

Summer 2006 Newsletter

Ernie Malamud, Editor

IN THIS ISSUE

Articles

Message from the Chair by Peggy McMahan	2
JLab's Outreach Programs submitted by Douglas W. Higinbotham	4
The Laboratory Science Teacher Professional Development Program by Todd Clark and Jennifer Coughlin	4
Online Physics Education Resources from the American Museum of Natural History by Robert V. Steiner	9
Improving Science Teaching in California by Dick Farnsworth and Stanley F. Hitomi	12
Engaging Faculty Scientists in K-12 Education Collaborations by Elizabeth Stage	15
The San Diego Science Alliance: Fostering Community Wide Industrial and Academic Outreach by Patricia Winter, Nancy Taylor, Christopher M. Smith and Rick Olson	18
Education in Nuclear Science by Peggy McMahan and Joseph Cerny	20
Nanosense: Introducing High School Students to Nanoscale Science by Patricia Schank and Alyssa Wise	22
The Bose In Harmony With Education program by Jason Brisbois	25
The General Atomics Fusion Education Outreach Program by Rick Lee	27
<u>Teacher Preparation Section</u>	
A Note from the Teacher Preparation Section Editor by Chance Hoellwarth	30
The Learning Assistant Model for Teacher Education in Science and Technology by Valerie Otero	31
Undergraduate Learning Assistants at the University of Arkansas by Gay Stewart	36
Creating and Sustaining a Teaching and Learning Professional Community at Seattle Pacific University by Lane Seeley and Stamatis Vokos	38
Browsing the Journals by Thomas D. Rossing	42
FEd Executive Committee	44

AAPT Summer Meeting in Syracuse, NY

Please join us at the joint FEd/DNP/AAPT plenary session.

Session AM: Plenary I - Nuclear Physics in the 21st Century, the Legacy of Hans Bethe

Monday, July 24 10:15am-11:45am

AM01 10:15 Hendrik Schatz (MSU) - Frontiers in Nuclear Astrophysics

AM02 10:45 Timothy Hallman (BNL) - Making Quark-Gluon Soup at the Relativistic Heavy Ion Collider

AM03 11:15 Elizabeth Beise (NSF and U. Md) - News and Views of the Proton

There will be a reception sponsored by the FEd following the session.

2007 APS Meetings

The FEd will sponsor invited paper sessions at the March, 2007 meeting in Dallas, TX, and the April, 2007 meeting in Jacksonville, FL. We seek your suggestions for session topics and speakers. Volunteers to organize sessions are encouraged. Please send your suggestions to David Haase (david_haase@ncsu.edu) before August 15.

Message from the Chair

Peggy McMahan

Greetings! I'm Peggy McMahan from Lawrence Berkeley National Lab and I am Chair of the Forum on Education for 2006. I have spent my career as a physicist (nuclear and some accelerator) at Lawrence Berkeley National Laboratory - at 75 arguably the oldest national laboratory - thus it is very appropriate that the theme of this first newsletter of my term is programs in place at national laboratories, in industry and at museums, with an emphasis on reaching out to K-12 teachers and students. Kudos to editors Ernie Malamud, Larry Wolfe and Chance Hoellworth (Teacher Preparation Section) for putting together a great issue.

While one often thinks of STEM (Science-Technology-Engineering-Mathematics) outreach programs as being strictly in the domain of the NSF, the Department of Energy (DOE) Laboratories have a long history of activity in this area as well. Our own laboratory is a good example. This summer Berkeley lab has over 80 undergraduates participating in programs funded by the DOE (the Science Undergraduate Laboratory Initiative, the Community College Initiative, Faculty and Student Teams, and the Preservice Teacher Initiative), 12 teachers participating in the DOE-funded Laboratory Science Teacher Professional Development Program (LSTPDP), and 40 high school students participating in research internships paid for by the research programs directly. On top of a total lab population of about 3800 science, engineering and support staff, these students and teachers make a noticeable impact, particularly in the cafeteria lines and shuttle buses. One example of the breadth of outreach programs undertaken by Education Departments at our various DOE national laboratories is given by Doug Higinbotham in *JLab's Outreach Programs*.

In this issue you will be introduced to a number of outreach programs that have made an impact on a national or regional level. Many of the programs provide professional development opportunities for inservice teachers. For example, in *Laboratory Science Teacher Professional Development Program*, Todd Clark and Jennifer Coughlin of the DOE Office of Science describe a program which gives inservice teachers the opportunity to spend three summers working at one of seven DOE national laboratories, either as part of a research group or in working on curriculum development. With increased

funding projected for 2007, it is hoped to expand this program to 17 national laboratories. In *Online Physics Education Resources from the American Museum of Natural History*, Rob Steiner describes several of their innovative web-based professional development programs for K-12 teachers. In *Improving Science Teaching in California*, Dick Farnsworth and Stan Hitomi describe the partnership between the LLNL Science and Technology Education Program and the University of California at Davis' Edward Teller Education Center to provide professional content development in four scientific disciplines leading - should a teacher choose to follow the program to completion - to mentored research experiences. This program has served several hundred teachers in the first three years of operation.

Other articles describe alliances and partnerships designed to leverage resources and reach more teachers and students. In *Engaging Faculty Scientists in K-12 Collaborations*, Lawrence Hall of Science Director Elizabeth Stage proposes motivation and strategies for engaging faculty in large-scale outreach efforts. In *The San Diego Science Alliance: Fostering Community Wide Industrial and Academic Outreach*, by Patricia Winter, Nancy Taylor, Christopher Smith and Rick Olson, the authors describe a few of the many activities of the SDSA, a non-profit consortium of industry and academic institutions in the San Diego area. In an alliance forged along scientific lines, *Education in Nuclear Science: A Status Report and Recommendations for the Beginning of the 21st Century* describes the recent exercise by the Nuclear Science Advisory Committee to examine the state of nuclear science education at all levels and to make recommendations to NSF and DOE.

Other articles describe resource and curriculum development, often in conjunction with a school visit program. In *Nanosense: Introducing High School Students to Nanoscale Science*, Patricia Schank and Alyssa Wise describe the design and implementation of a nanoscience curriculum for the high school classroom, an NSF-funded project of SRI. In *The Bose In Harmony With Education program*, Jason Brisbois of Bose Corporation describes his company's commitment to developing interdisciplinary education modules in music, science and math, which they use in elementary school visits around the U.S. and other countries in which they have offices. In *The General Atomics Fusion Education Outreach Program*, Rick Lee describes the curriculum material they have developed to introduce plasma physics and fusion energy to the K-12

(Continued on page 3)

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classroom. This material is also used as part of a nationwide effort of members of the Division of Plasma Physics.

The Teacher Preparation section for this issue focuses on Learning Assistants programs that have been introduced at several universities. Learning Assistants are undergraduate physics majors who assist in the classroom teaching undergraduate courses. It gives the students valuable teaching experience and has led to a demonstrated increase in the number of students considering K-12 teaching as a career option.

Our Summer newsletter concludes with the always popular Browsing the Journals section with long-time newsletter editor Thomas Rossing.

Ray Orbach, Director of the DOE Office of Science,

has been quoted: *"Scientific literacy is an essential task to which we must all contribute. Otherwise, our ability to adapt to our rapidly changing technological environment will be at risk. Yet, 42% of scientists do not engage in any form of public outreach. . . . The beauty of science, its import, and its logic have much to contribute to our national heritage. All of us are teachers. We must continue to show the way."*

We hope that the material presented in this newsletter will inspire you and perhaps give you ideas to pursue in your community or at your institution, so that you too can show the way.

Peggy McMahan (p_mcmahan@lbl.gov), Research Coordinator for the 88-Inch Cyclotron at LBNL, is Chair of the FED and a long time member of the DNP Education Committee.



The author with five preservice teachers, two inservice teacher mentors and one undergraduate learning assistant at the LBNL Intensive Research Institute for preservice science and math teachers, August 2004

JLab's Outreach Programs

This article, submitted by Douglas Higinbotham, summarizes the collective work of the Jefferson Lab Office of Education

The Thomas Jefferson National Accelerator Facility (Jefferson Lab) is a basic research laboratory, funded by the U.S. Department of Energy, in Newport News, Virginia, to study and understand the detailed structure and behavior of the nucleus of the atom. Physics experiments started in 1995. As a world-class research facility, Jefferson Lab is a valued partner to the local, regional and national education community. Jefferson Lab's long-term commitment to science education continues to focus on increasing the number and quality of undergraduate and graduate students who complete degrees in science, increasing the number of teachers with a substantial background in math and science, strengthening the motivation and preparation of all students, especially minorities and females, and addressing the serious under representation of minorities and females in science, math, engineering and technology careers.

In addition, Jefferson Lab has been working with public school divisions to enhance the quality of science, math and technology education, and to help effectively address the problem that minorities and females are lost to the science, math and technology career pipeline long before they are of college age. Our unique re-

search environment and use of science, math, and technology skills and knowledge create the baselines for extraordinary educational partnerships that are solidly grounded in the laboratory's scientific programs and expertise, with benefits to both the participants and the laboratory's dedicated staff. Over a third of the laboratory staff and many Jefferson Lab scientific users participate as mentors and career role models, interacting with the students and teachers.

Jefferson Lab's outreach programs include a weeklong laboratory immersion experience for middle school students called *Becoming Enthusiastic About Math and Science* (BEAMS). Jefferson Lab sponsors physics fests where a day each month is set aside for groups of students to attend science presentations in the Lab's auditorium. Monthly seminars are given by the lab's scientists and engineers on topics aimed at sixth through twelfth grade students. Jefferson Lab's high school summer honors program hires students who are strong in math and/or science to expose them to career opportunities in science. Jefferson Lab also participates in the Department of Energy's Science Undergraduate Laboratory Internship (SULI) where some of our nation's best undergraduate students get to experience what life as a doctoral candidate working at a national lab is like. Details about these programs, as well as many other outreach programs that the Lab is involved in, can be found at <http://education.jlab.org/indexpages/program.html>.

US Department of Energy Professional Development for K-12

Teachers: *Todd Clark and Jennifer Coughlin*

The Laboratory Science Teacher Professional Development (LSTPD) Program Provides K-12 Science Teachers Research Opportunities at the DOE National Laboratories.

In his State of the Union Address, President Bush stated, "We need to encourage children to take more math and science, and to make sure those courses are rigorous enough to compete with other nations." [1] The National Academies' *Rising Above the Gathering Storm* states, "Improvements in student achievement are solidly linked to teacher excellence, the hallmarks of which are thorough knowledge of content, solid pedagogical skills, motivational abilities, and career-long opportunities for continuing education." [2] Furthermore, in recent testimony before the House of

Representatives Science Committee, Dr. James Decker, Principal Deputy Director of the Office of Science, US Department of Energy stated, "The two most important ways the Federal government can improve science and math education is first to help ensure that there is a highly qualified teacher in every classroom and second, to help ensure that students have the opportunity in their schools to study science and math every day of the school year and every year throughout their K-12 education." One proposed solution to this method would be by "incorporating K-12 STEM teachers into the scientific community of the National Laboratories, teachers are provided many of the tools they need to improve their professional performance, their leadership abilities in the STEM education communities, and most impor-

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tantly, their students' achievement.” [3] For this reason, Secretary Bodmann has suggested a proposed budget in 2007 to expand the DOE role in science and mathematics education by expanding its Laboratory Science Teacher Professional Development (LSTPD) program.

The DOE has always been supportive of science education, but reestablished their role in teacher professional development in 2004 when the U.S. Secretary of Energy Spencer Abraham announced a new science education initiative to reinvigorate the DOE’s involvement in K–12 science education. [4] Part of this new initiative is the LSTPD program. The LSTPD program has received new attention as part of the President’s American Competitive Initiative, and the expected budget for 2007 will allow the DOE to triple the number of participating teachers and more than double the number of DOE National Laboratories hosting an LSTPD program.

The Office of Science at the DOE designed the LSTPD program with teacher input and using current research and standards for the best practices of teacher professional development. The program’s objectives are to help teachers become ambassadors for the science community to students and their parents, agents for positive change in science education, and the inspiration for the next generation of scientists, engineers, technicians, and mathematicians that support scientific research for the DOE and the United States.

The DOE has incorporated the latest research and standards for teacher professional development into the LSTPD program. The National Science Education Standards [5] list four standards for professional development of teachers of science that serve as the foundation for the LSTPD program design. In addition, research from the American Institutes for Research [6]

and publications from the National Institute for Science Education's Professional Development Project [7] were used in the program design.

Current LSTPD teachers make a three-year commitment to the national program, but are allowed to move between seven DOE labs. The seven labs participating include Argonne National Lab near Chicago; Brookhaven National Lab on Long Island, New York; Lawrence Berkeley National Lab in the San Francisco Bay area; the National Renewable Energy Lab near Denver, Colorado; Oak Ridge National Lab in eastern Tennessee; the Pacific Northwest National Lab in Washington; and the Thomas Jefferson National Accelerator Facility near Norfolk, Virginia (Figure 1). With the anticipated additional funding in 2007, the LSTPD program will grow to run at up to 17 DOE National Laboratories. Teachers may participate in programs at the same lab for all three summers, or they may move between programs during successive summers.

Each participating lab is required to design a program or programs using one or more of the following formats (Figure 1).

- **Teachers as Investigators** is designed for teachers looking for ways to relate research frontiers to the classroom and update their skills and knowledge of research methods, scientific instruments, laboratory technology, and how scientists operate and think. These programs are typically four weeks and may include time at the lab during the school year.
- **Teachers as Research Associates** is designed for teachers seeking an independent research project with a mentor scientist at a DOE National Laboratory. These programs are typically eight weeks.

Teachers receive a stipend, in addition to funding for

(Continued on page 6)

<i>Figure 1</i>	Teachers as Investigators	Teachers as Research Associates
Argonne National Lab	•	
Brookhaven National Lab	•	
Lawrence Berkeley National Lab	•	•
National Renewable Energy Lab		•
Oak Ridge National Lab		•
Pacific Northwest National Lab	•	•
Thomas Jefferson National Accelerator Facility	•	

(Continued from page 5)

travel, housing, professional development, and purchasing lab equipment for their classrooms. The commitment goes far beyond time during the summer, as teachers are expected to collaborate during the school year.

