SYMPOSIUM PP

Forum on Materials Science Education

November 29 - 30, 2005

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SESSION PP1
Chairs: Richard Corkish and M. Grant Norton
Tuesday Morning, November 29, 2005
Berkeley (Sheraton)

8:00 AM *PP1.1
Preparing the Materials Researchers of the Future: Who, What, How. Rosemary R. Haggett, Division of Undergraduate Education, National Science Foundation, Arlington, Virginia.

Developing the next generation of materials scientists and engineers in the face of changing demographics and students' interests and values requires new approaches and strategies. New models to increase the number of students that are attracted to and retained in science and engineering disciplines are needed. Further, a broader pool of talented individuals must be attracted to sciences and engineering fields. Broadening participation in science and engineering ensures that all citizens have the opportunity to contribute to and benefit from advances in these fields. In order to create new knowledge and the next innovations, the scientists and engineers of the future will be required to be interdisciplinary in their approach, comfortable in functioning in a global society, and able to lead in their fields. Innovative education that engages students and provides them with the skills and knowledge base needed in this new environment is an imperative. Examples of successful approaches and the role of NSF in the preparation of the Materials Researchers of the future will be discussed.

8:30 AM *PP1.2
What Every Materials Scientist Should Know.
Elizabeth A. Holm, Materials and Process Modeling, Sandia National Laboratory, Albuquerque, New Mexico.

The undergraduate curriculum in materials science must prepare students not only for their jobs but also for their profession. Every profession maintains a fund of common knowledge. The cardiologist can converse about the SARS outbreak; the corporate lawyer on the Michael Jackson case. Likewise, the professional materials scientist should understand the materials issues that confront the public, from the collapse of the World Trade Center to a flat tire. With the movement of undergraduate materials science away from the materials in common usage toward materials that are more hidden (for example in electronic devices), imparting this common professional knowledge becomes more difficult, requiring a conscious effort by faculty. In this talk, I shall present examples of materials common knowledge, tailored to engage the interest of undergraduate students in a seminar, a lecture, or even a dedicated course. There will be a quiz.

9:00 AM *PP1.3
Utilization of Interactive Science Exhibits as a forum for Materials Science Education. Lisa Anne Pruitt, Mech Eng, UC Berkeley, Berkeley, California.

Undergraduate materials science education provides a great forum for providing science education at the K-8 levels. Over the last several years we have utilized the use of interactive teaching demonstrations with undergraduate and graduate classes in the areas of engineering materials, polymers, and biomaterials. These exhibits were developed by students and resulted in Lawrence Hall of Science exhibits entitled, The Way Things Break, The Human Body Shop, The Body Builders, Fantastic Plastic, and The Bionic Bear. These projects replaced a final examination component of the course. Students worked in teams of four to build projects aimed at teaching science and engineering concepts to children with a target age of 8-10 years. Students were provided with lectures on education, outreach, teaching plans and exhibit design. The evaluation of the success of these exhibits as a platform for outreach and science education will be discussed.

10:00 AM *PP1.4
Implementing an Undergraduate Interdisciplinary Concentration in Nanomaterials Science and Engineering.
Lisa C. Klein, MS&E, Rutgers University, Piscataway, New Jersey.

In 2002, the Ceramic and Materials Engineering Department at Rutgers University began offering courses in Nanomaterials Science and Engineering. The courses are designed to be one introductory course and 3 advanced courses emphasizing (a) photonic and electronic applications, (b) structural and chemical applications, and (c) biomaterials applications. Each of the advanced courses has a laboratory component. The introductory course is the prerequisite for the advanced courses, along with completion of 60 credits, or approximately second-semester sophomore standing. These courses satisfy the definition of a technical elective in all of the engineering departments and chemistry and physics. The initiation of these courses was facilitated by a grant from the New Jersey Commission on Higher Education, and all aspects of the grant have been described on the MRS Curriculum Crossroads Webpage [1]. This talk will focus on the first course in the series. With 4 years of experience teaching the introductory course, we have identified certain practices that improve the content of the course and increase the understanding of concepts fundamental to nanomaterials in all of the applications. In order for all of the students to be thinking along the lines of structure-property-processing relationships, we start off with concepts such as point defects, dislocations, surfaces, and diffusion. While these concepts are practically second nature to materials majors, they are not embedded in the coursework in the other majors. We have to define these concepts explicitly, so we have developed a series of glossaries to make sure that we share the same definitions. Another challenge has been to come up with homeworks and tests where students can plug in numbers to get a feel for the consequences of nanostructure on properties. We have collected problems that are quantitative relating to surface-to-volume ratios, aspect ratios, particle packing, critical nucleation size, Brownian motion, strength, etc. At this time, so much of what is found in undergraduate level texts on nanomaterials is purely descriptive. With experience, we are making progress in putting together what we need to offer a rigorous introduction to how nanomaterials are synthesized, processed and characterized. Each year we revise and refine the information to reflect the latest advances and maintain high student interest. At the same time, we try to balance this with a solid foundation in the underlying concepts. [1] L. C. Klein, S. C. Danforth, and B. R. Mayer, "Nanomaterials Science and Engineering: An Enabling Paradigm Shift for Photonics, Energy, Electronics, and Biology" presented Education Conference, TMS (The Minerals, Metals & Materials Society), 2004, electronic version at http://www.mrs.org/connections/curriculum/.

10:30 AM PP1.5
A New Undergraduate Curriculum In Nanoscale Materials Science And Engineering. Peter K. Davies, Materials Science & Engineering, University of Pennsylvania, Philadelphia, Pennsylvania.

The undergraduate program in Materials Science and Engineering at the University of Pennsylvania has been completely revised to reflect the explosive of interest in the nano and bio sectors of engineering science and technology. The new program, focused on "Nanoscale Materials Science and Engineering", builds upon an introductory knowledge of physics, mathematics and chemistry and starts with an "Introduction to Nanotechnology", followed by the courses "Introduction to Nanoscale Functional Materials" and "Structural and Biomaterials". Each course incorporates the fundamentals of modern materials science with illustrations focusing on applications in nano and bio technology. The parallel courses "Nanoscale Materials Laboratory" and the "Energetics of Macro/Nanoscale Materials" round out the sophomore year. At the next level students focus on the structure, bonding, and phase transformations of materials systems at the atomistic, nano and macro-level; stand alone courses are offered on the unique properties of "Soft Materials", and on the selection of materials for specific technological applications. Armed with a basic understanding of materials of all types, students are able to select upper level courses that concentrate on specific areas of interest such as polymers, biomaterials, nanostructured systems, mechanical properties, and electronic materials and a course on the modeling of nanoscale phenomena. The new program has attracted tremendous interest from engineering freshmen and sophomores, and since it was launched the undergraduate enrollment in MSE department has risen to all-time highs.

10:45 AM PP1.6
Trans-disciplinary Graduate and Recurrent Programs for Education, Research and Training in the Fields of Nanoscience and Nanotechnology. Tadashi Itoh[2,1], Hisazumi Akai[3,1], Hisahito Ogawa[1], Wison Agerico Tan Dino[1] and Satoshi Ichikawa[1]; [1]Organization for the Promotion of Research on Nanoscience and Nanotechnology, Osaka University, Toyonaka, Osaka, Japan; [2]Department of Materials Engineering Science, Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka, Japan; [3]Department of Physics, Graduate School of Science, Osaka University, Toyonaka, Osaka, Japan.

