratories are similar to recitation sections except that measuring reality checks the solution to the context-rich problem. Fading is accomplished by slowly withdrawing worksheets outlining a specific problem solving strategy.

Overview Case Study concentrates most heavily on the modeling aspects of cognitive apprenticeship. It adds explicit modeling of concept building through lectures, a study guide, and worksheets to that of problem solving. The problems and the explicit problem solving strategy modeled are very similar to Cooperative Group Problem Solving. Coaching is accomplished primarily by the instructor and by peers when the students work in informal groups during the lectures. Laboratories are also used as vehicles to solve concrete problems.

The 1998 Physics Education Research Conference Proceedings

Thomas C. Koch and Robert G. Fuller

Introduction

A Physics Education Research Conference (PERC98) was held August 1-2, 1998 in Lincoln, Nebraska. Approximately 100 faculty and graduate students participated in the conference; a working meeting for practitioners of physics education research (PER). Nearly all of the conference presentations were tape-recorded, transcribed, lightly edited, and collected to form the PERC98 Proceedings. In addition to the transcripts, the proceedings contains an appendix with historical PER information, a list of PER PhDs granted in the U.S., and extensive information about U.S. research groups currently doing PER.

Some history

By the late 1960s, it was evident to physicists concerned about education that research was needed on how students learn physics and on how to teach physics most effectively. An article and a letter to the editor published in the *American Journal of Physics* in the 1970s encouraged the physics community to think about student reasoning, in addition to physics content. [See McKinnon and Renner (1971), "Are Colleges Concerned with Intellectual Development?" *Am. J. Phys.* 39, 1047-1052, and Arons and Karplus (1976), "Implications of accumulating data on levels of intellectual development" *Am. J. Phys.* 44, 396.]

A PhD program for graduate students with strong backgrounds in physics (or in another science or mathematics) was developed at the University of California, Berkeley, through the efforts of Robert Karplus, Alan Portis and Frederick Reif, who were in the Physics Department. The program was established as an interdisciplinary Graduate Group in Science and Mathematics Education and became known as SESAME. The first SESAME PhDs in physics education were awarded in 1972. In 1975, Arnold Arons supervised the dissertation of a student who received a D.A. in physics at the University of Washington. In 1979, the Physics Department at the University of Washington awarded the first PhD in physics for research in physics education to a student supervised by Lillian C. McDermott. By the middle of the 1980s, other PhD programs focusing on research in physics education had begun to produce a few graduates. There are currently about sixteen such PhD programs in the USA.

Socratic Dialog Inducing Laboratories concentrate most heavily on the coaching aspect of cognitive apprenticeship and are more of a hybrid with a developmental approach. This effort is a laboratory in which students are guided to make expert-like representations of what they observe. The laboratory exercises are designed to help students confront their conceptual misconceptions using worksheets that help guide them into a more expert-like conceptual framework. Students who work together in groups provide some coaching. Additional coaching comes from an instructor who engages group members in a Socratic dialog.

We are now evolving the structure of higher education for the 21st century. The emphasis is once again an interactive learning style of education originally used only for the elite. Now everyone prepares for a career distinguished by the importance of decision making and leadership. In other words, everyone is "elite." In striving for a higher level of instruction, we can minimize the educational oscillations so characteristic of the past by viewing teaching as a form of engineering. Our job is to apply research results in pedagogy to our own specific application guided by a relevant theoretical framework. Only in this way can we achieve the continuous progress characteristic of physics and "stand on the shoulders of giants."

Kenneth J. Heller is the Chair-Elect of the Forum on Education and a professor at the University of Minnesota.

PER PhD Programs in the U.S.A., 1998-99

Arizona State University (Physics)

Carnegie Mellon University (CIL)

Iowa State University (Physics)

Kansas State University (Physics and Education)

Montana State University (Physics and Education)

North Carolina State University (Physics)

Ohio State University (Physics)

Rensselaer Polytechnic Institute (Physics)

San Diego State University/University of California at San Diego (CRMSE)

University of California Berkeley (SESAME)

University of Maine (Physics and Education)

University of Maryland (Physics and Education)

University of Massachusetts (Physics)

University of Minnesota (Education)

University of Nebraska-Lincoln (Physics)

University of Washington (Physics)

Why a proceedings?