Teachers, scientists, and program managers designed the LSTPD program to:

- Use facilities and the research communities of the DOE National Laboratories. The DOE has been providing mentor intensive science research opportunities for thirty years, and performs the most unique and innovative research on the planet, reaffirming its role to provide access to these resources to science and mathematics teachers.
- Represent a long-term commitment between the DOE and the teachers involved in the program. For teachers to believe they can use DOE resources in their classrooms, they need to feel connected to the DOE scientific community and that will not happen in a short-term program. Participants in the program make a three-year commitment to the program, allowing meaningful relationships to be built and changes in pedagogy to take root.
- Be flexible. Teachers need options of differing summer program commitments—four to eight weeks—depending on, for example, their science backgrounds, family obligations, and what they expect to get from the program. Some DOE labs may be able to provide independent research experiences for high school teachers and other labs may be able to run workshops that focus on a particular research topic for middle school teachers.
- Address content knowledge that teachers will use in their classrooms. 31% of Life Science Teachers and 46% of Physical Science teachers are taught by teachers without a major or a minor in the subject area they teach. [8] There are many studies to suggest that strong preparation in teachers' subject area improves student achievement. [9] By allowing teachers to select labs based upon their self-selected needs for content improvement we can match teachers' content needs to lab expertise.
- Allow teachers to work in a collaborative manner. Teachers should be able to share ideas about how to translate their lab experiences into ways

that will impact student learning. Teacher collaboration has been shown to be effective tool in teacher professional development

- Treat teachers as professionals. Teachers should be paid for work that they do to improve their teaching ability and they should have opportunities to attend conferences and workshops that will help them stay current with the latest research in science and science education. Program structure allows for teachers to write mini-grants that enhance each teacher's unique needs for professional improvement and resources for their classroom.
- Be scalable so that it can reach as many science teachers as possible. Based upon feedback from reviewers of the program we have made regional assignments to help ensure that all fifty states will have representation in our program.

Preliminary data on the potential success of the program are hopeful. The program has a ninety-five percent retention rate and has to date provided over seventy thousand dollars in funds for science and math resources. The program is inspiring our teachers to become leaders as evidenced by increased participation and presentation in conferences and awards such as the prestigious Milliken Award. The teachers themselves provide very positive feedback regarding their participation in the LSTPD program. For example:

- "LSTPD has had a significant effect on my leadership within our group of science teachers in our building and with the science specialist that coordinates instruction for all of Richmond City science. I am looked upon as a source of information and teaching ideas as well as a resource to draw upon lab suggestions and curriculum guidance." LSTPD Teacher, Jefferson Laboratory
- "LSTPD has increased my confidence in speaking to other teachers. I have a better understanding of the content and I also have super hands-on materials to help me." LSTPD Teacher, Jefferson Laboratory
- "I had become ingrained in the history of old science and was no longer embracing new science. This experience renewed my questioning ability and inquisitive attitude." LSTPD Teacher, Oak Ridge National Laboratory.

This program increases science teacher credibility be-

(Continued on page 7)

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cause participants will be science and mathematics teachers who have actively engaged in the process of research in their fields. With increased credibility, these teacher-scientists will be better able to advocate for positive changes within the system that will improve science and mathematics education for all students.

On the web

LSTPD Program:

www.scied.science.doe.gov/scied/LSTPD/about.htm

Office of Science: www.science.doe.gov

US Department of Energy: www.energy.gov

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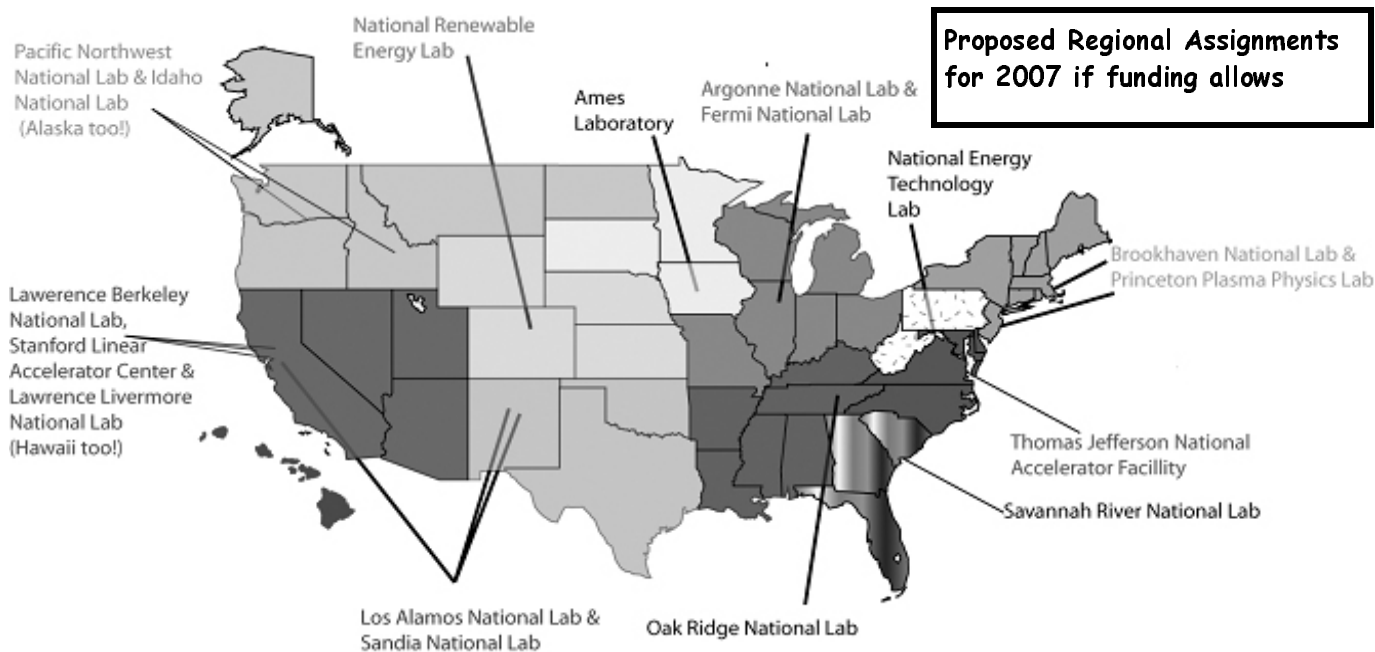
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(Continued on page 8)



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Laboratory Science Teacher Professional Development Program (LSTPD)



June 20 to July 15, 2005

Middle School teachers at Argonne National Laboratory in Argonne, Illinois, who participated in the Teachers as Investigators Model.



Middle school teachers from Thomas Jefferson National Accelerator Facility Teachers as Investigators in Washington, DC for the National Board for Professional Teaching Standards National Conference.



Lawrence Berkeley National Laboratory Teacher as Researcher performing Electrophoresis of DNA from *Mycobacterium tuberculosis* genes.

(Continued on page 9)

(Continued from page 8)



Pacific Northwest National Laboratory Teachers as Researchers in Advanced Materials laboratory.



Thomas Jefferson National Accelerator Facility Teacher as Investigator marvels at magnetic experiment she built for her classroom.

Online Physics Education Resources from the American Museum of Natural History

Robert V. Steiner

The need to strengthen science education in general - and teacher content knowledge in the physical sciences in particular - has received considerable national attention. One important aspect of this challenge is the need to provide teachers with authentic scientific resources and to deepen their understanding of the process of scientific inquiry. In this article, we briefly describe the efforts of one informal science institution to utilize the Web to connect scientists and scientific resources to current and future teachers across the United States in an innovative and engaging manner.

Since 1869, the American Museum of Natural History, located in New York City, has been dedicated to the discovery, interpretation and dissemination of science. Generations of students have walked the hallowed halls of the Museum, taking in dioramas of Asian and Afri-



can mammals, gems and planetary landscapes. However, far more than a mere exhibit hall, the Museum is also a vibrant enterprise of scientific research, including more than 200 scientists in major divisions of zoology, anthropology, paleontology and - of particular interest here - Earth science, astrophysics and cosmology.

The Museum's National Center for Science Literacy, Education and Technology, founded in 1998, utilizes a cadre of educators, professional developers and educational technologists to leverage the Museum's research, collections and exhibitions in order to create powerful web-based resources for teachers, students and the general public. It has also led a major R&D effort in online science professional development. We briefly

(Continued on page 10)

(Continued from page 9)

describe each of these efforts below, focusing in particular on areas of interest to physics educators. (Each of these projects can be accessed by scrolling to the bottom of the Museum's home page at www.amnh.org.)

Science Bulletins: Current Research and Recent Discoveries

Science Bulletins (<http://sciencebulletins.amnh.org>) presents the latest developments in the fields of astrophysics, Earth science, and conservation biology through features that highlight scientists in the field, cutting-edge data visualizations of Earth and the cosmos, and news snapshots of the natural world. Discussion questions and links to other Web resources offer effective uses for the compelling videos, high-quality data visualizations and interactive simulations to kindle students' interest in science, stimulate inquiry, and support in-depth student research projects. A guide for teachers suggests specific ways to incorporate *Science Bulletins* into their science curriculum in ways that correlate with the National Science Education Standards.

Recent *Science Bulletins* stories have highlighted the Sloan Digital Sky Survey; the protective effects of the Earth's magnetic field from the solar wind; the tracking of near-Earth asteroids; gravitational wave detection; colliding galaxies; and extrasolar planet detection. These stories typically utilize high-performance computing and visualization to model effects such as the solar wind's interaction with the Earth or the collision between galaxies. They also incorporate game strategies, for example, in asking participants to find an asteroid amidst a starry background or to confirm the presence of a gravitational wave.

For those teaching Earth science, the many resources include a tsunami simulation, a profile of melting glaciers, current earthquake and volcano activity, the North Atlantic Oscillation and research on the early evolution of the Earth's atmosphere.

Ology

Ology (<http://ology.amnh.org>) (from the Greek, "the study of") introduces the excitement of scientific discovery to children ages 7 and up. Stories, images, interactives and activities in many scientific disciplines are provided. In their own private area, kids can collect online cards (akin to baseball cards) highlighting differ-

ent sciences – and can even design their own.

Among the many *Ology* topics are gravity as "the Universe's main attraction," thought experiments on the speed of light, the life of Albert Einstein, the Hubble Space Telescope, cosmology and the laboratory study of rocks. Student activities include making rock candy, making a compass and dropping fruit into Jell-O to better understand the curvature of space.

Ology and *Science Bulletins* each has its own special guide for educators.

Resources for Learning

Resources for Learning (<http://amnh.org/resources>) is a searchable database of educational resources – typically related to Museum research, exhibits or education projects - for K-12 teachers, which can be sorted by grade, subject matter and other categories. It includes resources from *Science Bulletins* and *Ology*. There are approximately 1,000 resources in the collection, which include websites or downloadable files involving content or activities. Each resource is accompanied by a digital "index card" that summarizes the resource. The physics-related resources include astronomy (including the universe, galaxies, planets, history, etc.) as well as Earth science (including the atmosphere, geologic time, minerals, volcanism, etc.). Many of the resources found in the other websites described here can also be quickly retrieved from the *Resources for Learning* site.

Seminars on Science

Seminars on Science (<http://learn.amnh.org>) provides online graduate courses to K-12 teachers across the United States. There are currently eight courses in the life, earth and physical sciences. Each course is co-taught by an experienced educator and a Museum scientist and lasts six weeks. The courses include original essays by Museum scientists, compelling imagery and video, interactive simulations, links to other websites and rich asynchronous discussion that engage educators in both scientific content and classroom application. The courses provide teachers with a unique opportunity to deepen their content knowledge, to learn authentic science, to interact with working scientists and to gain valuable classroom resources. Through partnerships with eight institutions of higher education, the courses are providing graduate credit and serving the needs of current and future teachers on a national basis.

(Continued on page 11)

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Courses in the physical sciences include “The Ocean System”, “Earth: Inside and Out” and “Space, Time and Motion.” The latter course, for example, provides a broad introduction to special and general relativity, quantum mechanics and theories of everything, using materials developed for the landmark Einstein exhibit launched at the Museum in 2002. Participants grapple with the Michelson-Morley experiment, time dilation, the photon hypothesis, the Equivalence Principle and the social responsibility of scientists. Sample essays, videos and interactives for this and other courses can be viewed at <http://learn.amnh.org>.

Online courses provide accessible professional development that fits into the busy schedules of working teachers. Particularly in combination with face-to-face experiences (including laboratory work), such courses also provide remarkable opportunities for both curricular and pedagogical innovation. Those interested in partnering with the American Museum of Natural History in offering *Seminars on Science* courses through institutions of higher education, school districts or other entities are encouraged to contact the author at rsteiner@amnh.org.

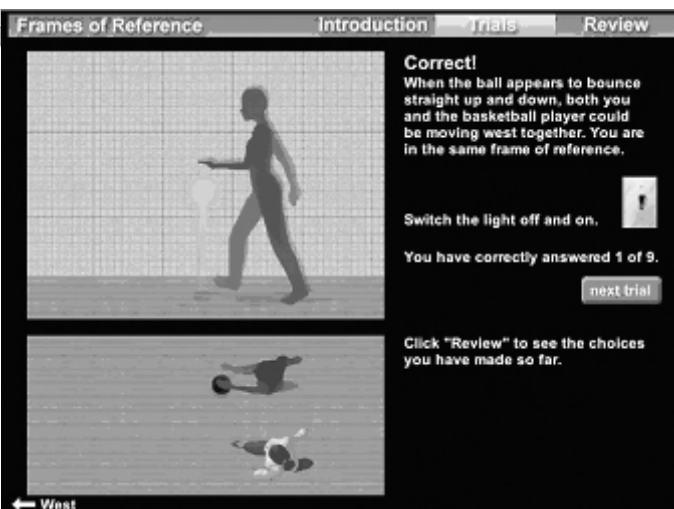
Closing Thoughts

These projects are but a small sampling of the range of exciting Web-based efforts in science education that are taking place in various institutions across the United States and around the world. The Museum’s experience in this realm has taught us the value of forging connections – between formal and informal science institutions, between face-to-face and online efforts and between K-12 and higher education. Our experience has also highlighted the need to place scientific content in a context that is useful for teachers. Both the connections and the context are essential if we are to provide effective support to educators and, ultimately, their students.

Robert V. Steiner is the Project Director of Seminars on Science, the online professional development program of the American Museum of Natural History. He is a member of the adjunct faculty of the Department of Physics at Queens College, City University of New York and also within the Program in Science Education at Columbia University’s Teachers College. His professional interests include experimental elementary particle physics, undergraduate physics labs and online learning. He is currently completing a book on mathematics for physics students, which will be published by McGraw-Hill in 2007.



Coverage of the Sloan Digital Sky Survey, from *Science Bulletins*



Frames of Reference* Interactive from the online course *Space, Time and Motion

Improving Science Teaching in California

Richard Farnsworth and Stanley F. Hitomi

The Lawrence Livermore National Laboratory (LLNL) is a U.S. Department of Energy (DOE) research institution for science and technology applied to national security. The LLNL security mission requires special multidisciplinary research capabilities that are used to pursue programs in advanced defense technologies, energy, environment, biosciences and basic science to meet important national needs. LLNL has a tradition of sharing these multidisciplinary research resources to support science instruction in schools. These science outreach programs are developed and offered to students and teachers by the LLNL Science and Technology Education Program (STEP).

Currently, LLNL is using some of its scientific resources to help solve a problem critical to California: having sufficient numbers of students prepared to meet the state's future technological and economic demands. At the root of this problem is a serious shortage of adequately trained science teachers capable of producing these students. In California in 2003, many of the teachers of physical and life science did not have the subject matter knowledge, training, and skills essential to helping students learn. Thirty-four percent of physical science teachers, and twenty-two percent of life science teachers were under-prepared to teach their subject. Source: California Department of Education, Educational Demographics Unit (2003). Public School Enrollment and Staffing Data Files (CBEDS); SRI analysis.