Nowadays, 'nanoscience and nanotechnology' are one of the most important basic and applicable tools for creating multi-disciplinary research and development among various kinds of science and technology. Here, we would like to introduce the outlines of our trans-disciplinary graduate and recurrent education programs for nanoscience and nanotechnology that have been started in Osaka University from 2004. The programs are prepared as one-year minor courses (subsidiary programs) for graduate school students in order to make full use of knowledge in their major courses. There are five courses, 1: Computational Materials and Device Design, 2: Nanoelectronics and Nanoprocesses, 3: Supramolecules and Nanobio Processes, 4: Nanostructure Measurements and Analysis and 5: Nanophotonics. All the courses consist of series of lectures and practical experiments guided by the lecturers and researchers belonging to six different graduate schools and three research institutions closely relating to nanoscience and nanotechnology and the students can take at least five subjects from one of the courses at their own choice suitable for their carrier. There is another project-aimed-learning PhD program which is a joint training program in cooperation with industries including a short-term research internship in industries. This is the first unique attempt in Japanese universities. Recurrent graduate-level education programs in evening classes are also started for young scientists and engineers working at nanotech-related industries. The live lectures together with detailed documents are transmitted through the internet to distant classrooms in Tokyo, Kyoto, etc. The graduate and recurrent education program for nanoscience and nanotechnology should be flexible enough in the curriculum so as to catch up such rapidly changing fields. Therefore, we emphasize the importance of flexibility and trans-disciplinary character of graduate education programs. This innovative program for five years has been selected as one of the 'Fostering Talent in Emergent Research Fields' Programs in Special Coordination Funds for Promoting Science and Technology supported by the Japanese Ministry of Education, Culture, Sports, Science and Technology.

11:00 AM PP1.7
Undergraduate Nanotechnology in Australia: 5 years on.
Mike Ford[1] and Joe Shapter[2]; [1]Institute for Nanoscale Technology, University of Technology, Sydney, Broadway, New South Wales, Australia; [2]School of Chemistry, Physics and Earth Science, Flinders University, Adelaide, South Australia, Australia.

Undergraduate degrees in Nanotechnology have been in existence since 2000, the original degree being developed at Flinders University of South Australia. Five years further on, there are now 12 Australian universities offering an identifiable nanotechnology undergraduate course, together with a number of universities offering majors within a general science program. The motivation for the development of these degrees is simple: to attract students into the physical sciences. Their broader purpose is to provide skills that will allow students to participate in the technological changes that nanotechnology will bring over the next 5 to 10 years. The 12 degrees in Australia, by and large, adopt a similar approach, treating nanotechnology as a multidisciplinary science degree containing elements of physics, chemistry and biology. In addition, some of the degrees have recognised the importance of linking a more traditional science education to aspects of the commercial environment and entrepreneurship. There are however, a number of important differences. For example, the particular discipline the degree is slanted towards, the way in which the broad scope of nanotechnology is covered, the length of the programs and level of mathematics included in the core curricula. Now that these programs have been around for up to 5 years, nanotechnology graduates are beginning to appear across Australia. This paper follows on from an earlier submission to this conference which outlined the first nanotechnology undergraduate initiative at Flinders. The aim of the paper is to review the degrees now available and offer some analysis of how successful the initiative has been overall in Australia. In the first part of this paper we will compare the current degree structures and content to illustrate the different approaches that have been taken. In the second part we track the progress of the degrees in terms of how well they continue to attract students and the outcomes for the graduates, such as where they go after graduating.

11:15 AM PP1.8
Zoom in on Life: Using Biological Processes to Teach the Public About Nanotechnology. Beth Tinker[1], Maya Wade[1], Andrew Greenberg[2,3,4] and Ronald Dean Redwing[2,5]; [1]The Franklin Institute, Philadelphia, Pennsylvania; [2]Center of Nanoscale Science, Penn State University, University Park, Pennsylvania; [3]Chemistry, Penn State University, University Park, Pennsylvania; [4]Chemistry, University of Wisconsin-Madison, Madison, Wisconsin; [5]Physics, Penn State University, University Park, Pennsylvania; [6]Education, Cornell University, Ithaca, New York; [7]Education, Penn State University, University Park, Pennsylvania.

Through a partnership between the NSF-funded Material Research Science and Engineering Center, Center for Nanoscale Science, at Penn State University and Philadelphia's science museum The Franklin Institute the "Nano-Bio: Zoom in on Life" program has been produced and distributed to 21 science and children museums in the United States, Canada and Lebanon. Distributed shows include the materials needed to perform the demonstration, supplies for a year and additional information including educational materials and a training video. This cart based program includes interactive demonstrations that highlight processes in the human body that occur at the nanoscale and how scientists are exploring natural processes to develop new nanotechnology and nanomaterials. This show is the second in a series of collaborations to create programs for the informal science education world. A development team including Penn State University faculty, postdoctoral fellows, graduate students and Franklin Institute staff worked over two years to develop the show. Instrumental in the development were graduate students who were part of a jointly run Penn State-Franklin Institute NSF-funded Internships in Public Science Education (IPSE) program. These science education graduate students helped create, test, and enhance the demonstrations for the Zoom in on Life program.

11:30 AM PP1.9
Development of Nanotechnology and Material Science Training Modules for Elementary Science Teachers.
Souheil Zekri[1], Ashok Kumar[1], Geoffery Okogbaa[2] and Louis Martin-Vega[2]; [1]Mechanical Engineering, University of South Florida, Tampa, Florida; [2]Industrial Engineering, University of South Florida, Tampa, Florida.

An ongoing plan to integrate nanotechnology and materials science concepts is being conducted as part of a National Science Foundation (NSF) GK-12 project at the University of South Florida. The objective of the GK-12 STARS (Students, Teachers and Resources in the Sciences) program is to promote systemic change in primary grade levels enhancing math and science curricula and encouraging long-term professional development for teachers in the K-5 band. The program also aims to decrease the current educational gap in science and math curricula prevalent among certain schools within the same school district as reflected in students performance on the Florida Comprehensive Assessment Test (FCAT). The target population was determined in collaboration with the county science coordinator and is composed of 60 teachers selected from different schools around the county. The selection criteria were based on the teachers science background and interest in teaching science at the elementary level. The purpose behind the science training program is to form a group of lead teachers that will provide the rest of the elementary science teaching population the necessary in class support. This paper provides a detailed discussion of the tools that are currently being employed to assist in the integration of materials science and nanotechnology concepts into the teacher training curriculum. The integration plan encompasses: (1) the development and implementation of a Materials Science and Nanotechnology training Module; (2) hands on research experience as a summer program at the University of South Florida; and (3) long term institutionalization of the GK-12 teacher training project throughout the year within the community for a long term impact on the education system.

11:45 AM PP1.10
An Evolutionary Approach to Nanoscience Education in the Undergraduate Chemistry Curriculum. Brian H Augustine, Kevin L. Caran and Barbara A Reisner; Department of Chemistry, James Madison University, Harrisonburg, Virginia.