PERC98 was the third gathering of the physics education research community. (The first two took place in 1994 at North Carolina State University and 1997 in Denver.) During the planning stages of the conference, we decided it was time to create a printed record of the community's activities—a snapshot of the PER community. We hope the proceedings will be useful in several different ways. It contains a record of the activities at the conference; it can be used as a reference and a contact guide for those interested in current physics education research and it provides an introduction to the history of physics education research in the USA.

Highlights of the conference and proceedings

1998 Physics Education Research Conference Proceedings

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- Research in Physics Education: The Early Years (Arnold Arons, Univ. of Washington)
- Aspects of Validity in Quantitative Research
- The Basics of Qualitative Research
- Twelve to Twenty Contact Hours and Research Too
- But How Do We Pay for All of This?
- The US National Science Policy Study
- Graduate Students Present and Discuss Their Current Thesis Research.
- Frontiers in Research in Physics Education
- Forming a Consortium on Physics Problem Solving
- Lone Rangers Get Lonely: Getting Your PER Team Larger than One Professor
- Appendix

During the two days of the conference, 13 different sessions were conducted. More than 50 of the conference participants were represented in at least one of those sessions, which included a poster session. The complete conference schedule and proceedings table of contents can be found on the web at <http://physics.unl.edu/perc98/>. A few highlights from the proceedings are described below.

Arnold Arons talked began his talk, "Research in Physics Education: The Early Years," by saying, "I was asked to talk a little bit about what it was like in the old days, and that invites personal reminiscences and anecdotes." He proceeded to tell stories about his life in physics education, starting with his early discovery, made by listening to students who came into his office, that "lucid lectures and demonstrations were depositing virtually nothing in the minds of the students" and his experimentation with making students verbalize their ideas to help them recognize when they didn't understand terms. The stories continued through the publication of his first paper on physics education and his experiences with "complex" physics education projects—which he characterized as requiring real money and producing imaginary results—and finished with the beginnings of graduate programs in physics education research. Dr. Arons went on to urge the PER community to continue to pay close attention to teacher education, ratio reasoning, and linguistic aspects of teaching and learning physics.

Beth Thacker (Grand Valley State University), David Maloney (Indiana University-Purdue University-Fort Wayne) and Rand Harrington (University of Maine) formed the panel for "12-20 Contact Hours and Research Too." Dr. Thacker and Dr. Maloney discussed issues related to trying to do physics education research while

simultaneously teaching a large number of classes at institutions without graduate programs in physics. Dr. Harrington told the story of a "day in the life" of a young faculty member starting a physics education group in the physics department of a research university.

"Frontiers in Research in Physics Education" was a panel presentation given by Jose Mestre (University of Massachusetts), Ron Thornton (Tufts University), Bruce Sherwood (Carnegie Mellon University) and Alan Van Heuvelen (Ohio State University). The panelists had been instructed to discuss the research they would do if time and funding were no object. Dr. Mestre concentrated on assessment—investigating the design of assessment and instructors' use of assessment to inform their own teaching, as well as trying to investigate successful programs of physics education to see what factors drive their success. Dr. Sherwood urged the community to look carefully at the content taught in physics classes with an eye toward weeding out topics that are no longer relevant. He also brought up the issue of studying student beliefs about the learning of physics. Dr. Thornton described a research project he is already doing, and discussed preliminary data suggesting that there may be ways to identify at-risk students from their behavior early in a course. Dr. Van Heuvelen presented ideas on the roles of representations in understanding physics, the importance of workplace skills, and the use of computers and technology to improve physics learning.

The largest part of the Appendix is information organized by research group. The research groups submitted short group histories, lists of dissertations that have come out of the group, descriptions of projects in which the group is currently involved, lists of group members, and contact information. Also included in the appendix are historical information about physics education research, compiled lists of PER PhDs, and contact information for each conference participant.

We would like to thank some groups whose financial support made PERC98 and the proceedings possible: Nebraska EPSCoR, the UNL Math/Science Area of Strength of the College of Arts and Sciences, Nebraska Technology Development Corporation, and the UNL Department of Physics and Astronomy.

You can order a copy of the PERC 1998 proceedings for \$30, including shipping. Send a check or purchase order to RPEG, 314 Ferguson Hall, University of Nebraska-Lincoln, Lincoln, NE 68588-0109. Phone: 402-472-2790 or 1-800-332-0265 (ask for Color Images). Fax: 402-472-6234. For additional information, visit our web site: (<http://physics.unl.edu/perc98/>).