To more effectively address the issue of too few qualified science teachers in California, LLNL-STEP joined with the University of California Davis, School of Education Edward Teller Education Center (ETEC) to produce a program that enables middle and high school science teachers to develop and maintain mastery in their scientific field. The program follows the successful strategy outlined in a report submitted for publication by Columbia University's *Summer Research Program for Secondary School Science Teachers* that "effective teachers of a discipline must have hands-on experience with the practice of that discipline."

In creating this program, STEP brought access to the rich scientific resources and expertise at LLNL, and ETEC added the expertise in teacher professional development methods and pedagogy. Together they created the Teacher Research Academy (TRA), a professional development program for middle and high school science teachers. The teachers practice using advanced scientific instrumentation with classroom ac-

tivities that link their usage with state science content standards. Each of the content areas offered in TRA is derived from the cutting-edge science conducted at LLNL providing a context for teachers to explain how this science is used to solve real, large-scale problems. A team comprised of master science teachers and LLNL researchers develops the materials used in the TRA program. Together they create standards-based instruction that can be used in the classroom that reflects current science research at LLNL. Currently there are three fields of study in the TRA: Fusion and Astrophysics, Biotechnology and Biophotonics. A fourth content area, Environment and Energy Technologies, is under development for release in 2007. Additional topics will be added over time.

The Fusion and Astrophysics Research Academy:

The Fusion and Astrophysics Research Academy provides experience in promoting and conducting research using spectroscopy with students. Spectroscopy is important in a wide variety of fields such as fusion research, astrophysics, and atomic physics. Instruction in the Academy focuses on the properties of electromagnetic radiation and how it is produced. Participants discover how scientists can learn about inaccessible objects like the Sun and the interior of fusion reactors using a research grade spectrometer.

Biotechnology Research Academy: The Biotechnology Research Academy is designed to give teachers experience in promoting and conducting research in biotechnology with their students. LLNL has participated in the Human Genome Project and supported programs in bioinformatics, microbial diagnostics, microbial detection, and structural and computational biology. In the Biotechnology Research Academy teachers learn about research at LLNL and its connections to the classroom, including hands-on activities in genomics, proteomics, and bioinformatics. Highlights include: PCR, DNA fingerprinting, column chromatography, protein fingerprinting, sequencing, and bioinformatics.

The Biophotonics Research Academy: Biophotonics is the science of generating and harnessing light (photons) to image, detect and manipulate biological materials. It is used in biology to study molecular mechanisms, function and structure, and in medicine to study tissue at the macro and micro level to detect, diagnose and treat disease. Biophotonics is also playing a

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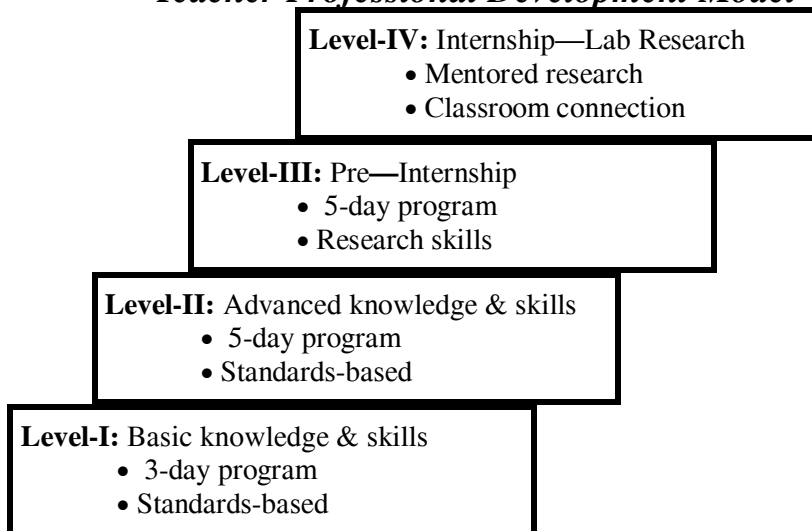
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key role in biodefense and homeland security. Biophotonics integrates the many science disciplines including physics, chemistry, biology, mathematics, and engineering, providing an excellent avenue for introducing students to the truly interdisciplinary nature of much of scientific research.

For each scientific discipline, the TRA model is di-

vided into four levels where Level-I teaches entry-level skills and knowledge. Each subsequent level then builds on the knowledge and skills of the previous level, creating a depth of understanding that leads to mastery. The description and chart below outlines what a teacher can expect to do when they participate in a TRA.

Teacher Professional Development Model



Level-I: This is the entry level for the TRA and provides instruction in basic knowledge and skills associated with a specific scientific discipline. It is comprised of three days of instruction, including hands-on activities, use of scientific equipment, tours of research labs, and lectures by research scientists. In Level-I teachers are provided with content materials and activities that they can use to integrate cutting-edge science in their standards-based instruction at grades 6-14. An equipment loan program is available for graduates of Level-I. No prerequisites are required.

Level-II: This level provides instruction in advanced knowledge and skills. The program is comprised of five days of instruction, including hands-on activities using the science technology of the discipline and science lectures by practicing scientists. Level-I is the prerequisite, however, a waiver is available for teachers who can demonstrate competency in the requisite skills and knowledge. The Level-II curriculum develops advanced skills and knowledge consistent with the requirements to teach advance placement or college preparatory courses.

Level-III: Teachers who have completed Levels I and II participate in a pre-internship experience that prepares them to become a member of a research team. They

develop their knowledge of research methods and practices sufficient to enable them to work in a mentored research assignment. The program is comprised of five days of instruction, including research methods, lectures by scientists on research strategies, and job shadowing in research labs.

Level-IV: This level is a minimum of a 30-day mentored research experience as a member of an interdisciplinary research team. Participants produce deliverables, including a research paper based upon the experience, a lesson to extend the research into the classroom, and a final presentation to the Level-IV cohort on their research experience and how they believe it will contribute to their teaching practice in coming years.

The TRA has two pathways to support a teacher's professional development plans. A teacher can choose to be an Investigator, exploring several disciplines to develop a breadth of knowledge and skills, or they can choose to become a Teacher Researcher, developing a deep understanding within one scientific discipline as a member of a multidiscipline research team. Teachers who want to build a breadth of skills and knowledge and can choose to complete Levels I, or I and II, in sev-

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eral disciplines. By completing Levels I through IV in one discipline, the teacher becomes a researcher where they apply their skills and knowledge to solve a problem. These research experiences stretch teachers intellectually and personally, and enable them to understand the way successful scientists practice science. (A report submitted for publication by Columbia University's *Summer Research Program for Secondary School Science Teachers*)

The ongoing nature of the program, with the same content being offered year-after-year, allows teachers to move as rapidly as they wish through the curriculum. They can spread out their participation over time, matching their development to their changing needs as their career matures.

The Teacher Research Academy is starting the fourth year of operation in 2006. In the initial three years, 267 teachers have participated in the workshops with eight completing mentored research internship. In 2006, an additional 136 teachers have registered to participate in TRA including two who will complete a research internship.

The program evaluation scheme is scheduled to be initiated in 2007. Currently only anecdotal information is available to assess the success of the TRA. These anecdotes from participants express how their participation has changed their teaching practice. Participating teachers report they are learning new skills and upgrading their knowledge of current scientific practices and that they are integrating these new standards-based skills and activities into their instruction. Several of the participants have reported that they are using these new skills as the basis of creating new lessons and new courses not previously offered in their schools. In at least three instances, participants have used this experience as the basis of writing and being awarded grants in excess of \$400,000 to create new programs for their

schools.

The TRA instruction is offered free of charge to science teachers. The majority of the instruction occurs at LLNL, however many of the workshops are offered through collaborative partnerships at regional training centers in several California Central Valley locations. These centers enable teachers unable to travel to Livermore to have local access to this professional development. In addition to Livermore, the TRA program is offered in Davis, Stockton, Merced, Fresno, and Bakersfield. The STEP-ETEC collaboration will provide the TRA curriculum and train master instructors to disseminate TRA at other sites. Institutions interested in establishing a Regional Center can find information about the TRA program at the STEP web site: <http://education.llnl.gov>, and by contacting the Manager of STEP, Richard Farnsworth by email at rfarnsworth@llnl.gov.

Richard Farnsworth, Manager of the Lawrence Livermore National Laboratory Science and Technology Education Program (STEP) has worked in STEP for 16 years. He directed the development and implementation at LLNL of a variety of professional development programs for teachers and enrichment programs for students in biotechnology, biophotonics, fusion, astrophysics, and technology for web development.

Stan Hiromi, Director of the UC Davis School of Education Edward Teller Education Center (ETEC) has taught high school science for 25 years, was a Carnegie Scholar, Co-chair of the task force sponsored by the Center for the Future of Teaching and Learning and Chair of the California Teacher Advisory Council.

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Engaging Faculty Scientists in K-12 Education Collaborations

Elizabeth K. Stage

2001 Nobel Prize winner Carl Wieman has attracted considerable attention in recent months by leaving the University of Colorado, where he has been for more than twenty years, to go to the University of British Columbia to focus on improving undergraduate physics education. In May, he visited Berkeley and his lecture, "Using the tools of science to teach science," brought an overflow crowd to the lecture hall; faculty and students were asking themselves, "How could a person with Wieman's research accomplishments walk away from physics research and devote the rest of his professional career to physics education?"

The main point of the lecture was that education can and should be improved by applying scientific methods—using evidence instead of anecdote, testing ideas with experimental trials, refining ideas systematically—and Wieman reported research from his group as informed by others in the physics education and broader cognitive science community. From my perspective as a science educator who has met more than a handful of scientists who think that their scientific accomplishments allow them to ignore the data in science education, this was a refreshing point of view.

As part of the visit, Wieman visited the Lawrence Hall of Science. The "Hall" is a public science center and organized research unit; our mission is to inspire and foster learning of science and mathematics for all. We incorporate research about teaching and learning in our development of exhibits, programs for the public and teachers, and instructional materials that are used widely across the United States and increasingly internationally. Hall staff work very hard to involve scientists in our work for a variety of reasons; involving faculty helps us to improve the quality of everything that we do, particularly to fulfill our goal of giving visitors a window onto the campus research and to provide a service to the campus. Sometimes we benefit economically from being written into a proposal; sometimes we use our core resources to make the collaboration possible.

Our most obvious examples of UC Berkeley faculty involvement are our exhibits; for example, Ian Carmichael, a geologist, conceived *Forces that Shape the*

Bay, our outdoor exhibit that helps to explain our breathtaking view. Recently, Lisa Pruitt held the final exam for Mechanical Engineering 117, Structural Aspects of Biomaterials, on our exhibit floor by her having students explain the engineering behind hip replacements, heart valves, and dental implants. In our professional development institutes for teachers, it is not uncommon for faculty to give lectures on their areas of expertise; less common, but particularly valued, is mathematician Hung-Hsi Wu, who co-teaches with a teacher leader for a full month's session. Less obviously, but as important in improving quality, scientists like General Atomic's Larry Woolf review drafts of our curriculum materials for their scientific accuracy before they are sent to publication.

Carl Wieman asked the Hall staff how we go about recruiting scientists for this work. Since he is focused on being systematic in the improvement of science education, he was clearly surprised by our answer, "One by each." Scientists are singular in their focus, have very definite and well-honed opinions; while there are some generalizations that we can share, the first is to form partnerships with individuals rather than looking for a formula.

Since we ran out of time to elaborate, this essay could be viewed as a follow-up note to Professor Wieman and an open letter to other physicists who are interested in thinking about ways to involve colleagues in K-12 education work. As luck would have it, the Berkeley Outreach Roundtable met a few days later and that discussion of faculty involvement in outreach enhanced my thinking.

Incentives

For most faculty, the starting point for their involvement in K-12 activities is altruism, doing the right thing, particularly when it comes to equity and diversity goals, or evangelism, sharing their enthusiasm for the discipline and wanting others to share in the excitement. Many scientists like to spread the word to the public about the work that they do and how important it is. NASA was the first federal science-funding agency that realized that the survival of their public support depended on public understanding of the results of their missions; they have set aside a percentage of the budget for every scientific mission for Education and Public Outreach (EPO). The National Science Foundation has also figured out that public support for research will diminish if only one hundred people can appreciate the

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results of the research that they fund; Criterion 2, "Broader Impact," is a placeholder for the idea that more than those 100 people need to appreciate the results of the research. By putting their time and funding into existing mechanisms, such as the Center for Science Education at Berkeley's Space Sciences Institute for EPO, or activities at the Hall or the Graduate School of Education in the case of Broader Impact, researchers can contribute to a larger enterprise, rather than doing some small thing on their own. A different starting point may be the opportunity to share their intellectual assets at the same time as they are strengthening their research base, such as the Museum Informatics Project, where Berkeley's Natural History Museums are collaborating on a database that will enhance their research and other scholars', their teaching and other instructors', and have the intentional byproduct of making their collections available to the general public, with a special emphasis on teachers. The National Digital Library is a larger and more comprehensive example of a shared resource that benefits scholars and teachers.

Closely related to altruism and evangelism is intellectual engagement. One has to take advantage of any initial window of interest to get faculty to see how challenging education is, perhaps even more challenging than their discipline. K-12 work can give them an opportunity to try out their ideas about curriculum, teaching, and learning in a place that is more open, perhaps, than their own department. Berkeley's charter school, Cal Prep, is a place where faculty from a range of disciplines have become involved because it provides a test bed for innovation. Collaborations with the Hall provide another venue on campus that provides access to schools, teachers, and the public.

Work in K-12 provides faculty with an opportunity to fulfill a service requirement, whether imposed by funding agency or encouraged by promotion criteria. It used to be said that you shouldn't ask a faculty member to work in outreach activities until he or she had attained the level of full professor, as such work would be considered negatively in promotion decisions. After years of debate, in July 2005, the UC Academic Personnel Manual added the following paragraph:

The University of California is committed to excellence and equity in every facet of its mission. Teaching, research, professional and public service contributions that promote diversity and

equal opportunity are to be encouraged and given recognition in the evaluation of the candidate's qualifications. These contributions to diversity and equal opportunity can take a variety of forms, including efforts to advance equitable access to education, public service that addresses the needs of California's diverse population, or research in a scholar's area of expertise that highlights inequalities.

Contributions to equity and diversity were added to each of the promotional criteria--research, teaching, and service--including examples of activities that count as evidence. It is too soon to see if this explicit recognition is taken seriously by review committees, but it is certainly a step in the right direction, and should at least reduce the negative weighting assumed to have been applied in the past. (The section is available online at www.ucop.edu/acadadv/acadpers/apm/sec2-pdf.html.)

At some point, however, altruism runs out of steam, grants have been obtained, and promotions have been achieved; there's research to be done! For work in outreach to be sustainable, more compelling and systemic rewards have to be provided. One tangible reward is money for the faculty member, such as stipends, honoraria, or summer months. (You should investigate the rules for additional compensation for faculty within your institution before you make an offer that you cannot fulfill.) And, increasingly one needs to be careful to be accountable for money that is paid directly to faculty, to be able to say what it's paying for.