We report on an interdisciplinary approach to nanoscience education across all levels of the undergraduate chemistry curriculum from introductory to advanced classes and laboratory work being developed through a newly proposed Nanotechnology Undergraduate Education program. We have been developing lecture and laboratory topics in lower-division courses that can subsequently be used in upper-division characterization courses. An example of this is molecular brush and dendrimer compounds synthesized in a sophomore organic chemistry lab are then subsequently used in physical chemistry experiments using atomic force microscopy and luminescent nanoparticles, respectively. Nanoscience topics have been introduced in all subdisciplines of chemistry from general to physical including materials science and biochemistry as a common thread tying these subdisciplines together. We will also report on recently developed courses for non-science majors with a nanotechnology theme. Finally, we will report on the micro and nanofabrication of devices that we are preparing that can be used by high school and college-level science, engineering and technology teachers as demonstrations of nanometer-scale phenomena.

SESSION PP2
Chairs: David F. Bahr and Peter Davies
Tuesday Afternoon, November 29, 2005
Berkeley (Sheraton)

1:30 PM PANEL DISCUSSION I - Funding for Educational Innovations in Materials
Participants: Rosemary Haggett (National Science Foundation), Velda Goldberg (Simons College), Laura Bartolo (Kent State University).
Moderator: David F. Bahr (Washington State University).

3:30 PM PP2.1
NSF NSDL Materials Digital Library & MSE Education.
Laura M. Bartolo[1], Sharon C. Glotzer[2], Cathy S. Lowe[1], Adam C. Powell[3], Donald R. Sadoway[3], James A. Warren[4], Vinod K. Tewary[4] and Krishna Rajan[5]; [1]Kent State University, Kent, Ohio; [2]University of Michigan, Ann Arbor, Michigan; [3]Massachusetts Institute of

Technology, Cambridge, Massachusetts; [4]National Institute of Standards and Technology, Gaithersburg, Maryland; [5]Iowa State University, Ames, Iowa.

The National Science Foundation created the National Science Digital Library (NSDL) in order to establish a technical, community, and organizational framework for access to high quality resources and tools that support innovations in teaching and learning at all levels of science, technology, engineering, and mathematics education. As part of the NSDL, the Materials Digital Library (MatDL) focuses specifically on serving the materials science (MS) community with a target audience that includes MS undergraduate and graduate students, educators, and researchers. MatDL is a collaborative effort involving the Materials Science and Engineering Laboratory at the National Institute of Standards and Technology (NIST), Massachusetts Institute of Technology (MIT), the University of Michigan (U-M), and Kent State University (KSU). Our network of collaborations will soon extend to include other materials initiatives, such as an International Materials Institute based at Iowa State University (ISU). A primary goal of MatDL is to bring materials science research and education closer together. MatDL promotes innovative uses of digital libraries and the web in the MS community with emphasis on providing: 1) tools to describe, manage, exchange, archive, and disseminate scientific data 2) services and content for virtual labs in large undergraduate introductory science courses, 3) workspace for collaborative development of core undergraduate MS teaching resources for emerging areas, and 4) workspace for open access development of modeling and simulation tools. This presentation will provide an overview of the MatDL project as educational media. Presentations by our collaborators will provide additional details about specific aspects of the project as well as interactions between research and education.

3:45 PM PP2.2
Integration of Laboratory and Lecture: Using Two Separate Classes to Re-Enforce Each Other. R. Allen Kimel, Materials Science and Engineering, Pennsylvania State University, University Park, Pennsylvania.

A common occurrence in many science and engineering programs is the separation of lecture and laboratory. This paper will review new integration of lecture and laboratory procedures being implemented in the Department of Materials Science and Engineering at Pennsylvania State Univeristy. This integration of existing classes has been accomplished using two different formats. One format involves aligning the syllabi of independent laboratory and lecture classes such that the two courses are covering the same material in a sequential manner. The second format involves the adsorption of a laboratory class into a lecture class such that they become one course. This requires the scheduling of lecture time for hands-on experience as well as dedicated laboratory space for 'non-traditional' hours education. This paper will review the logistics of organizing the two different formats and the positive impact the new formats have had at the undergraduate level.

4:00 PM PP2.3
Teaching what you can't see: museum exhibits as a bridge to learning materials science. Olivia M. Castellini[1], Carie E. Holladay[2], Terra Theim[3], Gina K. Walejko[2], Greta M. Zenner[1], Paul Krajniak[4] and Wendy C. Crone[1,5]; [1]Materials Research Science and Engineering Center, University of Wisconsin-Madison, Madison, Wisconsin; [2]Department of Life Sciences Communication, University of Wisconsin-Madison, Madison, Wisconsin; [3]Department of Botany, University of Wisconsin-Madison, Madison, Wisconsin; [4]Discovery World Museum of Science, Economics and Technology, Milwaukee, Wisconsin; [5]Department of Engineering Physics, University of Wisconsin-Madison, Madison, Wisconsin.

The use of exhibits in informal science education venues such as science centers and museums is an integral part of engaging students in science, encouraging them to take science courses in school, and motivating them to pursue science and engineering careers. Through an Internships in Public Science Education Program funded by the National Science Foundation and in partnership with the education efforts of a Materials Research Science and Engineering Center (MRSEC) and the Discovery World Museum of Science, Economics and Technology, we have built and tested interactive components for museum exhibits on advanced materials science and nanotechnology concepts. Our front-end assessment revealed a gap in scientific understanding about objects smaller than can be seen by the naked eye. Facts learned through standard teaching methods were easily recalled, but in-depth, conceptual knowledge and application of those facts are lacking in both children and adults. We designed interactive exhibits to specifically address this disconnect in comprehension. By inviting the learner to actively participate in an interactive exhibit activity, he or she is able to develop a deeper understanding of advanced materials concepts that are difficult to teach with textbooks alone. Formative assessment of our exhibit prototypes show that students and adults not only participate in the interactive exhibit activity, but are able to learn and apply the concepts contained within them.

4:15 PM PP2.4
The Design, Implementation and Assessment of an On-Line, Open-Book Quizzing Environment for an Introductory Materials Science Course. Paul R. Howell and Ralph H. Locklin; Materials Science and Engineering, Penn State University, University Park, Pennsylvania.

The authors have developed, implemented and assessed an on-line, open-book quizzing environment for the introductory materials science course, Materials In Todays World. The course is offered as an E-Education course and students may access the course from anywhere that permits access to our course management system, ANGEL. For reasons that were both pragmatic and philosophical, we decided that the exams/quizzes would not be proctored, they would be delivered wholly on-line, and would be open-book. In the current presentation, we will justify out philosophy, of on-line, open-book quizzes, and will describe our satisfaction with the quizzing tool: QuestionMark Perception. We will place particular emphasis on the rich feedback, which is a feature or our quizzing system, and how this feedback may be used as a teaching tool, and as a means to refine the quiz database. The authors will also discuss the current strategy, which has replaced the original high-stakes midterm and final exams, with a series of lower-stakes, weekly quizzes. Finally, the structure of the quiz database will be presented. It will be shown that for databases that contain large numbers of questions relative to the numbers employed in each quiz, the integrity of the database is not compromised. Finally, but perhaps most importantly, we will present information on student responses to the quizzing environment, and student performance on innovative question types. We will also illustrate how information from item-by-item analyses helps to shape adjustments to the course.