Thomas C. Koch is a graduate student in the Physics Education Research Program at the University of Nebraska and Robert G. Fuller is professor of the program.

Physics Education Research Ph.D. Programs in the USA

Physics Department Programs

Arizona State University

Research in scientific inference, inquiry and evaluation. Models and modeling in physics instruction and software design.

David Hestenes hestenes@asu.edu
<http://modeling.la.asu.edu/modeling.html>

Iowa State University

Research on learning physics with multiple representations; assessing and analyzing individual variability in student learning; curriculum development and instructional methods for active learning in large-enrollment classes; teacher preparation, and assessment of learning in elementary physics courses

David Meltzer dem@iastate.edu
<http://www.public.iastate.edu/~physics/personal/meltzer.html>

Kansas State University

Research on students understanding of modern physics, integration of physics research and education, applying technology to teaching physics

Dean Zollman dzollman@phys.ksu.edu
<http://www.phys.ksu.edu/perg>

University of Maine

Electric and magnetic effects, radiation and radioactivity, in-service and pre-service professional development for K-12 teachers

Randal Harrington randal@maine.maine.edu
<http://lrpe.umefphy.maine.edu>

University of Maryland

Physics education research, student attitudes and expectations, student understanding of mathematics in physics, student conceptual difficulties in the areas of waves and quantum mechanics

E.F. Redish, David Hammer
redish@quark.umd.edu, davidham@physics.umd.edu
<http://www.physics.umd.edu/rgroups/ripe/perg/>

University of Massachusetts

Expert-novice differences in knowledge organization and problem solving in physics, assessment of conceptual understanding, classroom communication systems, active learning in large classes, and materials development.

Bill Gerace, Jose Mestre wjgerace@phast.umass.edu, mestre@phast.umass.edu
<http://www-perg.phast.umass.edu/>

Montana State University

Active inquiry-based teaching/learning in large introductory physics and astronomy courses, interdisciplinary science courses, and teacher preparation (K-12)

Jeff Adams, Greg Francis
adams@physics.montana.edu francis@physics.montana.edu
http://www.montana.edu/~wwwph/research/phys_ed.html

University of Nebraska-Lincoln

*Using multimedia to teach physics
Special Student Support: NSF Graduate Research Traineeships in Research and Development in Using Hypermedia for Knowing Physics*

Robert Fuller rfuller@unlinfo.unl.edu
<http://www.unl.edu/physics/Education.html>

North Carolina State University

Instructional technology research, development, and evaluation, assessing student understanding of various topics, collaborative learning in large and small enrollment courses, revising instruction and popular texts to incorporate the findings of physics education research. effects of web-based delivery of animation and video, application of ideas about human visual perception and cognition to instructional software design, teacher development.

Robert Beichner, John Hubisz, David Haase, Karen Johnston, John Risley
John_Risley@NCSU.edu Beichner@NCSU.edu
http://www2.ncsu.edu/ncsu/pams/physics/Physics_Ed

Ohio State University

Using verbal reports as data (think aloud techniques) to analyze student conceptual beliefs and problem solving, investigation of student attitudes about physics, determination of the impact of "inquiry techniques" on the development of problem solving ability, integrating the results of physics education research and the use of technology into coherent learning systems for introductory college and high school physics courses

Alan Van Heuvelen, Gordon Aubrecht
gvanh@mps.ohio-state.edu
<http://www.physics.ohio-state.edu/~physedu/home.htm>

Rensselaer Polytechnic Institute

Creation of alternate learning environments for Physics and other Science, Mathematics, and Engineering fields. Particular emphasis on technology and collaborative learning in large enrollment courses. Research on networked based distributed (distance) learning techniques and technologies. CUPLE, Computational Physics, and Studio Physics.