More important than money, *per se*, is money that gives faculty members support for their research and their graduate students. Course release, for example, can give faculty members time and can sometimes be bought out at a reduced, replacement cost, making that a win-win. Relieving a graduate student from being a teaching assistant for an introductory course for the sixth semester in a row is not only doing the faculty member a favor, it's providing the student with an opportunity to consider teaching and learning at a different age level and motivation. Money that allows the faculty member and his or her graduate students to attend and present at educational conferences will not usually be in the lab's budget, but can be considered a valued opportunity.

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Strategies

- Listen for motivations. Some scientists are interested in fame and fortune, others are interested in “doing good” or becoming more effective educators. It helps to match opportunities to specified goals.
- Be the solution to somebody’s problem. Individuals need to do something for “Broader Impact” or public service; department chairs and deans are looking for opportunities to support institutional goals of equity and diversity or more general public relations.
- Put your cards on the table. Partnerships are two-way; be clear about what you want or need from the scientist and what he or she can expect to gain.
- Use time wisely. Doing your homework about a scientist’s areas of interest, even reading his or her publications, can allow you to make requests in specific areas of expertise. Don’t let scientists spend their time on administrative duties; it’s the surest way to dampen their enthusiasm. Do leverage their time by making an interview into a video, a piece of software, or a children’s book so that they don’t have to come in person to have their story told.



- Make it as easy as possible to get their feet wet, but bring scientists in early in a project, not to review at the end. They don’t want to be stuck grading your paper after you’ve decided what the important concepts are and what activities or investigations best exemplify them
- Ask! (and not just the usual suspects.) Before he went to the National Academy of Sciences to become its president, Bruce Alberts used to say that he never turned down an invitation from a teacher.
- Identify funding opportunities, such as NSF’s GK-12, that allow sustained engagement.
- Document contributions, write thank you letters suitable for promotion cases, and otherwise celebrate success.
- Consider an institutional home. Many research institutes have outreach offices, such as the Berkeley Space Science Laboratory’s Center for Science Education, <http://cse.ssl.berkeley.edu/> Some universities, such as Stanford, have established offices to support faculty involvement in outreach, <http://oso.stanford.edu/>.

Hopefully this article has provoked you to think about getting involved in K-12 education (it’s both challenging and rewarding) or recruiting others to work with you. We are still learning at the Hall and I would welcome your comments or suggestions. You can learn more about the Lawrence Hall of Science at www.lawrencehallofscience.org and you can reach me at stage@berkeley.edu.

Elizabeth K. Stage is the director of the Lawrence Hall of Science.

Families enjoying the *Forces that Shape the Bay* outdoor exhibit at the Lawrence Hall of Science.

The San Diego Science Alliance: Fostering community wide industrial and academic outreach

Patricia Winter, Nancy Taylor, Christopher M. Smith, Rick Olson

The San Diego Science Alliance (SDSA), a 501 (c)(3) non-profit organization, is dedicated to the support of science and math literacy in grades K-12 within San Diego County. The primary goal of the SDSA is to enhance educators' knowledge of local resources for science education. Toward that end, SDSA provides tools and networking opportunities to connect teachers with resources that are available to enrich science education. SDSA also works with local science educators to identify areas of need and to develop new programs for San Diego students and teachers. In addition, SDSA seeks to foster communication among the business community, colleges, and other organizations that support science education. And finally, SDSA strives to create interest in the sciences in the community at large.

The San Diego Science Alliance, just starting its eleventh year, has established a dedicated, hands-on board that continues to deliver science opportunities for K-12 teachers and students. The Resource Catalogue of SDSA is recognized by K-12 educators throughout the county as "the" definitive volume of every local resource for Science Educators. It is available in print and on-line at www.sdsa.org. The SDSA has developed and sustained innovative programs that are well recognized for their value. These include an annual *High Tech Fair* for junior high and high school students and 60 local high tech business and industry exhibitors; the *Better Education for Women in Science and Engineering (BE WiSE)* program for middle school girls; the *Partnerships Involving the Scientific Community in Elementary Schools (PISCES) Project* for grades K-6, and most recently the Robotics Program.

The Board of Directors of the San Diego Science Alliance has representation from various sectors of local science and engineering related businesses, K-12 educational institutions, universities and community colleges and informal science education institutions. Every member of the Board of Directors is an active volunteer on one or several programs serving K-12 science teachers and students. The stories of two companies that participate in these programs are described below.

High Tech Fair Participation by the UCSD Center for Theoretical Biological Physics

The Center for Theoretical Biological Physics (CTBP) at the University of California San Diego is an NSF-funded Physics Frontier Center facility charged with conducting leading-edge research at the interface of biology and physics. Part of our mission is training and encouraging new scientists, especially K-12 students, to pursue studies in science and mathematics. Mimicking CTBP research, we decided to present fundamental chemistry and physics concepts in the context of biological phenomena. We wanted to demonstrate to young learners the connection between physics, chemistry and mathematics and what we observe and use everyday, e.g., vision. Since much of our research work is based upon computer simulations and modeling, we used multi-media and molecular visualization tools in our presentation. We demonstrated how light (a wave of energy) is focused onto the retina of the eye, absorbed by the retinal molecule embedded in the protein rhodopsin, and how the subsequent conformational change of rhodopsin causes a nerve impulse (vision). Once students understood the basic process, they were free to virtually explore the intricate features of the rhodopsin protein with a molecular modeling program. We wanted to reinforce the idea that computers and computer graphics aren't just for gaming: one can actually do some real modeling and discovery using their desktop PC. In addition, we also wanted our learners to gain self-confidence over their knowledge. That is, the self-realization that "I can understand this, I can do this [science]." As scientists, the interactions with the young learners provided an opportunity for us to step back from our centric molecular and the atomic views, and think about the relevance of our basic research to the common man, towards the betterment of society. We were able to experiment and build new pathways to communicate with learners, young and old. We look forward to hosting another CTBP learning activity at next year's SDSA High Tech Fair.

LEGO robotics competition participation by the University of San Diego

A few years ago, I (R.O.) agreed to help officiate at a FIRST LEGO League robotics competition. It seemed

(Continued on page 19)

(Continued from page 18)

like a nice way to spend a Saturday. As an engineering faculty member at the University of San Diego (USD), I'd be able to encourage some 3rd-8th-grade students and maybe some of them would eventually become engineers. At the day's end, I'd return to my usual routine.

That day I herded students from one venue to another as they gave presentations, modified their robots, compared designs with students from other schools and, incidentally, competed with their robots. The excitement was palpable. It didn't matter how their robots actually did in the competition, what mattered was that it was *their* robot and it *did* something. Ten year olds had built autonomous, programmed robots that roll, turn, lift, and drag. These kids were excited, funny, engaging, enthusiastic and appreciative. I was hooked.

That spring I volunteered at the Southern California Botball competition for 7th-12th grade students. The kids were older, the robots were more sophisticated, and the desire to win was stronger, but again the predominant mood among the students was celebration. *They* designed the robot, *they* wrote the programs (in C no less), *they* learned how to use servos and photosensors, *and they* discovered unexpected ways of solving problems. There were 30 teams and 30 different ways of doing things. And they were all great.

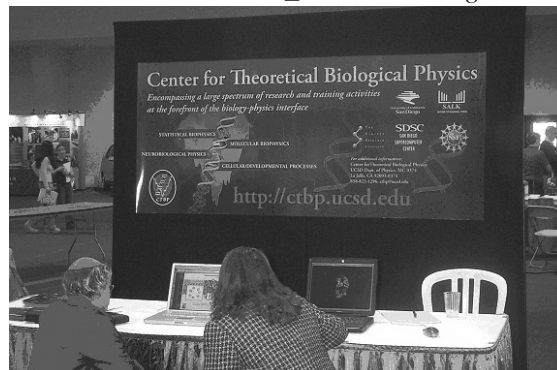
In the afterglow I suggested that the Botball tournament be held at USD. This has entailed a fair amount of work at time, but that pales compared to the psychic payback I get from working with and, truth be told, learning from the kids. When someone shouts as their robot follows a line for the first time I'm reminded of the joy of learning new things. Watching eight students huddle around a broken 'bot reinforces the importance of teamwork and that everyone has something important to contribute. And now, as robot season rolls around, I look forward to seeing the students again -- the new faces and those who are back for more. From them, and for me, robotics has become the usual routine.

Patricia Winter is the founder and former Executive Director of the San Diego Science Alliance. She can be reached at Pat.Winter@gat.com.

Nancy Taylor is the Science Coordinator at the San Diego County Office of Education and an SDSA Board Member. She can be reached at ntaylor@sdcoe.net.

Christopher M. Smith is the Associate Director for Education, Outreach and Training for CTBP, and can be reached at csmith@ctbp.ucsd.edu.

Dr. Rick Olson is an Associate Professor of Industrial and Systems Engineering at the University of San Diego. He can be contacted at r_olson@sandiego.edu.



During Botball workshops volunteer Rick Olson helps students learn to build and program their first robots

The Center for Theoretical Biological Physics exhibit at the San Diego High Tech Fair



The San Diego High Tech Fair



Education in Nuclear Science: A Status Report and Recommendations for the Beginning of the 21st Century

Peggy McMahan and Joseph Cerny

In April 2003, the DOE/NSF Nuclear Science Advisory Committee charged its Subcommittee on Education with broadly assessing “how the present NSF and DOE educational investments relevant to nuclear science are being made” and with identifying “key strategies for preparing future generations of nuclear physicists and chemists.” In particular, the agencies asked the Subcommittee to examine current educational activities, including K-12 education and public outreach, and to “articulate the projected need for trained nuclear scientists, identify strategies for meeting these needs, and recommend possible improvements or changes in NSF and DOE practices.”

The Subcommittee members were Joseph Cerny (Chair, Univ. of California, Berkeley and Lawrence Berkeley National Lab), Cornelius Beausang (Univ. of Richmond), Jolie Cizewski (Rutgers Univ.), Timothy Hallman (Brookhaven National Lab), Calvin Howell (Duke Univ.), Andrea Palounek (Los Alamos National Lab), Warren Rogers (Westmont College), Brad Sherrill (Michigan State Univ.), Robert Welsh (William and Mary College and Thomas Jefferson National Accelerator Facility), Sherry Yennello (Texas A&M Univ.) and Richard Casten (ex-officio, Yale Univ. (NSAC Chair)).

Nuclear Science is a vital and exciting field. The nuclear science research enterprise continues to make great strides in exploring the nature of nuclear and nucleonic structure, probing matter at extreme energy densities, understanding the processes of nucleosynthesis and stellar evolution, elucidating the nature of matter in the universe, and exploring the fundamental symmetries of nature. New facilities have come on line in recent years, and others are planned for the future. At the same time, however, there has been a slow decline in the production of nuclear science PhDs, a scarcity of nuclear science courses available to undergraduates, a lack of ethnic and gender diversity in the field, and broad public misconceptions about all things “nuclear.”

In order to “document the status and effectiveness of the present educational activities” as called for in the charge, the Committee conducted comprehensive web-based surveys of i) the graduate student population, ii)

the postdoctoral population, and iii) those individuals who had received PhD’s in nuclear science between July 1, 1992 and June 30, 1998. They also conducted more informal surveys of undergraduates involved in REU programs in nuclear science and the APS Division of Nuclear Physics sponsored Conference Experience for Undergraduates (CEU) program. Over the course of a year, they met frequently and formulated the following recommendations, taken from the Executive Summary of the full report:

Outreach

We recommend that the highest priority for new investment in education be the creation by the DOE and the NSF of a Center for Nuclear Science Outreach.

PhD Production

We recommend that the nuclear science community work to increase the number of new PhDs in nuclear science by approximately 20% over the next five to ten years.

Diversity and Professional Development

We recommend that there be a concerted commitment by the nuclear science community to enhance the participation in nuclear science of women and people from traditionally under-represented backgrounds and that the agencies help provide the support to facilitate this enhanced participation.

We recommend that there be a concerted commitment by the nuclear science community to establish mentoring and professional development programs and that the agencies support such efforts through the funding of competitive proposals.

Undergraduate Education

We recommend that the NSF and DOE continue supporting research mentorship opportunities in nuclear science for undergraduate students through programs and research grant support.

Additionally, we recommend that they consider expanding support if proposals for undergraduate stu-

(Continued on page 21)

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dent involvement in nuclear science research increase.

We recommend the establishment of a third summer school for nuclear chemistry, modeled largely after the two existing schools.

We recommend that there be a concerted commitment by the nuclear science community to be more proactive in its recruitment of undergraduates into nuclear science, particularly among underrepresented groups.

We also recommend that the NSF and the DOE continue to be supportive of requests for recruitment and outreach support.

We recommend that the Division of Nuclear Physics of the American Physical Society consider the establishment of a community-developed recognition award for individuals providing research opportunities and/or mentoring to undergraduates in nuclear science.

We recommend the establishment of an online nuclear science instructional materials database, for use in encouraging and enhancing the development of undergraduate nuclear science courses.

Graduate and Postdoctoral Training

We recommend that the nuclear science community assume greater responsibility for shortening the median time to the PhD degree.

We strongly endorse the Secretary of Energy Advisory Board's 2003 recommendation that new, prestigious graduate student fellowships be developed by the Office of Science in the areas of physical sci-

ences, including nuclear science, that are critical to the missions of the DOE.

We also strongly endorse the accompanying recommendation that new training grant opportunities in nuclear science be established.

We recommend that prestigious postdoctoral fellowships in nuclear science be established, with funding from the NSF and the DOE.

The Subcommittee also endorsed the broad principles reflected in the NSF's Criterion 2, which seeks to ensure that research activities have an impact beyond their narrowly defined intellectual objectives. Ancillary benefits of proposed research should be considered, including its success in promoting teaching, training and learning; broadening the participation of underrepresented groups; enhancing the infrastructure for research and education; increasing scientific and technological understanding; and broadly benefiting society.

The detailed survey results which led to the above recommendations are documented in the final report and make very interesting reading which is relevant to all subdisciplines of physics. The report can be downloaded at http://www.sc.doe.gov/henp/np/nsac/docs/NSAC_CR_education_report_final.pdf

Joseph Cerny (jcerny@uclink4.berkeley.edu) , a Faculty member in the Chemistry Department at UC Berkeley and a Senior Scientist in the Nuclear Science Division (NSD) at LBNL, was Chair of the NSAC Subcommittee on Education.

Peggy McMahan (p_mcmahan@lbl.gov), Research Coordinator for the 88-Inch Cyclotron at LBNL, is Chair of FED and a long time member of the DNP Education Committee.

NanoSense:

Introducing High School Students to Nanoscale Science *Patricia Schank and Alyssa Wise*

NanoSense (nanosense.org) is one of a few innovative programs addressing the question of how to teach nanoscale science at the high school level. Working closely with scientists and educators, we are creating, classroom testing, and disseminating curriculum units to help high school students understand science concepts that account for nanoscale phenomena and integrate these concepts with core scientific ideas in traditional curricula. As part of our participatory approach, we have also hosted two national workshops to bring together leading experts and practitioners in nanoscience and science education to identify and elaborate core concepts and learning goals for nanoscience education (see <http://nanosense.org/workshops.html>).