4:30 PM *PP2.5
Materials Engineering Education in Two New Engineering Degree Programs at the Centre for Photovoltaic Engineering. Richard Paul Corkish[1,2], Stuart R. Wenham[2], Martin A. Green[2], Alistair B. Sproul[2], Jeff Cotter[2], Armin G. Aberle[2] and Anna Bruce[2]; [1]Centre for Photovoltaic Engineering, University of New South Wales, Sydney, New South Wales, Australia; [2]Centre of Excellence in Advanced Silicon Photovoltaics and Photonics, University of New South Wales, Sydney, New South Wales, Australia.

The photovoltaics (PV) and other renewable energy industries are growing at over 30% p.a. (PV manufacturing grew 67% in 2004), driven by a mix of environmental, resource depletion and global security concerns. The establishment, in 2000 and 2003, of new degree programs in Photovoltaics and Solar Energy Engineering and Renewable Energy Engineering at the Centre for Photovoltaic Engineering at the University of New South Wales, Sydney was in response to predictions of such dramatic global market and employment growth. They were developed by the well established photovoltaics research group at UNSW that has produced many important advances, including two commercially important solar cell technologies. Materials-related aspects of these programs are mainly focussed on the PV aspects, including study of the fundamental optical, electronic, phononic and excitonic properties of silicon, crystal structure, semiconductor properties, doping and contacts. Cell manufacturing is taught in detail, including by the use of an interactive virtual production line which realistically models the etching of wafer saw damage, surface texturing, solid state phosphorus diffusion, edge junction isolation, metal contact printing and firing, antireflection coating deposition, texturing, multicrystalline processing and grain boundary passivation. Students have opportunities to select practical projects to be carried out in the laboratories, including in the deposition, crystallisation and characterisation of thin films of amorphous and crystalline silicon for thin film solar cells. Third generation cell concepts, including use of silicon nanostructures and up- and down-conversion of incident light, are also included in a course for advanced undergraduate and postgraduate students. Materials engineering of PV modules has allowed their development into a highly reliable product, lasting decades under outdoor exposure, which places great demands on all aspects of material selection and compatibility, including interconnections, terminals, mounting frames, cover glasses, encapsulants and sealing techniques. Additional materials engineering issues related to the currently restricted supply to the photovoltaics industry of silicon of suitable purity are, at least temporarily, of critical importance but are not a major focus within the degree programs. Early graduates of the Photovoltaics and Solar Energy Engineering program are still few in number and many have chosen to continue their studies in commerce or in photovoltaic device research, but several are employed in photovoltaics engineering in Australia and Germany.

SESSION PP3: Poster Session
Chair: M. Grant Norton
Tuesday Evening, November 29, 2005
8:00 PM
Exhibition Hall D (Hynes)

PP3.1
Demonstration and Testing of Student-Designed Impact Testing Devices. Amy Hsiao, Mechanical Engineering, Union College, Schenectady, New York.

This work describes a multi-week team project to design and demonstrate an impact testing device on selected everyday materials. The project is part of a sophomore level course on the mechanical behavior of materials. Students were divided into teams of three to four members each and given the task of designing a simple, functional impact testing device to test three out of four selected materials, namely, a glass slide, aluminum foil, plastic wrap, and a piece of acrylonitrile butadiene styrene (ABS) polymer fabricated by a three-dimensional printer. Teams were given the task of exploring the conventional types of impact testing devices and drawing their own design, customized to their given materials, by using the computer-aided design (CAD) software, SolidWorks. Students were given a list of provided materials and an additional budget of $15, of which its use had to be approved by the submission of an itemized budget request. A memorandum describing their design was also submitted one week prior to presentation for approval. Access to a student machine shop enabled teams to construct and test their impact devices before presentation. Teams presented the background, design, and budget of their impact testing device in a fifteen-minute talk and demonstrated its use on each of their selected materials. In addition, the presentations were required to include a discussion of quantitative calculations of the energy absorbed to fracture of each material and a qualitative comparison of all materials tested. Students also discussed factors related to impact testing, such as the inclusion of a notch in tested materials and accounting for permanent deformation in impact testing, as opposed to immediate shear fracture. This project resulted in the teams being divided almost evenly between designs similar to either the Charpy impact test or the drop-impact test. Unique aspects of this experimental activity as a design-oriented team project that focuses on materials testing and develops the technical presentation skills for the undergraduate engineering student will be presented in this paper. Student work will be presented and student assessment of this project will be also be discussed.

PP3.2
Natural, Bioengineered, and Engineered Materials: Compression Testing and Comparison of Wood, Bone, and Fiber-Reinforced Composites. Amy Hsiao, Union College, Schenectady, New York.

This work describes an experimental experience designed for an introductory materials science and engineering course at the undergraduate level that incorporates the testing and analysis of "everyday" and "innovative" materials that are familiar to students. Compression testing of a block of spruce wood, a sample of a cervical bone allograft, and a rod of fiberglass-polyester composite are performed by the students. These three different composite materials were selected for having interesting mechanical properties that have been used for centuries, or that have been used recently as a lightweight alternative to traditional structural materials, or because they are at the cutting edge of a new field, i.e., bioengineering. Students observe the stress-strain behavior of these materials, identify the modulus of elasticity (E), yield strength (σ_y), and ultimate strength (σ_{ult}) of each material, and draw key conclusions by the comparison of the elastic and plastic behavior of each material. In the comparison, students evaluate the significance of stress and strain being dimensionally normalized values and they see that the physical characteristics of the stress-strain curve illustrate concepts such as stiffness, elasticity, brittleness, plasticity, resilience, and toughness. In addition, factors related to composite materials, such as anisotropy, volume fraction, and fracture toughness are discussed. In terms of anisotropy, the grain of the wood is placed both parallel and perpendicular to the compressive load in two consecutive tests. For the compression testing of the cervical bone allograft, samples that are freeze-dried, thawed in air, or rehydrated for a given amount of time are tested. Quantitative analysis is performed by the students from the stress and strain data they collect during the compression testing. Experimental values for modulus of elasticity, yield strength, ultimate strength are calculated and compared. The stress-strain curve of each material is plotted simultaneously and the students present and analyze their results in the form of a formal laboratory report. Students must conclude whether anisotropy has an effect on compressive properties for wood and support the conclusion. Students must also conclude whether rehydration has an effect on the compressive properties of the cervical bone allograft. For the fiber-reinforced polymer composite, the students are asked to assume a percentage volume fraction and compare their experimentally determined values of E, σ_y, and σ_{ult} with known values for this fiber-matrix composition. The unique details of this laboratory project will be presented, from materials and methods, to apparatus used, i.e., different load capabilities were required for each testing, to the development of technical analysis and presentation for the undergraduate engineering student. In addition, student work will be represented and assessment of this project will be discussed.

PP3.3
Scientific Mentorship: Developing Survival Skills in Science. Federico Rosei and Tudor W. Johnston; EMT, INRS, Varennes, Quebec, Canada.