Jack Wilson, Jim Napolitano, Chun Leung, Philip Casabella
wilsoj@rpi.edu, napolj@rpi.edu, leungc@rpi.edu, casabp@rpi.edu
<http://www.rpi.edu/dept/phys/physics.html> <http://cde.rpi.edu>

University of Washington

Research on the learning and teaching of physics in introductory and upper-division physics courses, introductory engineering courses, special courses for precollege teachers (K-12), and courses for preparing graduate teaching assistants, use of research as a guide to the development and assessment of curriculum

Lillian C. McDermott, Stamatis Vokos, Peter Shaffer, Paula Heron (Phys. Ed. Group)
valles@phys.washington.edu
<http://www.phys.washington.edu/groups/peg/>

Multidisciplinary programs**University of California at Berkeley**

*SESAME - Graduate Group in Science and Mathematics Education
Research in science and mathematics education with a particular emphasis on the role that cognitive science and technology can play in improving physics education*

Barbara White, Andrea DiSessa
kate@socrates.berkeley.edu
<http://www-gse.berkeley.edu/program/CD/cdprogramssesame.html>

Carnegie Mellon University

*CIL (Center for Innovation in Learning)
Classical mechanics, and electricity and magnetism*

Richard Hayes, Ruth Chabay, Fred Reif, Bruce Sherwood
Bruce.Sherwood@cmu.edu
<http://cil.andrew.cmu.edu/>

University of Minnesota

Research in student problem-solving, cooperative group techniques, and gender differences from instructional techniques, development of a comprehensive computer environment to support the construction of physics ideas by students, development of computerized data acquisition and analysis using a LabView environment, graduate student teaching orientation and teaching support.

Kenneth Heller, Patricia Heller
physed@physics.spa.umn.edu
<http://www.physics.umn.edu/groups/physed/>

San Diego State University/University of California at San Diego

Studying learning from multiple perspectives in a computer-rich collaborative learning environment; development of innovative computer software to promote physics learning; development of innovative physics courses for middle school and high school.

Fred Goldberg, fgoldberg@sciences.sdsu.edu
<http://public.sdsu.edu/CRMSE/jointdoctoral.html>

Iowa State University is New Entrant into Physics Education Research Community

David E. Meltzer

Last year the Department of Physics and Astronomy at Iowa State University inaugurated a new group devoted to physics education research. Thus ISU has joined about a dozen other physics departments around the country in which the new sub-field of Physics Education joins more traditional fields as a legitimate area for scholarly research, and for training of graduate students. Department Chairman Douglas Finnemore said that "We want to put Physics Education on the same intellectual and competitive level as particle physics, nuclear physics, condensed matter physics, and astronomy."

The origins of physics education research (PER) lie in the strong desire of physics instructors to maximize the effectiveness of the teaching and learning of physics. It seems only natural that physicists are now applying their training and systematic analytical methods – so successfully used to understand the physical world – to explore the problems related to the learning of their subject. Within the past two decades, physicists in the colleges and universities have initiated intense efforts to study physics learning, particularly among undergraduate students. The efforts of PER to identify and address learning difficulties in physics should result in improved learning by both average students and high-performing students.

At Iowa State, in common with other PER groups, we engage in three distinct yet closely linked activities: (1) develop and assess more effective curricular materials; (2) implement and assess new instructional methods that make use of the improved curricula; (3) investigate learning difficulties, and carry out other basic research on the teaching and learning of physics. Our particular focus is on curriculum and instructional methods for large lecture classes.

Our objective is to address areas of pedagogical concern previously identified by physics education researchers. For instance, many if not most students in introductory courses develop weak *qualitative* understanding of concepts, even when they may be able to solve successfully certain types of quantitative problems. When lacking exact quantitative solutions, students often have difficulty in determining qualitative features such as comparison of magnitudes, determination of direction, and evaluation of trends.¹

More broadly, students frequently lack a "functional" understanding of physics concepts, which would allow problem solving in a context *different* from the one in which the concept was originally learned. Students find it difficult to transfer an ability to solve standard textbook problems to situations involving actual, real-world physical objects and phenomena.² Moreover, there is a strong tendency to view phenomena and concepts as distinct, unrelated and highly dependent on context, rather than as comprehensible and derivable from just a few underlying universal principles.³

A number of factors have been identified as playing a role in these learning difficulties. For example, students enter introductory classes with their own ideas about the physical world that may strongly conflict with physicists' views.⁴ Often called "misconceptions" or "alternative conceptions," these ideas are widely prevalent; there are some particular ideas that are almost universally held by beginning students. These ideas are often well-defined; they are not merely a "lack of understanding," but a very specific idea about what *should* be the case (but in fact is not). Examples of these ideas are that an object in motion *must* be experiencing a force, and that a given battery

always produces the *same* current in *any* circuit. These ideas are often – usually – *very* tenacious and hard to dislodge.