Using the design features shown in the Table as our framework, we have developed and tested two units:

- *Size Matters* (5 lessons) focuses on concepts of size and scale, unusual properties of the nanoscale, tools of the nanosciences, and example applications.
- *Clear Sunscreen* (6 lessons) focuses on interactions of light and matter; in particular, why zinc oxide nanoparticles block UV light but are transparent to visible light.

Each unit includes lesson plans, essential questions to drive learning, active learning experiences (labs, visualizations), student and teacher readings, slide presentations for class discussion, worksheets, quizzes, and performance assessments. Units in development focus on how nanoscience could advance energy production (*Clean Energy*) and water treatment (*Fine Filters*).

Table. Key design features and their use in NanoSense units.

Key Design Feature	Example from NanoSense Units
Situate the units in one discipline (chemistry) to facilitate adoption in the existing high school structure.	Lessons build on knowledge of atomic models, ionic and covalent bonding, emission of light by gases, etc. (<i>Clear Sunscreen</i>)
Center the units around exciting applications as a “hook” for students.	Science fiction story illustrates how nanotechnology could affect their lives in the future. (<i>Size Matters</i>)
Guide the units with essential questions.	Why can some sunscreens block harmful UV light but let visible light through? (<i>Clear Sunscreen</i>)
Elaborate core science concepts and view them through a new lens.	“Unique Properties” labs illustrate surface area to volume ratio effects (e.g., catalysis). (<i>Size Matters</i>)
Make explicit ties to biology, physics, material science, and engineering.	Slides and performance assessment explore nanoscience applications in several disciplines. (<i>Size Matters</i>)
Include visualizations of molecular entities and interactions generated and manipulated by students.	Students generate animations of scattering of visible light by nano- and large-size particles of zinc oxide. (<i>Clear Sunscreen</i>)
Highlight important features of the nature of science (inquiry process, use of models, etc.).	The “Black Box” activity considers the limitations and challenges in using probes to “see.” (<i>Size Matters</i>)

Based on our experiences designing and testing NanoSense units, we have identified three main challenges and implications for developing nanoscience curricula.

Challenge 1: Defining the Curriculum. Agreeing on a few central concepts through discussion and debate is an important first step in making sure that curricula meet the needs of the many stakeholders involved. An-

other issue is how to organize the curriculum: should it be topically based around applications, organized by underlying themes, or structured around content topics within traditional scientific disciplines? Our work suggests that organizing units around content topics helps students connect their prior knowledge to the new information. A third issue is finding reliable and verifiable information in a rapidly evolving area. For exam-

(Continued on page 23)

(Continued from page 22)

ple, in the literature we found numerous terminology differences and explanations that contradicted each other on various fronts regarding whether zinc oxide blocks UV radiation by absorbing or scattering the radiation. There are few common frameworks for understanding emerging science—particularly ones that are understandable at a high school level.

Challenge 2: Situating the Science. We are targeting our materials for high school chemistry, but knowledge of physics and biology are quite helpful for both teachers and students in understanding nanoscience and its applications. This raises the question of whether nanoscience is best taught toward the end of the general high school science sequence. Team teaching approaches could also be effective, but coordinating such efforts adds another layer of complication. Another approach is to leverage student knowledge of other disciplines, which could also reduce some of the burden on the teacher. A final issue is how to help teachers determine where the curriculum fits with what they currently teach. We have found it useful to provide teachers with alignment charts of where the curriculum addresses core science topics. Providing teachers with multiple ways to use the materials and a “drill-down” structure

for progressively greater depth of understanding enables adjustment for different levels of students.

Challenge 3: Preparing Teachers. A final challenge is developing teacher support materials for an area in which the content reaches outside teachers’ expertise. Lack of familiarity with the content made it difficult for our teachers to stimulate discussion by asking follow-up questions and to identify and address student misconceptions. Developers must create materials that provide deep explanations, provide strong guidance for discussion topics and questions, and identify and highlight potential misconceptions. The novelty of the content, combined with the newness of the field, raises pedagogical demands that some teachers may not be prepared to deal with. Teachers are not able to know all the answers to students’ (and their own) questions, and many questions go beyond our current understanding as a scientific community. To help teachers engage these challenges, we have recast them as opportunities to model the scientific process and provide concrete strategies for how to do so (see Figure). In this way, we aim to have teachers and students experience science in action as an empowering and energizing experience rather than as an exercise in frustration.

Figure. Excerpt from teacher’s guide addressing pedagogical challenges of teaching nanoscience.

THE CHALLENGE...	PROVIDES THE OPPORTUNITY TO...
<p>1 Traditional chemistry and physics concepts may not be applicable at the nanoscale level</p>	<p>Address the use of models and concepts as scientific tools for describing and predicting chemical behavior:</p> <ul style="list-style-type: none"> • Identify simplifying assumptions of the model and situations for intended use • Discuss the advantages and limitations of using conceptual models in science and of specific models • Integrate new concepts with previous understandings • Note that industry may be able to manipulate properties without necessarily being able to fully explain why

Despite these challenges, it is possible to introduce emerging science at the high school level. Cutting-edge science topics can engage students, reinforce core science concepts, and give students a better idea of how the traditional disciplines tie together. NanoSense units are available at nanosense.org, and we invite you to use them and send us feedback to improve the materials.

Acknowledgement

NanoSense is supported by NSF Grant No. ESI-0426319. Any opinions, findings, and conclusions or

recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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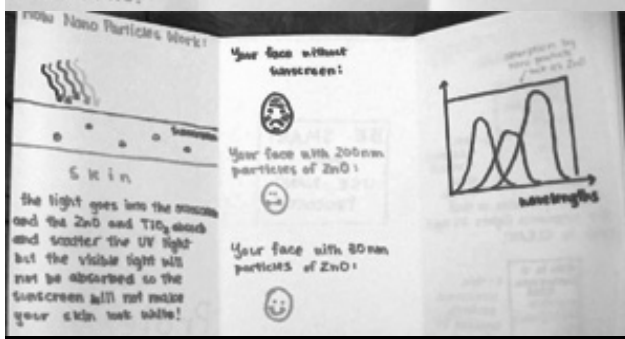
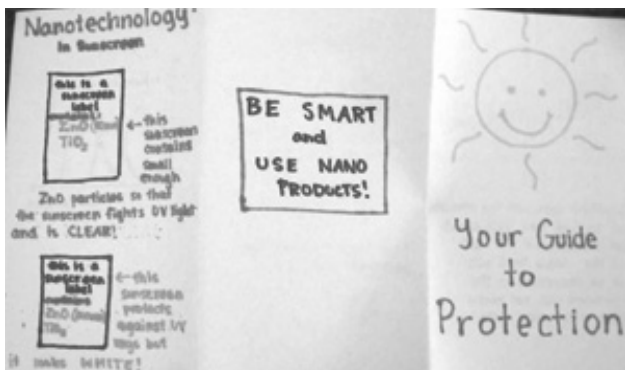
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Students testing the UV blocking ability of a sunscreen.



Using ChemSense to animate the scattering of visible light by different sunscreens.



Students create pamphlets to tell consumers about sunscreens with nanoparticulate ingredients.

The Bose® In Harmony With Education® program

Jason Brisbois

Why do I have to learn this stuff? When am I ever going to use this in the real world? Why should I care about this? If these questions sound familiar to you, chances are you are in the company of youths challenging the lessons provided by many educators, professionals and parents.

There are many approaches to address questions such as these, but perhaps you wouldn't expect them to be addressed by a privately held research corporation. "In order to be better, you must be different" – guiding advice from Bose Corporation's Founder, Chairman and Technical Director, Dr. Amar Bose. This is a fundamental value bred throughout the company since its founding in 1964. Since Dr. Bose is a former educator, it seemed natural that Bose Corporation should develop an education outreach program to provide students with a unique way to learn standards-based academics.

The Bose® In Harmony With Education® program is an education outreach initiative developed by Bose Corporation in conjunction with MENC: The National Association for Music Education. The purpose of this program is to provide the education community with a free and engaging program that educates late elementary to early middle school level students about fundamental concepts in science, music, and mathematics.

We quickly learned from speaking with educators that a field trip experience would be fantastic, but it would also need classroom activities to support its retention. For this reason, there are two components to the In Harmony With Education program: an in-class curriculum and a field trip experience.

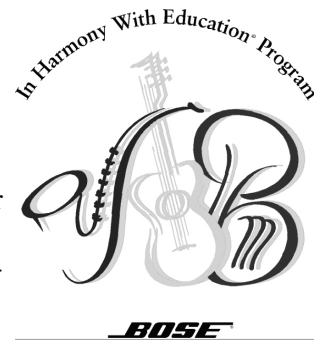
The in-class curriculum is available online at www.bose.com/inharmony, where there are downloadable lessons focusing on interdisciplinary instruction in music, science, and math. These lessons are designed for any teachers to use or modify to fit their unique classroom needs. The second component, the field trip experience, is currently available in the Northeast United States and Southern California. Additionally, the program has been launched in the United Kingdom, Singapore, Australia, Canada and India.

During the field trip experience, students participate in a 90-minute field trip consisting of two 45-minute stations. One station defines sound in terms of vibration, pressure waves and detection, and also consists of a

surround sound show produced by Bose exclusively for this education initiative. The other station focuses on scientific methods for analyzing sounds. Therefore an oscilloscope is introduced, explained and used to present audio/visual connections such as pitch/frequency and loudness/amplitude. After these science points are introduced, students use authentic musical instruments to reaffirm these sound wave characteristics, and gain multi-cultural enlightenment about the instruments themselves. Finally, this session wraps up by having all students play together as an orchestra using simple-to-make instruments (emulating the authentic ones), with each instrument type assigned to its own rhythm. This helps the students obtain musical appreciation, and a more thorough understanding of the concentration a musician must possess while contributing to the entire orchestra.

Developing this type of program takes considerable time input, management and resources, which is representative of Bose Corporation's dedication to education. Differentiating between "edutainment" and true education required collaboration among not only Bose employees, but also with credible organizations such as MENC and research within the education community itself. The result is an educational experience that teachers can harness and use to apply to new teaching methods. Consequently their students can learn in a new way. We're taking traditionally difficult concepts across multiple disciplines and making them fun to learn.

"Music is universal. It touches the human spirit at a very fundamental level. Everyone 'gets' music. But deeply rooted in music are mathematics and the physics of sound, topics that can be difficult for a young student to 'get.' Music is a door that students can easily open to illuminate topics in science and math. That is the aspect of IHWE that is most exciting for me: through enjoyable classroom and field experiences with music, students are exposed to some solid concepts in physics and mathematics." – Dr. William Short, Bose Fellow and key contributor to the Bose In Harmony With Education program.



(Continued on page 26)

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In the nine years the program has existed, an increasing emphasis on education emerged. Today nearly everyone knows what NCLB stands for and at least some of the ramifications it has had on the American education system. Accordingly, teachers are tasked with ensuring their students achieve academic standards. "Teach to the test" is unfortunately an all too common phrase. With this increased emphasis on standardized test scores, enrollment in the In Harmony With Education program has experienced constant growth. Why? Because although it is designed to be engaging and fun, the subject matter directly relates to the National Education Standards, and consequently to state education frameworks. This has proven an essential key to the existence of the field trip component of the program, with educators constantly needing to rationalize funding for busses, admission and other associated fees for field trips. With the Bose In Harmony With Education program, educators can state what frameworks will be addressed, and better understand how the expected outcomes go well beyond enrichment.

Most recently, Bose has expanded the In Harmony With Education program to international regions where Bose has a presence. Currently the program is operational in Singapore, Australia, the United Kingdom, Canada and India. For these regions, we used a similar approach of meeting local needs. While the primary content of the field trip experience stays intact, we conduct research on the regional education syllabi to ensure the program is promoted to the proper age group,

and we explore subtle changes to meet local cultural needs. In some of these countries, we also hire a dedicated program manager to ensure compliance with the governmental education requirements and to ensure a quality experience for everyone involved.

The Bose In Harmony With Education program regularly seeks to collaborate with universities and large primary schools throughout the Northeast U.S. and Southern California. With university collaborations, we look to host the field trips on a campus, provide a training seminar for the university-appointed instructors who will deliver the field trip experience and provide the materials necessary to teach the field trip. When collaborating with a primary school, we prepare classroom teachers to teach the field trip experience by providing a professional development seminar, and by temporarily installing the necessary materials to operate the field trip experience (instruments, theater equipment, etc.). For either operation model, we request that approximately 2,000 students from the region participate over a 4-5 week time period. This typically is accomplished by teaching 3-4 classes per day.

If you are interested in learning more about the Bose In Harmony With Education program, or would like to explore the possibility for a collaboration to implement this program, please call 800-905-1541 or email inharmonywitheducation@bose.com.

Jason Brisbois is the International Operations Manager at the Bose Corporation



A fifth grader plays a Peruvian maraca, while her classmates observe the wave patterns on an oscilloscope.

The General Atomics Fusion Education Outreach Program *Rick Lee*

Plasma, as the fourth state of matter, is making its way into more and more textbooks and it is an effective subject area to combine the concepts underlying matter, atomic structure, ionization, forces, and many other topics covered in middle and high school physical science, chemistry, and physics courses. The Fusion Education Program at General Atomics (<http://fusioned.gat.com>) has used plasma and fusion science to provide a rich and unique set of resources for teachers and students both locally and nationally for over 12 years. The sustained efforts of program team members from many laboratories across the US have helped to strengthen many students' understanding of how physical science plays a crucial role in their lives. Primary support for the GA Fusion Education Program is provided by a grant from the US Department of Energy's Office of Fusion Energy Sciences and General Atomics.

General Atomics has worked closely with academic and industry collaborators to develop and provide exciting opportunities for teachers and students to experi-

ence. As an industry member of the San Diego Science Alliance, an education-based academic and industry partnership, we have interacted with the San Diego County Office of Education and individual teachers to develop relevant workshops and curricular material. We also interact with members from other labs and universities such as PPPL, MIT, U. of Pittsburgh (Contemporary Physics Education Project – Fusion), and the U. of Wisconsin and share literature, demonstration ideas, and workshop strategies. The Division of Plasma Physics, DOE/OFES, and the Oak Ridge Institute for Science Education are examples of facilitating organizations that provide monetary support, promote educational outreach opportunities, or otherwise help smooth the logistics required for either local or national events. The DPP and OFES sponsored Teachers' Day and Student Plasma Expo events during the annual fall DPP meeting are great examples of how more than twenty-five individual groups can get together and promote grade 6-12 science education.



Teachers use soldering, drilling, and other construction techniques to make classroom demonstration items in summer "Build-it Days" workshops. A teacher is shown here performing the final touches to her Poynting vector used to model the relative electric and magnetic field orientation of light.