For the young scientist there is little to be found in terms of practical advice to help in making the many choices that fall under the headings of the strategy, tactics and planning. Without this as a young scientist your progress in the world science will be left essentially to chance. Far more advice can be found on buying a car or a house or starting a business. This talk summarizes a practical guide to how to manage your scientific career. Any would-be entertainer or author will acquire the services of an agent, a manager or an editor to help in managing to help planning career moves. Most scientists (and nearly all those beginning in science) attend to such matters only when faced with a deadline of some sort. You can do far better if you take the trouble to tend to your career at least on a weekly basis and become your own agent. The first and basic piece of advice, the zeroth law of scientific survival is pay attention to your scientific career. The basic aspects can be likened to the support from the three legs of a good tripod. All the legs are equally important, and they are (the first law) Know thyself, (second law) Know your tradecraft, and (the third law) Know thy neighbor. Know thyself. Pay attention to yourself, to your strengths and weaknesses and how to improve them. Also, pay attention to your likes and dislikes. Know thy tradecraft. In many spy novels the useful word tradecraft means the technique of organizing mail-drops, packaging and sending the information and so on, the technique of cultivating relationships to advance your professional ambition and so on. Here tradecraft means the craft of writing papers that people want to read, constructing seminars that are fun to hear and to give, writing compelling proposals that cannot be refused for funding, how to interview or to conduct interviews, etc. Know thy neighbor. Pay attention to the people with whom you will be interacting. Work diligently at putting yourself in their shoes so that you can do a better job of tailoring your impact on them. These will include co-workers, supervisors, listeners to your seminars and oral presentations of many kinds, readers of your publications, grant applications and job applications, and many more. With these three components in mind you are ready for the fundamental piece of advice for a successful scientific career. This basic concept is simple enough to say but takes a disciplined effort to put into practice. It simply is: plan ahead to do the best you can in your scientific career. Like much good advice it seems trivial, but as is so often the case, it is rarely carried through in practice. Do not just plan your work in science; plan your career in science. Scientific research is a world of opportunities. Those scientists who regularly plan ahead are the ones who are most likely to tune in and capitalize on opportunities, and thereby not only survive but also succeed and even thrive.

PP3.4
The Molecule, the Monomer and Materials Science. Paul R. Howell, Materials Science and Engineering, Penn State University, University Park, Pennsylvania.

There would appear to be a large disconnect between the content of a typical high school chemistry course, and an introductory, college materials science course. For example, A National Science Foundation report notes that, the historic bias of chemistry curricula towards small molecule chemistry, generally in the gaseous and liquid states, is out of touch with current opportunities for chemists in research, education and technology. In contrast, the typical introductory college materials science course concentrates almost exclusively on the solid state, and a discussion of small molecular materials is virtually absent. In the present contribution, it will be shown how the molecule forms part of a hierarchical series of structures, from the sub-atomic to the macroscopic. It will also be argued that the molecule is but one of several possible material sub-units, which can be aggregated to form e.g., the crystalline state. The author will also argue that the various structural sub-units are best described by the term monomer. Based on a strict definition of the molecule and monomer, the author will develop a complete hierarchical scheme for the structure of materials, which should be applicable to both a high school chemistry course, and an introductory materials science course. The same hierarchical scheme will also be used to provide a rather complete taxonomic scheme for the classification of materials.

PP3.5
Ideal and Real Structure Visualizations by Jmol with Database Support. Peter Moeck[1], Selvan Senthivel[2], Ondrej Certik[3,1], Phil Fraundorf[4], Bjoern Seipel[1], Girish Upreti[1] and William Garrick[2]; [1]Department of Physics, Portland State University, Portland, Oregon; [2]Academic & Research Computing for Instruction and Research Services and the Office of Information Technology, Portland State University, Portland, Oregon; [3]Department of Physics, Charles University Prague, Prague, Czech Republic; [4]Department of Physics & Astronomy/Center for Molecular Electronics, University of Missouri, St. Louis, Missouri.

Courses in materials science and engineering, crystal chemistry, crystal physics, and mineralogy typically employ two-dimensional sketches of the atomic arrangement in crystal structures and unit cells. The chapter on ideal crystal structures of widely used introductory materials science and engineering text by Schaffer et al. [1] contains for example 14 such sketches. Textbooks on mineralogy contain a much larger number of such sketches (e.g. ref. [2] features a picture with more than ten ball-and-stick models on the dedication page and approximately one hundred sketches of atomic arrangements in crystal structures and unit cells in the body of the text). Physical three-dimensional models of crystal structures and unit cells are also popular. While academic departments in the developed part of the world may possess some tens of such three-dimensional models and allow their students to explore those hands on, their counterparts in the developing part of the world may consider such models too expensive and fragile for class room usages. To help remedying this situation, teams (see affiliations of the authors above) at Portland State University and the University of Missouri at St Louis joint forces and are supported by a grant from the NorthWest Academic Computing Consortium [3]. We host a copy of the free on-line Crystallography Open Database [4] at Portland State University [5] and are developing platform independent software for the direct visualization of the entries in this database. Real structure such as dislocations, twins, and nanocrystal faces will also be visualized. The internet browser java bases applet Jmol [5] will be employed for these purposes, so that access to a computer with internet connection ensures access to the visualization of approximately 15,000 ideal crystal structures and unit cells. The so called Crystal Information Files that one obtains by querying the database will in the future be directly read into Jmol at the URL http://nanocrystallography.pdx.edu/ (and its mirror sites) so that students and their teachers all over the world no longer have to rely on either physical three-dimensional models of crystal structures and unit cells or the respective two-dimensional sketches. The "Reciprocal Net" project at Indiana University's Molecular Structure Center (http://www.reciprocalnet.org/) already serves the public with free access to the visualization of some 500 common ideal crystal structures and molecules. [1] J.P. Schaffer, et al., The Science and Design of Engineering Materials, WBC/McGraw-Hill, Boston, 1999 [2] M.J. Hibbard, Mineralogy: A Geologist's Point of View, McGraw Hill, Boston, 2002 [3] http://www.nwacc.org/about/members.html [4] http://www.crystallography.net [5] http://nanocrystal.research.pdx.edu/cod/ [6] http://Jmol.sourceforge.net

PP3.6
NIST MSEL CTCMS & MatDL: Modeling & Simulation Code Development. James A. Warren[2] and Laura M. Bartolo[1]; [1]Kent State University, Kent, Ohio; [2]National Institute of Standards and Technology, Gaithersburg, Maryland.

As part of its mission, the Center for Theoretical and Computational Materials Science (CTCMS) in the Materials Science and Engineering Laboratory (MSEL) of the National Institute of Standards and Technology (NIST) seeks new approaches to train students in the use of its modeling and simulation tools, to promote development of its tools via testing, and to develop a pool of users ready to transfer the technology to industry and academia. Through collaboration with the Materials Digital Library (MatDL), CTCMS pursues new methods to develop and disseminate its software tools, beginning with FiPy. FiPy is an extensible, powerful, and freely available tool that is an object oriented, partial differential equation (PDE) solver, written in Python, based on a standard finite volume (FV) approach. MatDL provides a flexible workspace for NIST CTCMS and its external collaborators to use for community development of materials modeling and simulation codes, supporting open source code development without the extensive security barriers that inhibit external collaborations required for servers residing within government institutions, such as NIST. The collaboration of CTCMS and MatDL promotes interactions between research code developers and 1) other similar code projects; 2) researchers generating scientific data which could be used to test code; and 3) educators interested in incorporating the codes into teaching materials or in having students write code modules as part of their coursework.