Another important factor is that most students in introductory courses lack "active learning" skills, and need much guidance in scientific reasoning. Physics concepts are usually subtle, counterintuitive, and required extended chains of reasoning. Of course, *some* students learn efficiently. Highly successful physics students (e.g., future physics instructors) are active learners. They continuously probe their own understanding of a concept, for instance by posing their own questions and examining varied contexts. They are sensitive to areas of confusion, and have the confidence to confront those areas directly.

By contrast, the great majority of introductory students are unable to do efficient active learning on their own. They don't know "which questions they need to ask." They require considerable prodding by instructors (aided by appropriate curricular materials), and need frequent hints and confidence boosts.³

To address these problems, innovative pedagogical methods are being developed. To encourage active learning, students are led to engage in deeply thought-provoking activities requiring intense mental effort (so-called "Interactive Engagement"⁵). Students are frequently required to provide written or oral explanations of their reasoning process. Instruction recognizes – and deliberately elicits – students' preexisting "alternative conceptions," which are then made a focus of discussion. As much as possible, the *process* of science – exploration and discovery – is used as a means for *learning* science. Instructors avoid *telling* students that certain things are true, and instead students are guided to "figure it out for themselves," either in the instructional lab, or by step-by-step theoretical analysis.

We have been developing curricular materials along these themes for elementary topics in electricity and magnetism, and modern physics. Our "Workbook for Introductory Physics" (in collaboration with K. Manivannan) guides students to construct in-depth understanding through step-by-step confrontation with conceptual sticking points and counterintuitive ideas. Contexts are varied by heavy use of multiple representations – intermixing equations, word problems, pictures, diagrams, graphs and charts. In collaboration with ISU chemistry professor Tom Greenbowe – a long-time researcher in chemical education – we are developing similar materials for the thermodynamics curriculum. All materials undergo continuous testing and redesign through day-to-day class use and student assessment. Our curriculum development has been most strongly influenced by the pioneering work of Lillian McDermott and Alan Van Heuvelen.⁶

An active learning classroom is characterized by very high levels of interaction between students and instructor, and among the students themselves. There is usually collaborative group work, and students all engage in intensive learning activities far beyond passive listening and note copying. Students may be asked to make predictions of the outcome of experiments, and give written explanations of their reasoning. Instructors pose specific problems that are known to consistently trigger certain types of learning difficulties, and subsequent activities are then structured to confront these difficulties. Instructors avoid "telling" and instead provide leading questions. "Peer instruction" methods are employed in which students explain their reasoning to each other, and then critique each others' arguments.⁷

In the small-class environment, we have implemented active learning techniques in an NSF-supported elementary physics course targeted at elementary education majors.⁸ For (some) large classes, we use the "Flash Card" response system to obtain instantaneous feedback on multiple-choice *Workbook* questions from all students simultaneously.⁹ Students also spend a large fraction of class time working in groups on carefully structured free-response sequences in the *Workbook*. Recitations in selected courses are replaced by University-of-Washington-style "tutorials": students work in groups on *Workbook* materials while T.A.'s provide guidance through Socratic questioning.

We also carry out basic research to support curriculum development. Graduate student Jack Dostal has been investigating student understanding of gravitation, by developing and administering free-response diagnostics and conducting in-depth videotaped student interviews. He is developing and assessing curricular materials to address learning difficulties identified in his research. In other research, we are investigating the comparative effectiveness of different representational modes, i.e., the relationship between the *form of representation* of physics concepts, and efficiency of student learning. We are also exploring factors underlying individual differences in student learning: why do some students start (conceptually) at the same point, yet finish at different points? How can instruction most effectively target these diverse groups of students?

We view PER as a systematic, multi-faceted endeavor to expand the horizons of physics education for the new millennium. By building on past achievements and relentlessly exploring new instructional possibilities, we hope to significantly increase the impact that physics instructors worldwide will be able to have on their students' educational development.

More information about our work can be found on our website <http://www.public.iastate.edu/~per> or by contacting us directly.