Hundreds of teachers and thousands of students have participated in one of the General Atomics Fusion Education Program's many facets, with a significant number of teachers returning each year to learn something

new. The fusion education program is dedicated to assisting educators in the teaching of gaseous plasma science and fusion science in their classrooms. In addi-

(Continued on page 28)

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tion, we provide opportunities for students to learn about plasma and its applications with a focus on fusion processes and how these age-old natural processes are being used today and where they might lead us in the future. Locally, the Fusion Education Team offers 3-hour tours of the GA DIII-D Tokamak facility for student groups. Students are presented an overview of magnetic confinement of plasmas in fusion research and global energy issues, and rotate through interactive stations covering radioactivity, plasma, states of matter, the DIII-D machine hall, and the electromagnetic spectrum. More than 300 students tour the facility each year. Unfortunately, not all students who would like to visit DIII-D are able to do so due to conflicts with the facility's operating schedule. To compensate for this, we send personnel out to the classroom to present topics in plasma and fusion science, the electromagnetic spectrum, and states of matter. Students find the interactions with an infrared camera, plasma balls, and other hands-on equipment to be stimulating and fun. The Scientist in the Classroom program started in 1997 when scientists visited a handful of schools and several hundred students. It has since grown to include more than 35 schools and more than 5500 students annually. About 20 different scientists, engineers, and technicians from GA and collaborating institutions participate in this exciting outreach program.

The Fusion Education Team has developed many classroom materials to supplement the teachers' already packed curriculum. The popular "Fusion: Nature's Fundamental Energy Source" VHS tape is a 22 minute introduction to magnetic confinement fusion for grades 7-12. The video is available in English, Spanish, and French and provides a group learning experience. It is also available in DVD format. Another popular learning tool is the highly interactive STARPOWER CD that allows the user to earn points through individual modules so they can enter the control room of the STAR 2020 Tokamak Facility and provide power to Fusion City. The CD format allows for self-paced learning. STARPOWER earned a rating of "Excellent" from *Physics Education* in March 2001. Our publications group has produced colorful and engaging literature and other curricular materials. A teacher's notebook, available online as well as in paper and CD formats, gives users an opportunity to perform laboratory exercises in topics already mentioned. Educational material distribution of over 6,400 notebooks, and more than 20,000 posters on fusion, the electromagnetic spectrum, and radiation has occurred on local and

worldwide levels. We have distributed more than 5,000 fusion videos with about 350 of these each in French or Spanish. Internationally, materials have been sent to India, Nigeria, Brazil, Finland, Sri Lanka, and the United Arab Emirates.

The DIII-D scientific collaboration is made up of over 20 institutions from the US and around the world. This collaboration provides a deep resource of individuals for the education team and it is not unusual to have persons from multiple institutions participating in any given program task. The shared vision of promoting plasma science education across the country relies on the continual interaction of many scientific collaborators and other laboratories, universities, government, and industry partners as stated previously. In addition, many other institutions play a vital role in providing excellent presentations and materials for students, teachers, and the public.

The sustained commitment of the fusion education team to provide informative and unique learning experiences to students and teachers alike for more than a decade has resulted in many outside groups incorporating some program facet directly into their curriculum. For example, teachers from the M. J. Murdock Foundation in the Pacific Northwest, middle school girls in the local Better Educated Women in Science and Engineering (BeWISE) group, and many college and high school groups make the interactive DIII-D Facility tour a 'must-see' destination each year. The Science and Technology Education Partnership (STEP) in Riverside, CA has invited us to present annual science stage shows to more than 2000 students for each of the last 5 years. In a similar fashion, the Kauai in STEP organization has done the same for 2 years. General Atomics regularly participates in local and national science teacher workshops and student science expositions. Fusion education team members have presented more than 60 educator workshops to over 1000 teachers and have participated in more than 20 expos having an estimated total of 40,000 students in attendance.

The success of these types of programs relies on dedication from team members and management alike. The management and staff of the institutions noted above have over and over again shown they can provide a sustained and enthusiastic level of commitment to educational activities. Many of us support programs like these because they are something either dear to us or important to the national interest, or both. We may also

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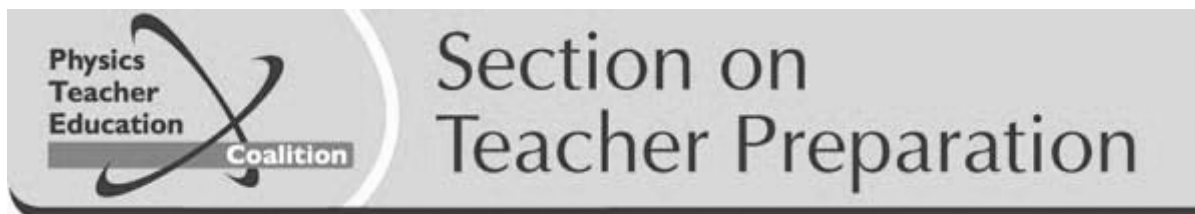
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participate because it's fun and we may have had similar experiences (or wished we had) as students that allowed us to view science in a more positive manner. In any case, educational outreach programs can provide unique learning experiences for students and teachers and offer each an opportunity to broaden their view of the universe. Let us know if you're interested in promoting science by starting up a program of your own. We'd be thrilled to help.

Rick Lee is a DIII-D Tokamak Operations scientist and Fusion Education Manager in the Energy/Fusion Group of General Atomics. He is also the APS/DPP Education and Outreach Chair. He can be reached at: Rick.lee@gat.com



Classroom materials produced by the Fusion Education Team offer a number of interactive tools for teaching about plasma and fusion science



A Note From the Teacher Preparation Section Editor

Chance Hoellwarth

We know that teachers teach the way they were taught. Therefore one of the most effective ways to impact how future teachers actually teach is to change the way we teach our undergraduate courses. If we, the physics faculty, want student-centered teachers who believe that teaching is an interaction, not just the transfer of information, then we need to become more student-centered ourselves. Of course, one way to do this is to incorporate more active-learning group work activities into the classroom. Unfortunately, group work requires more supervision. Groups require feedback and sometimes they need to be nudged at the right time with the right question to keep on track. The problem is that more supervision requires more time and manpower to implement; one person can only interact with so many groups at a time. However, what if I told you that there was a magic pill that could help solve this problem and potentially recruit more K-12 science teachers at the same time? That would be amazing. And amazing as it sounds, the pill exists, only it is not really a pill, it is a learning assistant program.

Learning Assistants, or LAs, are undergraduates who help teach undergraduate courses. They are like a Teaching Assistant, but probably more like a teacher's aide, since they are in the classroom with the instructor. The details of Learning Assistant roles vary by institution, but the main idea is that Learning Assistants help instructors facilitate interactions amongst their students. To a certain degree, this helps solve the manpower problem that comes along with group work. But in addition, institutions have found that Learning Assistant Programs have increased the number of physics majors pursuing teaching careers. At first glance that may seem surprising. However, if you stop and think about it, undergraduates have a very one-sided view of teaching. Giving undergraduates a chance to play the role of teacher in a more active style of learning gives them the opportunity to see how rewarding and challenging teaching can be. This, of course, is the real draw of teaching, so it isn't really surprising that this experience is a recruiter for future teachers.

The upshot of this introduction is that a Learning Assistant Program can be a valuable recruiter for future K-12 teachers. That is what the Section on Teacher Preparation in this newsletter is all about. In this issue you will read about the Learning Assistant programs at the University of Colorado-Boulder, University of Arkansas-Fayetteville, and Seattle Pacific University.

Chance Hoellwarth is an Associate Professor of Physics at California Polytechnic State University-San Luis Obispo (Cal Poly)

The Learning Assistant model for Teacher Education in Science and Technology

Valerie Otero

The Learning Assistant model^[1,2] at the University of Colorado at Boulder uses course transformation as a *mechanism* to achieve three related goals: (1) to recruit and improve the preparation of future mathematics and science teachers, (2) to improve the education of all students enrolled in our mathematics and science courses, and (3) to engage science faculty more thoroughly in the preparation of future teachers.

The Learning Assistant model was initially developed as a part of the STEM Colorado project headed by Richard McCray in response to studies that demonstrate that a majority of our nation's youth are not performing proficiently in mathematics and science,^[3,4] that many of our teachers, especially in the physical sciences, are under prepared--having neither a major nor minor in their field,^[5] and that large research universities are not producing adequate numbers of mathematics and science teachers.^[6]

At large research universities, few mathematics and science majors pursue careers in K-12 teaching. Those who do, typically learn about pedagogy only after they have completed most of their content courses. There is generally little or no interaction between disciplinary faculty and education faculty and between undergraduate programs designed to teach content to students and programs designed to help future teachers learn to teach that content. We regard this disconnect between disciplinary and education programs as a missed opportunity to both improve the effectiveness of undergraduate mathematics and science education and to recruit and prepare mathematics and science K-12 teachers.

The Learning Assistant Model

The Learning Assistant model is based on the premise that teacher preparation begins in the College of Arts and Sciences, where students begin their content preparation. In order to explicitly help undergraduate students integrate their content learning with their understandings of how content is learned and to encourage talented students to become teachers, we needed to establish a close collaboration between faculty members from the School of Education and faculty members from content-based departments. This collaboration was achieved through the LA model which is designed to couple mathematics and science departments' efforts to transform large-enrollment undergraduate courses with efforts to recruit and prepare talented mathematics and science majors to become K-12 teachers.

The transformation of large-enrollment courses involves creating environments in which students can interact with one another, engage in collaborative problem solving, and articulate and defend their ideas. To accomplish this, faculty members teaching in large-enrollment courses need several assistants to help facilitate small group interaction. Learning Assistants (LAs) fill this role. LAs are talented undergraduate students who are hired to facilitate small group interaction in our large-enrollment courses, and at the same time, they make up the pool from which we recruit new K-12 teachers.

Since the program began in 2003, we have recruited 18

(Continued on page 32)

Table 1. Learning Assistant Supported Courses

Applied Mathematics

APPM 1350: Calculus I for Engineers
 APPM 1360: Calculus II for Engineers
 APPM 3310: Matrix Methods
 APPM 3570: Applied Probability
 GEEN 1340: Calculus I (sem. 1 of a 2 semester sequence)
 GEEN 1345: Calculus I (sem. 2 of a 2 semester sequence)

Astrophysical and Planetary Sciences

ASTR 1010: Introductory Astronomy
 ASTR 1120: General Astronomy Stars and Galaxies
 ASTR 2000: Ancient Astronomies

Chemistry

CHEM 1021: Introductory Chemistry
 CHEM 1111: General Chemistry
 CHEM 4411: Physical Chem/Biochemistry Applications 1

Geological Sciences

GEOL1010/1030: Introduction to Geology

Molecular, Cellular, & Developmental Biology

MCDB 1111: Biofundamentals
 MCDB 1041: Fundamentals of Human Genetics
 MCDB 2150: Principles of Genetics
 MCDB 4650: Developmental Biology

Physics

PHYS 1010/1020: Physics of Everyday Life I and II
 PHYS 1110/1120: General Physics with calculus
 PHYS 2130: Modern Physics for Engineers

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LAs to teacher certification programs, most of whom have reported that they did not consider teaching as a career until participating as LAs. The most common reasons reported for making the decision to become a teacher were recognizing the complexities of teaching and encouragement and support from mathematics and science faculty.

The Difference

The differences between the LA model at the University of Colorado at Boulder and other standard models for undergraduate teaching assistants are (a) our focus on teacher recruitment and preparation, (b) a special seminar targeted at helping LAs integrate content, pedagogy, and practice, (c) a collaborative educational research program designed to evaluate the effects of the LA model, and (d) the involvement of mathematics and science research faculty in the recruitment and preparation of future teachers.

Course Transformation and the Role of LAs

LAs are paid a modest stipend to work approximately 10 hours per week in various aspects of course transformation. Approximately 60 LAs are hired each semester to work in six mathematics and science departments: Physics; Astrophysical and Planetary Sciences; Molecular, Cellular and Developmental Biology; Geological Sciences; Chemistry; and Applied Mathematics. Specific courses that have been supported by LAs are listed in Table 1. (previous page)

There is no dictated design of what course transformation should look like. Instead, faculty members who request LAs must (1) use LAs to promote interaction and collaboration among students enrolled in the course, (2) meet in weekly planning sessions with the LAs who support their courses, (3) attend biweekly meetings with other faculty participating in the program, (4) attend a summer session targeted at building a community of university faculty, high school teachers, and future teachers, and (5) actively evaluate transformations and assess learning in their own courses. Because there is little dictation as to exactly what a transformed course should look like, there exist several models of course transformation among our participating departments. For example, one of two models of transformation in the physics department utilizes the University of Washington's *Tutorials in Introductory Physics*^[7] in recitation sections each headed by one graduate TA and one undergraduate LA. The *Tutorials* involve conceptually-based group problem-solving activities which are based on research in physics education. LAs who work in *Tutorial* sessions formatively

assess student understanding, ask guiding questions, and facilitate collaboration within groups. These tutorial sessions are supplemented by weekly lectures which are made interactive through infrared response systems and collaborative peer instruction (Mazur, 1996). Average normalized learning gains in these courses, as measured by conceptual instruments such as the Force and Motion Conceptual Evaluation^[8] range from 40% to over 60%^[9], far above the learning gains measured for traditional courses (23%).^[10]

A different model for course transformation is used in the Applied Mathematics department. In weekly LA-led problem-solving sessions, each small group of students uses a 2' x 3' dry-erase board to collaboratively construct problem solutions. A more radical form of transformation is found in the Astrophysical and Planetary Sciences department where one lecture per week is replaced by *Learning Team* sessions headed by the LAs. In this model, enrolled students are assigned to one of several learning teams each headed by an LA who facilitates collaboration among groups as they analyze real astronomical data and generate and compare models to fit these data.

Although the LA experience is somewhat different for each course, the experience for all LAs involves three related activities: (1) LAs facilitate collaboration among learning teams by formatively assessing student understanding and asking guiding questions; (2) they meet weekly with their faculty instructor to plan for the upcoming week, reflect on the previous week, and analyze assessment data; and (3) LAs from all departments attend a special *Mathematics and Science Education* seminar where they reflect on their own teaching and learning and make connections to relevant education literature.

The Mathematics and Science Education Seminar

The Mathematics and Science Education seminar is jointly conducted by a faculty member from the School of Education and a K12 teacher. In this course, new LAs reflect on their own teaching practice, reflect on the transformations of the course in which they are working, investigate relevant educational literature, and engage in in-depth discussions about their own teaching and learning. Seminar readings and discussions include topics such as discussion techniques, learning theory, cooperative learning, student epistemologies, metacognition and argumentation, self-explanations and tutoring, multiple intelligences and differentiated instruction, the nature of science and mathematics, national standards, teaching with technology, and qualities of an effective teacher. Students in this course try

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out new ideas each week in their learning teams and report their results in seminar. In many cases, LAs provide guidance to one another regarding managing issues that typically arise in their learning teams. Each week, LAs complete online reflections on their teaching and the learning of the students in their learning teams. In addition, throughout the semester LAs turn in two reflective essays that integrate the education literature with their own teaching and learning experiences. LAs often report that by studying and reflecting on student learning, they have become better learners themselves. At the end of each semester, LAs in the seminar present a poster session attended by their lead instructors, School of Education faculty, University of Colorado administrators, graduate students, and their peers. Each LA or small group of LAs present a poster that focuses on aspects of the LA experience that influenced their thinking both as a learner and as a teacher.