PP3.7
An Undergraduate Course on Atomic Force Microscopy.
Nancy A. Burnham, Physics, Worcester Polytechnic Institute, Worcester, Massachusetts.

A course on atomic force microscopy (AFM) for undergraduates has been given four times at Worcester Polytechnic Institute. The instructor assumes only Introductory Mechanics, Introductory Electricity and Magnetism, and Calculus as background, so that students of many different disciplines and levels have enrolled. The students attend three hours of lecture, one hour of computer lab, and two hours of instrument lab each week. The course gives students a taste of the excitement of nanotechnology through studying one of its most important techniques. Moreover, important themes in physics and materials science are reinforced, and the students are exposed to life as professional scientists through writing professional-level reports and investigating and presenting a current research topic. One-third of the students have continued with AFM in their undergraduate or graduate research. Many of them have remarked how the course was helpful in securing summer internships or graduate research assistantships. The Nanotechnology Undergraduate Education Program of the National Science Foundation is supporting further development of the course materials, which will be incorporated into a textbook with electronic supplement, so that other educators may more easily teach AFM to undergraduates. In this talk, the syllabus and the challenges of teaching to an interdisciplinary and multilevel audience will be discussed.

PP3.8
A Tidewater Virginia Partnership for Materials Science Education. Michael J. Kelley[1] and Larry Mattix[3]; [1]Applied Science, Coll. of William & Mary, Williamsburg, Virginia; [2]Free Electron Laser Dept., Jefferson Lab, Newport News, Virginia; [3]School of Science & Technology, Norfolk State University, Norfolk, Virginia.

Historically Black Colleges and Universities (HBCU's) can make a unique contribution in recruiting talented African American youth into science. The College of William & Mary and the Thomas Jefferson National Accelerator Facility (Jefferson Lab) began partnering with Norfolk State (a HBCU) to enhance materials science education six years ago. Materials studies presently occur in docotral programs in Applied Science and in Physics at William & Mary, and a masters program in the Center for Materials Research at Norfolk State, intended to become a doctoral program. Courses in materials characterization and in surface science originate at William & Mary, and are delivered by interactive videoconference to Norfolk State. All course materials are available on a server prior to class; all class sessions are server-available for later viewing. The Colleges also own and share instrument facilities in the Applied Research Center located at Jefferson Lab. These include a ToF/SIMS, a scanning Auger, an XPS, scanning probe microscopes, XRD, FTIR, SEM/EDS and optical microscopes. *The support of the Commonwealth of Virginia is greatfully acknowledged

PP3.9
A Pittsburgh Perspective of the History of Steel Production and Its Role in Materials Science Education.
Nicole Elisabeth Hayward, Carnegie Mellon University, Pittsburgh, Pennsylvania.

While Materials Science and Engineering has had a rich and enduring impact on society, the field is not widely understood by the public. One method for improving public perception is to explain the historical role of materials as an economic driving force. In the U.S. there is perhaps no better example than the evolution of the steel industry. We have coupled with the Materials Research Bulletin to write a walking tour of Pittsburgh from a materials science view. The article highlights the historic and economic value of wrought metal structures such as the Alcoa building, Steel Tower, Smithfield Bridge, old Bessemer Converter, Monongahela Incline, an authentic copper brewery, and more. By walking an MRS tour, an average person can learn of materials-related industrial and historical developments in a region. By pointing out the historical context of materials, we intend to emphasize the broader role of materials in societal evolution. Further, we aim to spread this emphasis to not just material scientists, but to students and professionals of all ages and fields. On the interface between the convention bureau and public, this poster will highlight how the walking tour is a tool to qualify material science as a tertiary learning experience and a public science. The poster will display how the article has already served this purpose by its being published in the MRS Bulletin, introduced to a community college and high school, and used to guide a research group field trip. Because the research group is composed of material scientists and mechanical engineers, both undergraduate, graduate, and doctorate, the article also represents the inderdisciplinary nature of material science. Future plans are to use the Pittsburgh walking tour as a fun, educational activity to new engineers at Carnegie Mellon University, advertising the Material Science major to students who have yet to choose a concentration. We gratefully acknowledge financial support from the National Science Foundation through award number DMR-0406220.

PP3.10
Women in Materials: a Collaborative Effort between Simmons College and the Cornell Center for Materials Research.
Velda Goldberg[1], George G. Malliaras[3], Helene Schember[4], Michael Kaplan[1,2], Leonard Soltzberg[2], Richard Gurney[2] and Patrick Johnson[1]; [1]Physics Department, Simmons College, Boston, Massachusetts; [2]Chemistry Department, Simmons College, Boston, Massachusetts; [3]Department of Materials Science and Engineering, Cornell University, Ithaca, New York; [4]Cornell Center for Materials Research, Cornell University, Ithaca, New York.

The Women in Materials (WIM) program, supported by the National Science Foundation, is a collaboration between Simmons College, a predominately undergraduate women's college, and the Cornell Center for Materials Research (CCMR), a NSF-supported Materials Research Science and Engineering Center. For the past four years, this program has provided unique curricular and research opportunities for undergraduate women at Simmons College. The WIM program has helped to establish three separate research projects at Simmons College that involve approximately 25% of Simmons' science majors and that emphasize the participation of first and second year students. (Approximately 80% of the students started in the program as 1st or 2nd year students.) The program has also fostered the development of six new materials science courses (one held at CCMR) and the incorporation of materials-based laboratories in introductory physics and chemistry courses-all culminating in a new minor in materials science and a new major in physics that emphasizes materials. The program has also led to the separate acquisition of over $400,000 of new instrumentation including scanning electron and scanning probe microscopes and a MALDI TOF mass spectrometer. As direct results of the WIM program, the students participating in this research have jointly authored, along with Simmons and CCMR faculty, work presented at Materials Research Society and American Chemical Society meetings. The program has also led to an increase in the number of women majoring in physics, minoring in materials science, enrolling in materials-related REU programs, and entering Ph.D. programs in materials science or related disciplines.

PP3.11
Internships in Public Science Education program: Bringing Today's Science to Tomorrow's Scientists.
Ronald Dean Redwing[1,2], Natasha Eckert[1,3], Beth Tinker[4] and Barbara A. Crawford[5]; [1]Center for Nanoscale Science, Penn State University, University Park, Pennsylvania; [2]Physics, Penn State University, University Park, Pennsylvania; [3]Education, Penn State University, University Park, Pennsylvania; [4]The Franklin Institute, Philadelphia, Pennsylvania; [5]Education, Cornell University, Ithaca, New York.

This NSF-funded Internships in Public Science Education (IPSE) program provides the opportunity for graduate students majoring in education or science disciplines to be interns in an on-going collaboration between Penn State's NSF-funded Materials Research Science and Engineering Center, *Center for Nanoscale Science*, and *The Franklin Institute*. The *Internships for Bringing Today's Science to Tomorrow's Scientists* program has developed activities to deliver materials concepts demonstrated at museum shows created by the Center for Nanoscale Science and The Franklin Institute to the home. Interns work within center research groups, participate in internships at The Franklin Institute and collaborate with Penn State faculty and TFI development staff to design *Material Discovery Projects*. *Material Discovery Projects* are a collection of activities with a common materials theme based on a demonstration from one of the museum shows. Pamphlets which include selected projects that can be done at home, additional background narrative and the URL of a website providing additional projects and information, is distributed at the museum show. Interns use workshops for home educated students as a means of collecting data for the formative evaluation and field testing before distribution of their *Material Discovery Projects*.