1. Lillian C. McDermott, *Millikan Lecture 1990: What we teach and what it learned - Closing the gap*, Am. J. Phys. 59, 301 (1991).
2. Lillian C. McDermott, *Bridging the gap between teaching and learning: The role of research*, in *Proceedings of the International Conference on Undergraduate Physics Education*, edited by E. F. Redish and J. S. Rigden, AIP, Woodbury, NY, Part One, pp. 139-165 (1997).
3. Frederick Reif, *Millikan Lecture 1994: Understanding and teaching important scientific thought processes*, Am. J. Phys. 63, 17 (1995).
4. Arnold Arons, *Teaching Introductory Physics*, New York, Wiley, 1997.
5. Richard R. Hake, *Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses*, Am. J. Phys. 66, 64 (1998).
6. Alan Van Heuvelen, *Overview, Case Study Physics*, Am. J. Phys. 59, 898 (1991).
7. Eric Mazur, *Peer Instruction, A User's Manual*, Upper Saddle River N.J., Prentice Hall (1997).
8. David E. Meltzer, *Effectiveness of instruction on force and motion in an elementary physics course based on guided inquiry*, AAPT Announcer 28(2), 125 (1998).
9. David E. Meltzer and Kandiah Manivannan, *Promoting interactivity in physics lecture classes*, The Physics Teacher 34, 72 (1996).

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Report on the Educational Efforts of the European Physical Society

Gunnar Tibell

From many different countries in Europe one hears about difficulties to make young people interested in the natural sciences. Things do not look the same everywhere, of course, and there are also differences between topics within the sciences. Closer connections to environmental problems might, for instance, give biology and chemistry a greater significance in the minds of young people. In a recent symposium on Physics Studies for Tomorrow's Europe (Gent, Belgium, April 1995) many examples were given of the declining interest for physics - also at the university level - a natural consequence of the fact that things are changing in secondary schools.

In an attempt to analyze the situation more closely some possible causes for this trend were indicated in the Gent meeting:

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

Regarding the lack of balance between boys and girls in physics classes, it was recognized that this might also look different in different countries. Very roughly speaking, Northern Europe seems to be lagging behind the South in this respect, perhaps due to cultural differences. It is estimated that setting examples is an important issue, and in this regard countries like Italy, Spain or France have definite advantages over, for instance, the Scandinavian

countries. There are rather many women working in physics in the former countries whereas in the latter it is quite unusual, for instance, to find a female physics professor in the universities.

Exchange of students and teachers on the European scale will be supported by the new European Community programme, Socrates, to be implemented from 1996. In the second of its three chapters, called Comenius, the attention is focused on pre-university education, whereas Chapter I will continue the presently running Erasmus programme, in a slightly modified form. Also other parts of the Socrates action programme will promote European contacts in the school sector. As examples, mention is made in Chapter III of "European activities conducted by European associations working in the field of schools cooperation" (teachers or parents), "European projects for open and distance learning" and "Visits scheme for education decision-makers".

However important these international exchanges may be, there are certain things which can be done also within each country. In this respect the national physical societies could play an important rôle to encourage contacts between academia and schools. Such measures are already taken in many countries with societies belonging to EPS, but there are others in which improvements could be made. The inquiry made during 1994, under the auspices of the EPS Forum on Education, clearly shows that there is room for a further development along these lines.

In the November/December 1994 issue of Europhysics News the table on page 216 shows the results of the Forum inquiry, in a very condensed form. As seen almost two thirds of the member societies replied. The questions asked were very much geared to-

wards information on the degree of contacts between teachers and university personnel, thought to make up the majority of physical society members. This assumption turned out to be wrong for some countries where the majority consisted of school teachers. In countries where few teachers are society members and therefore few society activities concern school education, there may instead be frequent contacts with existing teachers' associations. Many physical societies, however, do have education or teachers sections as part of their structure with activities of various kinds. Internationally quite a few of the physical societies engage themselves in the Physics Olympiads and help organizing preparatory competitions within their school system, in order to select the best national team. Continuing education for school teachers is another activity of great concern to some of the interviewed societies. In their regular meetings as well as in their publications some of them also include educational matters.