Focus on Teacher Recruitment

Although the LA experience (represented in figure 1) is valuable for undergraduates who continue to any career, our program is specifically designed to actively recruit talented undergraduate students to careers in teaching. Therefore, a student can continue to be an LA for a second semester only if he or she shows commitment to finding out more about teaching. This may be evidenced by taking an education course or participating in an early K-12 field experience. LAs can be hired for a third semester only if they have been accepted to a teacher certification program at which time they are eligible for NSF funded Noyce Teaching Fellowships of up to \$10,000 per year. ^[11] As Noyce Teaching Fellows, students can become Lead LAs who mentor novice LAs, participate in the development course educational technology, or work with mathematics, science, and education faculty conducting educational research.

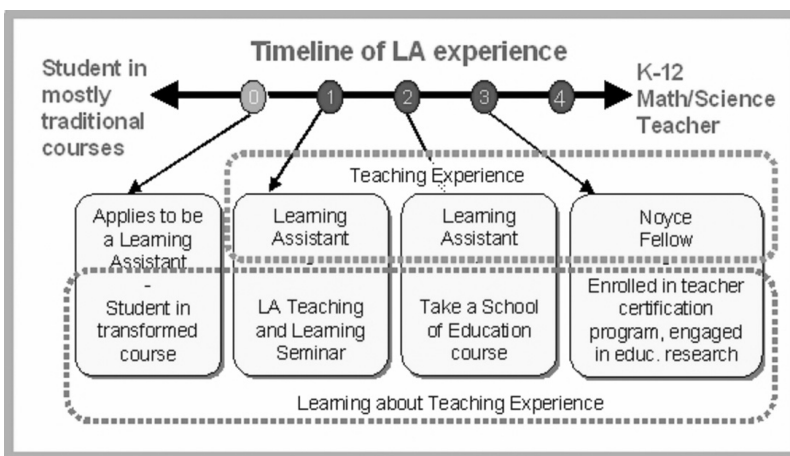


Figure 1. Timeline of the LA Experience

Faculty members who use LAs evaluate their own course transformations by systematically investigating student learning in their courses. In some cases this involves the design or modification of assessment instruments to measure students' levels of conceptual understanding of the content of the course. This type of research and development has been conducted by individual faculty members since the beginning of the STEM Colorado program in 2003. However, a coordinated research program to test the effectiveness of the LA model on multiple levels will officially begin in Fall 2006.

The LA-TEST research project

The NSF-funded Learning Assistant model for Teacher Education in Science and Technology (LA-TEST) research project ^[12] was designed to test the effectiveness

of the LA model specifically in terms of LAs' development of content knowledge, pedagogical knowledge, and their practice in K-12 schools. Faculty members from education, mathematics, and science, K-12 teachers, graduate students, and Noyce Fellows comprise three interacting research teams: the Discipline-Based Educational Research (DBER) team, the Conceptions of Teaching and Learning (CTL) team, and the K-12 team. These interacting research teams investigate teacher recruitment rates as well as the research questions shown in table 2 and synthesize results on an ongoing basis.

Preliminary Results

Recruitment.

Since the program's inception in 2003, 28 faculty

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members from 6 mathematics and science departments have used LAs to transform 23 courses; 125 mathematics and science majors have participated as LAs (18 LAs have enrolled in teacher certification programs); and 4 education faculty have been involved in this process. LAs recruited to teacher certification programs have an average cumulative GPA of 3.4, well above the average GPAs for mathematics and science majors at our university. Table 3 (Data from 18 colleges and universities with 10,869 candidates, 385 science majors) compares enrollments in certification programs in the state of Colorado and enrollments at the University of Colorado

at Boulder (not including LAs) to the numbers of students that have been recruited to certification programs through the LA program. In table 3, 6 of the 7 mathematics majors recruited through the LA program are from Applied Mathematics, a discipline traditionally underrepresented in our certification programs but specifically targeted through the LA program. The departments of Chemistry and Geological Sciences joined the program in mid-2006, so it is not surprising that the LA program has not yet recruited any students from these majors.

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Table 2. Research Questions for the LA-TEST project

DBER: Content Knowledge	CTL: Pedagogical Knowledge	K-12: Teaching Practice
(a) What effects can be observed on student achievement in courses that are supported by LAs? (b) How do LAs compare to other mathematics and science majors in terms of their content understanding, beliefs about the discipline, and beliefs about learning in the discipline?	(a) What is the effect of the LA model on the sophistication of LA pedagogical understanding? (b) Does sophistication of pedagogical understanding vary by length of exposure to the LA model? (c) How is the pedagogical sophistication of LAs different from the sophistication of non-LAs who become teachers?	How do teachers and teacher candidates who participated as LAs compare to those who did not in terms of: (a) Practicum-based coursework (b) Their teaching practices (c) Their own students' (K-12) attitudes and beliefs about mathematics and science (d) Retention and attrition rates

Table 3. Undergraduate students enrolled in teacher certification programs

Major	State of Colorado* (2004-2005)	University of Colorado Boulder Not including LAs (2004-2005)	Recruited from LA Program (2004-2006)
Physics	5	1	5
Astrophysics	0	0	3
MCD Biology	0	1	3
Math	162	14	7
Chemistry	14	0	0
Geosciences	11	0	0

Table 4. Views of students by faculty, teacher candidates, and LAs

View of Students	Specific statements indicating view	Faculty (% of codes)	Candidates (% of codes)	LAs (% of codes)
Learning Process	Students are trying to learn, are constructing understandings, must articulate/defend ideas	39	38	81
Condition of Student	Students want to learn/do not want learn, get it or they don't, have misconceptions	30	61	17
Property of Student	Students are smart/dumb, good/medium/bad, have/do not have ability, lazy/do least they can	30	0	2

(Continued from page 34)

These data are evidence that the LA program has some effect on recruiting mathematics and science majors to teaching careers.

Content Knowledge

LAs' content knowledge is beyond that of their peers and LAs learn content more deeply through the LA experience. For example, results from the Brief Electricity and Magnetism Assessment given to students enrolled in second semester introductory physics show average pre-test score of 27% for enrolled students and an average post-test score of 59%, with an average normalized gain of 0.44. The LAs who had taken the course the prior semester had pre-test score (the beginning of the semester of working as an LA in this course) of 75%, higher than their peers' post-test scores. More interesting is the fact that LAs' average post-test score (at the end of one semester of being an LA) was 90%, with an average normalized gain of 0.56. Thus, LAs developed their content knowledge as a result of teaching as an LA. Similar results are being found in other LA-supported courses and this is the subject of ongoing research.

Pedagogical Knowledge

LAs tend to view their students in terms of their students' *learning processes* rather than in terms of whether a student is good or bad or whether they do or do not understand the material. Our studies show that while faculty and teacher candidates tended to view students in terms of the learning process they also viewed their students in terms of whether the students do or do not understand, and in terms of whether they are good, bad, lazy, smart or dumb. Results are summarized in the table 3 (previous page)

The results shown in table 4 may indicate that LAs have a greater sensitivity to the struggles of learning mathematics and science among their peers. This may be an indication that there is great value in beginning the teacher preparation process early in students' undergraduate careers rather than waiting until they have decided to become teachers of students who are much younger and more inexperienced than themselves.

Summary

The LA model integrates the development of content knowledge, pedagogical knowledge, and practice for all participants by beginning the teacher preparation process early in students' undergraduate careers and by involving mathematics and science faculty in this process. Although we recruit approximately 15% of the

LAs who participate in this program to teacher certification programs, the experience is valuable for students who move on to any career. The participation of mathematics and science research faculty in the active recruitment of teachers has led to departmental cultures that encourage rather than discourage teaching as a legitimate and valuable career option for our most talented mathematics and science students.

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Undergraduate Learning Assistants at the University of Arkansas: Formal classroom experience, preparation for a variety of professional needs

Gay Stewart



Undergraduate Learning Assistants (LA) have been a valuable addition to the physics program at University of Arkansas. Learning assistants have improved our instruction, involved more faculty in teacher preparation issues, and attracted more people into physics teaching. When we embarked upon an NSF supported curriculum development project, it became clear that the first and greatest need for sustaining educational reform was for our future faculty to be prepared to be as professional about their roles as educators as their roles as researchers. Our focus at first was to add these kinds of activities to the graduate program, with the same sort of mentoring that accompanies the development of research skills, without extending the time needed to complete a degree. Our undergraduates going to graduate school said that they would like some of this same support. This led us to pursue undergraduate involvement in the program. The results of bringing these talented and highly motivated undergraduate students into a teaching apprenticeship have been wonderful for the undergraduates and their students! (We added more detailed information on some of the official coursework to the catalog to support the program. This is available at <http://www.uark.edu/depts/physinfo/pf/pf.html>. Choose the "resources" link from this page.)

Our learning assistants get course credit, not pay. It had to be something we could implement without added cost. The most common course taken is PHYS 400V--- Lab and Classroom Practices in Physics. It can be tailored for anywhere from one to three credit hours. One hour would be spent doing the readings and participating in discussion. Sometimes a student will simply observe teaching, planning on doing the actual teaching the following semester. The discussions focus on the pedagogy and the presentation of curricular materials used in class. Laboratory and demonstration techniques illustrating fundamental concepts are acquired through participation in the classroom as an apprentice teacher. Weekly readings are from physics education research

literature. The classroom time gives experience in using classroom methods that are measurably effective in promoting student learning. The course is tailored on an individual basis for the undergraduate students. Typical topics covered include preparation for classroom presentations, testing and grading, addressing student alternative conceptions, effective use of classroom demonstrations and interactive classroom techniques.

For three hours of credit, a student would participate in the same pre-semester activities as the incoming graduate students, four full-day meetings on topics essential to classroom experience, with 10-25 pages of reading per day. For the remainder of the semester, a one-hour meeting each week is used to discuss the week's reading (20-25 pages). Then, they take primary responsibility for teaching their own lab-practicum session. Their performance in class is observed. In the beginning, observations are used to provide feedback. The results of the observations as the semester progresses do factor in to the course grade. This full workshop is only held in the fall at our institution, so it takes careful planning on the part of the advisers to make sure students who may want to take the course in the spring have the opportunity to participate. Graduate teaching assistants coming into our institution in the spring semester are not allowed to teach in one of the reformed courses unless they have already had this or similar extensive preparation. For those students, the preparation workshop takes place the following fall. Our institution has a number of upper-division lab-based courses that require grading and technical support, giving us appropriate alternative assignments.

It is best if the faculty member supervising the PHYS 400V internship is actually teaching the course of which the internship is a part, or working in close collaboration with the instructor of the course. Then, much of the discussion of pedagogical issues associated with

(Continued on page 37)

(Continued from page 36)

the teaching internship is covered in the weekly teaching assistant preparatory meetings for the course. Preparing for and holding the weekly meeting to discuss the readings does add a time commitment to the supervising faculty member. At some institutions instruction for this course, which sometimes has as many as five undergraduates, could count as part of the teaching load. A small “cheat” is to only officially offer the course in the spring semester, whether the students do their internship in the fall or the spring, allowing the enrollment to be large enough to count as a class. At UA this is still impractical, as small (<14) classes for undergraduates are recognized as service, and not counted toward the teaching load. However, this is in part made up for by the fact that the graduate student, who would normally teach the lab being used for course credit by the undergraduate, can spend that time primarily grading or proofreading course materials. The TA is available as needed for the LA, but relieves some of the grading load associated with the course on the instructor. Our experience is that very early on, the TA often feels unnecessary in the course, as the LAs bring so much enthusiasm, and often talent!

Some LAs have asked for the opportunity to take the instructor role in one of our two big weekly discussion sessions that go with the course (officially, they are lectures). We choose a topic several weeks in advance. They bring in their discussion outline, reading quiz questions, end of class summary quiz questions, and examples for review at least a week in advance. The careful preparation that has gone into these in every case is amazing. My own course notes contain several cases of such student work. Then, the instructor sits in on the student’s lesson, to provide assistance if needed, but to allow an opportunity for helpful discussion afterwards to allow the student to become an even better instructor. This is amazingly useful if it can be scheduled for a day following a trip or proposal deadline for the instructor, when he or she would be less than at best anyway.

Sometimes our undergraduates who get truly serious about teaching will take a graduate course: Internship in College or University Teaching, PHYS 574V. The internship is a supervised experience in an organizational setting for students interested in education. We consider the internship as an important part of the preparation of a competent professional in the field. Research clearly shows that learning a subject does not adequately prepare one to teach it. Our learning assistants get excellent teaching evaluations from their students. They also often report a significant improvement in their own understanding of the material they are presenting.

Students who go on to graduate programs at other institutions often communicate with us about their teaching assignments, and how much more effective they feel they can be based on their experiences in such a supportive atmosphere. Students who have done this internship and gone on to graduate school have been successful in their studies. Some students, including a few engineers, decided that the teaching was what most interested them, and this has been a rich pool for recruiting future high school teachers.

While the mentoring associated with such an endeavor is not trivial, it is well worth it to a department and an institution (and, frankly beyond that!) These students go out into whatever career they are going to pursue with a much better appreciation of how to communicate science. It is easy as a faculty member to forget just how far out we are on the tail of the normal distribution academically, and that most students don’t think like we do. Building the awareness of how to successfully facilitate learning is vitally important if we are going to improve teacher preparation, impacting not just the preparation of the future teachers, but the future teachers of teachers!

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Creating and Sustaining a Teaching and Learning Professional Community at Seattle Pacific University

Lane Seeley and Stamatis Vokos

I. Introduction

It is sometimes remarked that the modern university is a collection of independent departments united by a common physical plant. The Physics Department at Seattle Pacific University views this state of affairs as an unfortunate symptom of specialization rather than a desired feature of academic life. An authentic collaboration between a university's Physics Department and School or College of Education, enriched through close ties with partner school districts, can align all major forces that feed (or starve) the professional trajectory of a science teacher. Putting together and sustaining such collaboration is inevitably time-consuming. Yet, the rewards for the Physics Department can be great as can be the positive impact on the continuum of science teacher preparation and enhancement. This article outlines two facets of collaboration at Seattle Pacific University—among faculty (physics and education) and among students (physics majors, minors, non-majors, and preservice teachers). Due to lack of space, this article does not address a third important area of collaboration, namely among teaching professionals (preservice and inservice teachers, school administrators, and university faculty (including resident master teachers)).

II. Collaboration among faculty

In 2002, the most senior member of the Physics Department had been at SPU for four years. In 2003, the Department was awarded a NSF CCLI grant, *Adapting and Implementing Research-Based Curricula in Introductory Physics Courses at Seattle Pacific University*. This grant has supported a complete restructuring of all introductory physics courses at SPU, both calculus- and algebra-based. We have integrated elements from exemplary research-based curricula, including *Tutorials in Introductory Physics* (Physics Education Group, University of Washington), *Activity-based Physics* (Physics Education Research Group, University of Maryland) and *Real Time Physics* (University of Oregon, Tufts University, and Dickinson College).