PP3.12
Using Technology, Humanities and the Arts as Tools to Attract Future Generations of Scientists and Engineers.
R. Allen Kimel, Materials Science and Engineering, Pennsylvania State University, University Park, Pennsylvania.

As the number of American students choosing to study science and engineering continues to decrease, educators need to find new and exciting ways to engage high school students, inspiring these students to pursue science and engineering at the university level. Through the use of summer camps, the Department of Materials Science and Engineering at Pennsylvania State Univeristy has begun to take on this task. Two new summer camps were introduced in the summer of 2005. Materials in Forensic Science: Using Materials Science to investigate the failure of Materials and Materials in Art and Archeology: Using Materials Science to Explore the Past were designed to entice students to explore interests in science and engineering through the use of popular culture and areas of interest typically thought of as outside the realm of engineering. This paper will review the themes behind the two camps and the activities used to engage the students and introduce them to the broad variety of careers possible by choosing to study science and engineering.

PP3.13
Pre-College Materials Science and Engineering Educational Outreach: 2005 ASM Materials Camp hosted by North Carolina State University (NCSU). Donovan Leonard[1] and Roberto Garcia[2]; [1]Materials Science and Engineering, North Carolina State University, Raleigh, North Carolina; [2]Analytical Instrumentation Facility, North Carolina State University, Raleigh, North Carolina.

The first pre-college materials science and engineering educational outreach, intended for North Carolina high school students entering grade 12, was hosted by the Materials Science and Engineering Department of NCSU during July 25-28, 2005. The ASM Materials Camp model was utilized to provide students an opportunity to learn how metals, polymers, ceramics and microscopy play key roles in everyday technologies, while in parallel developing team work, problem solving and communication skills. Hands-on curriculum activities were intended to increase the student involvement in their own learning and focus on macroscopic to microscopic concepts of real, practical objects that students could intuitively understand. Materials camp attendees were first given a presentation on safety and hazard control in the laboratory. Faculty then presented an enthusiastic materials science magic show demonstrating electro-rheological fluids, space vehicle heat shields, shape memory wire and other unique materials and their applications in the real world. The remainder of day one was spent introducing students to identification of materials by intrinsic properties and microscopy (OM, SEM, AFM and TEM). During these presentations samples were passed around to the students for up-close inspection and handling. Several samples were examined under the optical microscope and live-time images displayed on a large screen using a LCD projector. Day two of the materials camp included two unique and exciting hands-on learning modules developed to further the students understanding of metallurgy, heat treatment, mechanical testing, SEM and microelectronic materials. One hands-on activity, using samples of 1100 and 2024 series aluminum, was based on a metallurgical chemical identification included in the plot of a recent CSI television episode. This learning module demonstrated how material properties of similar materials can differ drastically on the micro-scale causing changes in macroscopic properties. A second hands-on activity let students perform physical demolition of a PC to determine the types of materials used in construction. Cross-sections of board level wiring, solder bumps, decoupling capacitors, interconnects and chip level devices were all examined with OM and SEM. Half of day three was spent touring GE aircraft engines located in Durham, NC. This tour allowed the students to appreciate the breadth of materials used in jet engine manufacturing and reinforced importance of safety in material design. The remainder of the day was reserved for preparation of camp summary team presentations and presented during to their peers during a liquid nitrogen ice cream party. A web page was created to archive pictures, data and presentations from the camp experience for future access by parents, friends and future attendees. Student survey responses were also analyzed and used to improve the curriculum and planning of camp next year.

PP3.14
From Inspiration to Retention: Multi-tiered Approaches to MSE Educational Outreach. Lysa D Russo, Andrew Gouldstone and Sanjay Sampath; Materials Science and Engineering, Stony Brook University, Stony Brook, New York.

Educating students as well as their teachers are equally important steps in preparing the next generation of engineers and scientists. At the NSF MRSEC Center for Thermal Spray Research (CTSR) our program self-assessment has revealed a strong initial pull and interest from students and teachers alike as well as an emotional tie in largely due to the highly visual and industrial aspects of the TS process. This 'inspiration' factor is crucial, but of arguably greater importance is the ability to transfer this initial excitement into a pathway of continued learning in the MSE field. In this talk we will present strategies used by the Center that allows for a large breadth of initial exposure to the K-12 community followed by a series of tiered programs aimed at increasing the depth of involvement for high-school through college level students. Field trips, Science and Technology Roadshows, teacher training programs such as Research Experience for Teachers (RET), and research internship programs such as

Undergraduate REsearch and Creative Activities (URECA), Research Experience for Undergraduates (REU), and International REU have all been found to be highly effective in providing the necessary follow through for successful retention. In addition, in today's rapidly evolving technology fields, providing a bridge between the industrial and academic communities is of great importance and one can readily apply the concept of multi-tiered program offerings that create an environment of 'lifelong' learning. Future plans, including the development of a industrially sponsored SPLAT (Spraying, Learning And Teaching) Center which will further link these two groups and fortify our outreach program offerings will also be discussed. Acknowledgement: Supported through NSF MRSEC award DMR 0080021.

PP3.15
The Transport Phenomena Archive: an Online Space for Collaborative Development in Materials Processing and Performance Education. Adam C Powell[1] and Laura Bartolo[2]; [1]Department of Materials Science and Engineering, MIT, Cambridge, Massachusetts; [2]College of Arts and Sciences, Kent State University, Kent, Ohio.

Initiated in June 2004, the Transport Phenomena Archive is a repository containing over one hundred resources from homework problems to handouts to courseware to extensive readings. Its resources are stored in a version control server such that multiple authors can share write access to documents and retrieve old versions as necessary. Courseware related to homework problems includes a Java applet performing flotation calculations, a C program modeling solidification in a box geometry using the enthalpy method, and a materials property grapher written in PHP which uses Materials Property Markup Language (MatML) files as its storage backend. Each resource includes a printable version (e.g. PDF, Postscript), editable "source" files (e.g. Word, LaTeX, GIMP .xcf, source code), and IEEE Learning Object Metadata which enables searching such as by key word and difficulty level. An editorial board reviews resources in the version control server for inclusion in the Materials Digital Library MatDL.org, which hosts the Transport Phenomena Archive.

PP3.16
Scanning Force Microscopy in General Physics.
Fredy R. Zypman, Yeshiva University, New York, New York.

Yeshiva University runs an Honors program for undergraduate students that emphasizes writing, presentation and current topics. Last year, we taught a General Physics course for engineers and scientists that included a recitation for Honors students. Standard recitations concentrate on the solution of problems either form class or from textbooks. In the recitation, we decided to teach topics in Mechanics and problem-solving strategies via the introduction of concepts in Scanning Force Microscopy. In large part due to their excitement of learning about a leading edge technique, students were extremely engaged. We introduced the basic concepts of SFM, and then explain how to develop simple force reconstruction algorithms. After the initial learning curve of about two weeks, students were already writing their own computer code in Mathematica to extract forces from bendings and vibrational spectra. In this talk, we will present the sequence of the topics introduced in the class as wells as show examples of programs developed in class. Work supported by the Jay and Jeanie Schottenstein Honors Program.