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

In most secondary schools in Europe there is a choice to be made by the pupils which line to follow in the last few years of their school, whether called gymnasium, lycée or something else. In order to recruit more of them to physics one could encourage the pupils to visit research laboratories or physics

related industry or at least have them exposed to some inspiring presentations of modern physics and all its applications in everyday life. For a few years CERN has been very helpful in this respect by inviting young people, or, beginning this year, teachers to spend a few days in the very stimulating environment of an active research laboratory.

The Forum on Education is now setting up a board to discuss the ways to proceed, with activities on the European scale. An immediate task would be to help organizing a session on physics education at the next Trends in Physics conference, in Sevilla, in September 1996. The Forum must also get in contact with other organizations with similar goals, like, for instance, the IUPAP International Commission on Physics Education, the Forum on Education of the American Physical Society and GIREP, the International Research Group on Physics Teaching. It was also proposed at Gent, in the symposium mentioned above, to call on the EPS Forum to help setting up a "European Physics Education Network (EUPEN)". An application for financial support will be sent to the European Community, in the Socrates framework, once the main lines of action of this network have been formulated. It is to be noted that EUPEN is planned to have a much broader field of activities than the EPS Forum on Education. It would assume responsibility also for issues on university teaching as well as student and teacher exchange programs.

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

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NSTA surveys science teachers on accuracy of TIMSS

According to the Bayer Facts of Science Education V, a Bayer/NSTA survey, the nation's pre-college science teachers say that the reforms outlined in the National Science Education standards, which emphasize hands-on, inquiry-based learning, can significantly strengthen science education and student performance if communities band together to support and properly implement them.

According to the survey, science teachers say they look to scientists to help strengthen science education. They say that working directly with scientists in the classroom offers substantial benefits to both them and their students.

Four out of five (78 percent) of the 80 percent involved in science education reform efforts, report experiencing barriers, including lack of adequate time for planning and working with other teachers (81 percent); a shortage of science materials, resources and facilities (58 percent); and, lack of financial support for relevant professional development (45 percent).

When it comes to programs that bring scientists into classrooms to work directly with students, even though only about half of the science teachers (48 percent) report having participated in this type of program, almost all of them (98 percent) say it is critical for students to be exposed to scientists and/or engineers, with nearly one-third (29 percent) calling it "essential" and half (51 percent) "very important." Moreover, among the half (51 percent) who have

not participated in student-scientist programs, three out of four (71 percent) say they would like to. The experience, say teachers, provides students with positive role models and solid information about science as a career.

Teachers, too, derive benefits from working with scientists on science curricula and professional development. Though fewer say they have experience with this type of volunteer program (36 percent), those who have say it bolstered their motivation and enthusiasm for teaching the subject (92 percent); helped them better understand science content (87 percent); and, improved their teaching of science content (87 percent). Of the 62 percent who haven't worked with scientists, almost two-thirds (60 percent) say they would like to.

57% of science teachers believe that the Third International Math and Science Studies (TIMSS), which shows U.S. middle and high school students performing substantially below those of leading countries in math and science, is an accurate reflection of their performance

The Bayer Facts of Science Education V survey was commissioned by Bayer Corporation and the National Science Teachers Association in celebration of National Volunteer Week and National Science & Technology Week. Conducted by Marketing Research Institute, it polled 1,712 NSTA members who report teaching students in grades K-12. The survey had a margin of error of +/-3 percent.

Browsing the Journals

Thomas D. Rossing

India's delegation to the Unesco/ICSU World Conference on Science (Budapest, June 26-July 1) plans to argue for compensation for the loss of trained manpower from developing countries, according to an article in the 20 May issue of *Nature*. The delegation will also seek funding from Unesco for critical areas of science of economic importance, as well as for regional networking of existing facilities. More information about the World Conference on Science can be found on the *Nature* website <www.nature.com>.

Another lecturer comments on Goldman's article on the benefits of the traditional lecture (see "Browsing" in the FED Spring newsletter) in the March issue of *Physics World*. The writer points to the benefits of lectures with demonstration experiments which illustrate material being taught. "I cannot remember a word you said," a former student commented, "but I thought the demonstrations were terrific."

A report entitled "US rethinks school physics" also appears in the March issue of *Physics World*. "The move to change school science education gained momentum last year when American students taking advanced physics finished last in the Third International Mathematics and Science Study (TIMSS)." To improve standards, Nobel laureate Leon Lederman thinks that students should start their science education with physics. Bill Schmidt, the US national coordinator of TIMSS, on the other hand, argues that students should be exposed to physics in each of their school years. "I don't see how, if we're going to address our shortcomings in the TIMSS, we can do anything else."