This adaptation process has resulted in significant gains

in student understanding on several measures. The fractional increase in student learning gains on national assessment instruments such as FCI, FMCE and CSEM is between 50% and 80%. Similarly, analysis of student performance on dozens of written research-based questions given before and after special instruction suggests strong improvement in student learning in several topical areas. Such fine analysis has also suggested topics with which students still struggle after instruction and modifications to the curricular materials that are necessary for a better match with our students' needs.

In addition to gains in conceptual understanding our curricular renovation has dramatically impacted the learning environment in our introductory classes. Students are now expected to take an active role in every aspect of their learning process. A majority of class time is devoted to small group activities in which the students work closely with peers and instructors to construct and test models and wrestle with new ideas. In this context students are forced to practice articulating scientific ideas and listening critically to the ideas of their peers.

Ongoing collaboration among *all* physics faculty has been a crucial ingredient of the program. In an environment in which individual faculty members have the freedom to structure their classes in almost any way they wish, agreement on the goals of each course and the common ways to work toward these goals have by now created positive student expectations about all introductory physics courses at SPU. A telling sign is that by the end of the first quarter of each three-quarter sequence the overwhelming majority of students consider the research-based materials as an indispensable part of their learning experience in physics.

Very early in the planning process for adopting new curricular approaches, Department members invited science education faculty to contribute to the design of a new learning environment in physics. Those initial discussions helped to establish the Physics Department as a credible voice on teaching and learning on campus. Since that time physics and education have developed a

(Continued on page 39)

(Continued from page 38)

substantial collaboration, at a scale that is unequaled in Washington State.

The collaboration between Physics and Education spawned successful grant requests to private foundations. As a result SPU received ongoing funding to partially support a Resident Master Teacher who plays a pivotal role in guiding the Department's ongoing efforts in teacher education and enhancement and who now serves as a Teacher-In-Residence for our participation in PhysTEC. Working on grant-funded projects only deepened the collaboration among the disciplines. In 2005, the Physics Department leveraged this close working relationship with Education to secure a major additional NSF grant. In four years, the Department went from offering zero professional development opportunities for teachers to now offering professional development for teachers in several partner school districts, including several hundred K-8 teachers in south-central Washington.

This Departmental climate of collaboration (both within and outside) did not escape the attention of the central administration. Within a few years, the Department was awarded (a) a new tenure-track faculty position when the science education position in the School of Education was vacated due to retirement and (b) a University-funded postdoctoral position to help new Ph.D.'s become immersed in results of research on the learning and teaching of physics so as to have a future impact on Christian higher education. Physics faculty were also invited twice to present to the University's Board of Trustees results of the Departmental efforts to improve student learning. Such results were also presented at a retreat on assessment of student learning for all SPU faculty and figure prominently in the University's national communications campaign. Collaboration among faculty (physics and education) is the centerpiece of these efforts.

III. Collaboration Among Students

Restructuring our curriculum to increase student engagement brought with it a significant challenge: the need to decrease the student to instructor ratio. The solution of this problem provided an ideal context for recruiting students for future teaching careers.

The single biggest obstacle to small group learning at the college level is the intensive instructor time that is required. Each one of the curricula that we adopted is

designed to be most effective with a student to instructor ratio of no more than 10:1. We have addressed this challenge by leveraging the collective talents of our students. In the first year of implementation of the new instructional approach we made do with a suboptimal number of Teaching Assistants who were prospective teachers enrolled in the MAT program at SPU. We quickly recognized that despite our best intentions, the whole program would sink or swim on the shoulders of our Teaching Assistants. Since SPU does not have yet a graduate program in physics, we have been utilizing undergraduates who (a) have participated in the reformed courses and (b) have shown a special willingness to help others understand the material. Since those early attempts, we have been developing a cadre of *Learning Assistants* (LAs), who are the true core of the physics program at SPU.

Our LAs serve, alongside the course instructor, as facilitators of guided small group learning. LAs receive either credit or monetary compensation for their participation. During a typical week LAs: attend one or two 80-minute preparation sessions; assist in one to three 80-minute tutorial sessions; perform up to two hours of homework grading; and read seminal articles from the physics education literature.

Our perspective toward developing a professional community among the LAs, which is intentionally centered around learning, is grounded on results from research on the nature of effective professional development of teachers (Darling-Hammond, 2000; Garet, 2001; Hawley, 2000; Kennedy, 1998; Loucks-Horsley, 2003; Mundry, 1999). Research suggests that high quality professional development programs pay attention to three things: (a) the deepening of content knowledge for teaching (Ball & McDiarmid, 1990; Kennedy, 1997; McDermott, 1990), (b) intentional development of a learning community (Borko, 2004, 1992; Grossmann, 2001), and (c) emphasis on the study of artifacts of classroom discourse.

Critical Elements of the SPU LA Program – At first glance, the LA program has many similarities to a more common 'teaching assistant' model in which senior students assist the introductory students with their use of laboratory equipment. We believe it is important to recognize that the role of LAs is different in a number of critical ways:

- LAs are explicitly trained in the pedagogical

(Continued on page 40)

(Continued from page 39)

techniques they are expected to utilize. They are taught to recognize and elicit student difficulties and guide students in the development of their own working understanding through a process of progressive questioning. Instructors model teaching through questioning during preparation sessions in which LAs work through the materials as learners. Special emphasis is given to specific prevalent and problematic student ideas during these training sessions.

- The curriculum used in our program is very different from standard laboratory curriculum both in methodology and objectives. Each of these curricula focuses primarily on building conceptual understanding rather than measurement techniques. Where a traditional lab TA provides an available reference for students and a source of technical expertise, an effective LA must fully engage the students and guide their learning trajectory.

SPU LA Program Attributes – Student gains on standardized assessment instruments attest to the impact of our LA program on student learning. We also have accumulated qualitative evidence that the LA program is having a significant positive impact on the LAs themselves. The most obvious measure is the popularity of the program. In 2002, we had one peer instructor. This past fall we had 21 students attend an organizational meeting for the program! This was a substantially greater number of LAs than we needed (or could accommodate easily) but we included all interested students because we came to realize that this opportunity is an important piece of the undergraduate education of *all* students who cross our Department doors and a wonderful recruiting tool, both for the physics major and a career in science teaching.

Despite the fact that serving as an LA is difficult work and can be intimidating, students seek out these roles because they have come to embrace inquiry-based instruction and they want to participate in this style of discourse both as learners and instructors. LAs also clearly view the experience as a way to further deepen their understanding. In fact, we have had a significant number of pre-med students serve as LAs in part because they see it as a good way to prepare for the MCAT. LAs overwhelmingly express what many professors have come to recognize, “I never really get these concepts until I need to help someone else under-

stand them.”

We believe that the LA program allows us to structure our introductory courses in a way that is more accessible to students who have a strong aptitude for teaching but might not immediately gravitate toward a physics major. Small group activities increase the participation level of students who are careful, reflective thinkers rather than quick problem solvers. In addition, group learning rewards talents that are not often recognized in standard lecture courses such as critically listening to peers and carefully articulating scientific ideas. These skills are important in many vocational pursuits and obviously crucial to effective teaching.

It is important to note that nearly half of our LAs are not physics majors. A common characteristic among our LAs is a strong interest and an apparent aptitude for teaching. We expect that the LA experience of non-majors who pursue teaching careers makes them more inclined to include physics as one of the subjects they feel prepared to teach in an effective way.

We also have strong evidence that the LA program has increased the level of interest in teaching among both physics majors and minors. Through their participation LAs come to regard teaching as an intellectually rigorous and rewarding pursuit. They recognize that content knowledge is not sufficient for teaching and have the opportunity to appreciate the roles pedagogical content knowledge and curricular content knowledge play in effective teaching. Many of our physics majors who participate in the LA program go on to undertake undergraduate research projects in curricular evaluation, adaptation and development. Recently our newly rejuvenated SPS chapter received a Marsh White Award to support outreach activities to local high schools.

Remaining Challenges – There are many challenges that must be overcome to successfully implement an LA program. These include funding, faculty participation, and course restructuring to make LAs an integral part of the learning process (not just laboratory supervisors). Strategies for overcoming these challenges may differ significantly with the size, priorities and culture of individual departments. In our case, these challenges were overcome largely thanks to the universal commitment of all members of the Physics Department and the constructive relationship and strong support of university administrators.

(Continued on page 41)

(Continued from page 40)

One challenge that we continue to confront in our LA program is the complexity of scheduling. All LAs should attend the corresponding preparation session before they teach that material in the classroom. For efficiency we hope that every time an LA attends a preparation session, she has the opportunity to teach that material at least once. With two distinct tracks of introductory physics, each with multiple sections and multiple LA-led activities each week, coordination has proven to be a big challenge! Beginning next fall we plan to begin holding preparation sessions where one faculty member will supervise several groups of students each working through distinct topics. With four of these sessions per week we expect this will lend significantly greater flexibility to our training protocol.

We have also encountered a somewhat unexpected challenge of balancing community with professionalism. On the one hand we want to encourage learning environments that are informal, relaxed, and collaborative. On the other hand, we want to call our learning assistants (many of whom are juniors) to a high degree of responsibility and professionalism. These two goals are certainly not contradictory; however, achieving both has proved to be quite challenging.

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Browsing the Journals

Thomas Rossing

- Life experiences before eighth grade and in elementary school may have an important impact on future career plans, according an article in the 26 May issue of *Science*. According to results in a survey conducted by the National Center for Educational Statistics, an average mathematics achiever with a science-related career expectation has a higher probability of earning a baccalaureate degree in the physical sciences or engineering than a high mathematics achiever with a nonscience career expectation (34% vs. 19%). To attract students into the sciences and engineering, we should pay close attention to children's early exposure to science at the middle and even younger grades. Encouragement of interest and exposure to the sciences should not be ignored in favor of an emphasis on standardized test preparation.
- "In the Quest for Coolness, Science Could Really Use a Vito Corleone" is the title of an essay in the May 23 issue of *The New York Times*. "You know, the film that finally does for science and scientists what 'The Godfather' did for crime and what 'The West Wing' did for politics, accurately reproducing the grandeur and grit of science while ushering its practitioners into the ranks of coolness." Scientists often say nice things about science-oriented plays, like "Copenhagen," "QED" and "Proof," to name a few that have been on Broadway in recent years, but you get mostly silence when you ask about movies. At the Tribeca Film Festival each spring several films and screenplays supported by the Alfred P. Sloan Foundation, under its program for the public understanding science, are given staged readings. Recently it was announced that David Strathairn would star in a production of "Challenger" about Richard Feynman and his adventures investigating the explosion of the space shuttle Challenger in 1986.
- Five years after making a trailblazing decision to require physics in ninth grade, the San Diego school board decided to do away with that mandate, according to a story in the May 24 *San Diego Union-Tribune*. The reversal follows years of controversy and months of intense lobbying and criticism by some teachers. For the physical science requirement, students now can choose between physics and chemistry; they must take biology to meet the life science requirement. Critics ridiculed the introductory physics curriculum, Active Physics, for its light math content and cartoon illustrations. The district is moving to replace Active Physics. The San Diego Unified School District boasts the highest percentage of students enrolled in science of any large urban district in the state. This year, for the first time, all 10th graders in California are required to take a life science test, whether or not they have taken biology. Because San Diego students take biology last, usually in 11th grade, they are at a disadvantage.
- "Testing the test: Item response curves and test quality" is the title of a multi-author Physics Education Research paper in the May issue of *American Journal of Physics*. The paper presents a simple technique for evaluating multiple-choice questions and their answers beyond the usual measures of difficulty and the effectiveness of distracters. The technique, based on item response theory from the field of education measurement, is applied to three questions from the Force Concept Inventory.
- The necessity of obtaining a graduate degree in the United States in order to acquire a U.S. work visa may be the most important reason for the recent increase in graduate school applications from foreign students, according to a Letter in the 12 May issue of *Science*. This appears to have been overlooked in the survey by the Council of Graduate Schools who reported a "flood" of applications to U.S. graduate schools by foreign students (*Science*, March 31. Also reported in "Browsing the Journals" in the Spring FED newsletter). The author comments that it is perhaps ironic that raising the bar on granting work visas has had the side effect of increasing the number of foreign graduate student applicants.
- Half of new U.S. teachers are likely to quit within the first five years because of poor working conditions and low salaries, according to an article in the May 9 issue of *Washington Post*. Although teachers are more educated than ever before, with the proportion of those holding master's degrees increasing to 50 percent from 23 percent in the early 1960s, the proportion of new teachers who leave the profession has hovered around 50 percent for decades. Only 6 percent of teachers are African American, and 5 percent are Hispanic, Asian or come from other ethnic groups. Men represent

(Continued from page 42)

- barely a quarter of teachers, which NEA says is the lowest level in four decades.
- A thoughtful editorial on “Pseudoscience” appears in the April issue of *The Physics Teacher*. The author reminds us that many students believe in pseudoscience; 40% of high school graduates believe in astrology, for example. At least as large a fraction believe in, or “aren’t sure about,” paranormal phenomena such as telepathy and extraterrestrial visitations, and the overall situation doesn’t necessarily improve as students progress through college. We often pride ourselves on teaching the scientific method and fostering critical thinking, but are we really succeeding? What *has* gotten our attention are the recent efforts to *require* the teaching of pseudoscience, such as intelligent design, in science classes. “Over the years we have learned a great deal about ways of teaching that promote the dispelling of all sorts of student misconceptions. We should now begin to direct more of our effort and expertise toward pseudoscience,” concludes the author.
 - A review of the book *Moderating the Debate* by Michael Feuer appears in the April 21 issue of *Science*. The debate is over how best to bolster mathematics and science education, as called for in President Bush’s State of the Union message. Although cognitive psychology has been central to modern theories of teaching and learning, the cognitive revolution has barely touched education policy and the organization of schooling “where decades of well-intentioned but unrealistic goals suggest the need for a new model of rationality.” He proposes that that researchers and policy-makers alike “lower their rhetorical and political thermostats.”
 - Science achievement scores recently released in the National Assessment of Education Progress show improvement among fourth-grade students in science, but scores for eighth-grade students remain flat, according to a report in the May 30 issue of *NSTA Express* online. The test was administered in early 2005 by the Department of Education to more than 300,000 students across the nation and on military bases around the world.
 - The April issue of *American Journal of Physics* is a special issue devoted to teaching of electricity and magnetism. Included are articles on theory, experiment, problems, history, philosophy, and physics education research related to E&M. The lead editorial reminds us that “As the first complete and mathematically rigorous field theory that prospective physicists learn, electromagnetism serves as the quintessential model of a physical theory.”
 - Last year, according to the 11 July issue of *The Institute*, more than 1500 people joined the IEEE Women in Engineering (WIE) group, the largest annual growth in its history, bringing the total number of WIE members to about 12 000. Last year also saw the formation of 43 WIE Affinity Groups and Student Affinity Groups, the most ever established in one year, for total of 103. Student IEEE membership increased by more than 8% last year, while membership in regular grades increased only 0.5%.
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