The International Federation of University Women, an organization of more than 180,000 women graduates, has criticized the draft of a declaration due to be adopted at the World Conference on Science, arguing that it makes too little reference to issues relating to women in science, according to another article in the 20 May issue of *Nature*. However, Unesco officials reply that the Framework for Action document, which will be considered at a dedicated session, gives detailed treatment of the issue.

"Headhunters Stalk the Halls of Physics" is the title of an article in the April 30 issue of *Science*. According to the article, high profile physicists and astronomers have become the object of bidding wars, "leading to a chaotic mobility from which some academics believe only a handful of the most prestigious and best funded institutions can benefit." One department recently lost two outstanding young faculty

members in spite of offering them "everything you could imagine, including sky-high salaries, new infrastructure, and fresh research funds." One factor may be that the value of endowed academic chairs has risen with the stock market. Some observers think the bidding wars could be a sign of a broader stirring in the long-stagnant job market in physics, although AIP employment statistics don't yet show any such trend.

The May issue of *The Physics Teacher* features a detailed review of seven leading high school physics texts (including one by FED past-chair Paul Zitzewitz). These thoughtful reviews are "must" reading for any physicist interested in physics education at the high school level. The reviews include data on content distributions, special features, and the reviewers' opinions on strengths and weaknesses. In addition to reviews of each text, the panel wrote a 10-page discussion of "Quibbles, misunderstandings, and egregious mistakes" found in high school physics texts. The review committee included both high school and university physics teachers.

During science week in March, sixth-form students from all over the UK and Ireland competed in the Institute of Physics' "Paperclip" physics competition according to a note in the May 1999 issue of *Physics World*. Teams of students had to demonstrate a principle of physics to a non-scientist in five minutes, using only household items. The winners from St. Anne's in Southampton explained why your hair stands on end when it is brushed too much. Their props included an "atom" made out of wire, sling film, and a red nose.

Older physics graduates in the UK are to be targeted by a recruitment agency to encourage them to become teachers, according to a note in the May issue of *Physics World*. The new initiative is an attempt to find 600 new maths and science teachers, 300 of whom would take up posts in physics and chemistry. To be targeted are graduates who have not found the career they are looking for and are seeking a "life change." Over the past five years the number of physics graduates training to become teachers has dropped by 68%.

"What Can We Learn from recent Changes in Physics Bachelor Degree Output?" is the title of an article in the March 1999 issue of *The Physics Teacher*. Among the approximately 750 US physics programs, 7 big and gainers and 28 big losers were identified. The article focuses on the seven colleges and universities with substantial increases in physics degrees from 1991 to 1997, one of which nearly had its physics program eliminated in 1990 due to low enrollment. Most of the gainers credited joint (3,2) programs with engineering for much of their gains. Others cited greater opportunities for student research, strong mentoring, and computational physics courses. The number of women getting US doctoral degrees in science and engineering continues to grow despite the first decline in this decade in overall PhD production, according to the latest NSF figures, summarized in the January 15 issue of *Science*. Both the number and percentage of women are going up; in 1997 they received 33% of the degrees, compared to 37% in 1988. Long dominant in fields such as nutrition, women in this decade have pulled ahead in biostatistics, developmental biology, endocrinology, and parasitology. Meanwhile, the number of non-US citizens getting PhDs fell to 9209 in 1997 after peaking at 10,542 in 1994.

A thoughtful editorial on scientific research at undergraduate teaching colleges appears in the May issue of *Journal of College Science Teaching*. Although research is expensive, the author argues that it is an essential component of higher education and should be a part of all institutions of high education, including small undergraduate teaching campuses. He points to the benefits of research to students, faculty, the institution, and to society.

The sixth annual State of American Education address by US Secretary of Education Richard Riley is summarized in the March issue of USDOEd's *Community Update*. He addresses such issues as the increasing shortage of quality math and science teachers, the math and science curriculum in schools, the achievement gap between the well-off and the poor, and the over-crowding of school buildings. "Although Americans tell us, in every poll, that being a teacher is one of the most important and valued jobs in this land, these same Americans often discourage their children from entering the profession because of low salaries."

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

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