PP3.17
A Comprehensive Exploration of Microscopy for Educational Applications in Introductory Physics. Ryan Fitzsimmons[1,2], Christine Caragianis Broadbridge[1], R. Koekkoek[1,3] and K. Cummings[1]; [1]Department of Physics, Southern Connecticut State University, New Haven, Connecticut; [2]New Milford High School, New Milford, Connecticut; [3]Ridgefield High School, Ridgefield, Connecticut.

This project was initiated with an exploration of several advanced research tools: the scanning electron microscope (SEM) and the atomic force microscope (AFM). This experience led to the hypothesis that students learn physics concepts better when exposed to advanced technology and its applications. To test this hypothesis, a research project was developed that included the study of microscopy tools with applications to materials science. Nine modules covering various aspects of introductory physics were created. Module components included discussions, laboratory experiments and assessments. Four of the nine modules were implemented in various high school and university classes. Assessments were used to compare student learning with the modules versus standard textbook/lecture techniques. The results indicate that when students are taught physics concepts using the microscopy modules they understand them better than when more traditional methods are used. The results of this study will be presented along with recently developed methods created to facilitate implementation of these modules within the high school classroom.

SESSION PP4
Chairs: Ronald Gibala and Linda Vanasupa
Wednesday Morning, November 30, 2005
Berkeley (Sheraton)

8:00 AM *PP4.1
International Perspectives and Progress: Report from the IUMRS Forum on Materials Education, Singapore, July 2005. John E. E. Baglin[1], B. V. R. Chowdari[2], Peter Goodhew[3] and G.V. SubbaRao[2]; [1]K10/D1, IBM Almaden Research Center, San Jose, California; [2]National University of Singapore, Singapore, Singapore; [3]University of Liverpool, Liverpool, United Kingdom.

This talk will present an informal summary of highlights and conclusions arising from the International Forum on Education in Materials Science, Engineering and Technology, held in July, 2005 as part of the IUMRS Meeting in Singapore. The principal sessions covered Global Perspectives on MSE, Innovative Programs and Curricula, Outreach (K-12 and Public Awareness), and E-Resources and Teaching Innovations. The concluding workshop discussion sessions reviewed, in particular: (A) Progress and expectations for the next few years for materials education in various countries; and opportunities for MSE to lead educational innovation, in diverse environments. (B) Keeping MSE programs current and compelling - especially with regard to dynamically evolving curriculum topics, and teaching innovations. (C) International interaction opportunities, now and in the near future, catalyzed by web-based resources. (D) Effective outreach to K-12 and to the broader, non-technical community in general. It is hoped that this Report will stimulate ongoing discussion, action, and innovation in these areas of interest to the global materials community.

8:30 AM *PP4.2
The Future of Materials Undergraduate Programs: Can We Avoid Extinction? Linda Vanasupa, Materials Engineering Department, California Polytechnic State University, San Luis Obispo, California.

In materials research, the current funding focus has shifted from largely mechanical-properties based aspects of materials to their molecular-level chemical nature, such as biomaterials or nanoscale phenomenon. Along with this shift in emphasis, we have seen many undergraduate materials programs become absorbed by other programs as a concentration in other engineering majors. Many programs have absolved departments in favor of a model where faculty from a variety of departments have adjunct appointments in, say, an interdisciplinary materials science and engineering program. What exactly is the fate of undergraduate materials programs? Is it time for materials science and engineering undergraduate programs to be absorbed into the sea of interdisciplinarity? In this talk, I will present data on the landscape of trends within the undergraduate materials community against the changes in the global arena. What is our role as materials science and engineering educators in the societal state of flux that we face? What are the opportunities? In an attempt to see into the future, we will consider all these questions.

9:00 AM *PP4.3
Design and Accreditation of Materials Programs – Perspectives of Department Chairs and ABET Evaluators. G. S. Cargill[1] and I. M. Robertson[2]; [1]Materials Science and Engineering, Lehigh University, Bethlehem, Pennsylvania; [2]Materials Science and Engineering, University of Illinois, Urbana, Illinois.

ABET criteria for accreditation of undergraduate engineering programs involve "design" in several ways: designing and conducting experiments, and designing a system, component, or process, including a major design using knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and realistic constraints. Additional criteria for materials programs require that graduates be able to apply and integrate knowledge of materials structure, properties, processing, and performance to solve materials selection and design problems. There are a wide range of opinions among ABET leaders, program evaluators, and college and university faculty and department chairs about what constitutes a meaningful capstone design experience within the framework of ABET criteria. In considering ABET accreditation criteria and procedures, particularly those involving design, we note that materials programs, often encompassing both scientific and engineering aspects of biomaterials, ceramics, electronic materials, metals and polymers, have much greater breadth and diversity than the more traditional civil, mechanical and electrical engineering programs. Design in materials programs requires a broader interpretation than in some other disciplines, in order to provide materials students with design experiences that are appropriate for the programs in which they are enrolled and for the career interests and goals of the students. Flexibility in meeting design requirements is needed to allow and encourage innovation and exploration of new opportunities to prepare students for successful careers in a globally competitive environment. We will describe examples from the wide range of approaches to design that are being pursued in different materials program, and we will propose guidelines to achieve a more consistent and constructive interpretation and understanding of design in the context of ABET EAC criteria and of objectives, outcomes, and resources of the nation's undergraduate materials programs.

10:00 AM *PP4.4
ABET: Some of the Good, the Bad and the Ugly. Ronald Gibala, University of Michigan, Ann Arbor, Michigan.

I've had the opportunity to experience ABET evaluation as a dean (currently), as a department chair and a faculty member under the new and old criteria, and as a relatively new ABET evaluator for MSE programs. I've also visited other MSE departments and talked in some depth with chairs and faculty given the responsibility of overseeing the ABET process for their programs. This presentation is a qualitative summary of impressions of the ABET process from my own perspective as tempered by input from many colleagues. As the title implies, the simple conclusion is that there are good (G), bad (B), and ugly (U) aspects to ABET as we experience it in MSE programs. I'll describe some of the GBU's and suggest that to a good approximation G > B plus U.

10:30 AM PP4.5
Non-Traditional Assessments for New Learning Approaches: Competency Evaluation in Project-Based Introductory Materials Science. Jonathan D. Stolk, Franklin W. Olin College of Engineering, Needham, Massachusetts.

Over the last twenty years, the National Science Foundation and the engineering community have called for systemic changes in engineering education, including an emphasis on contextual understanding; increased teaming skills, including collaborative, active learning; and an improved capacity for life-long, self-directed learning. The Accreditation Board for Engineering and Technology (ABET) has called for engineering graduates that demonstrate an ability to apply science and engineering, and to design and conduct experiments. In addition, ABET requires assessment processes designed to measure student achievement of defined learning outcomes. Olin College has responded to these calls for change by embracing new learning approaches and assessment techniques. The introductory materials science course at Olin College uses open-ended, team-based projects as a primary pedagogical mechanism, encouraging experiential understanding of content and methods, and the course encourages students to control their own learning process in a self-directed manner and develop life-long learning skills in the process. Since traditional assessment methods can be somewhat insensitive to the desired learning outcomes of new pedagogical approaches, Olin recently instituted a competency assessment system to accompany the traditional course grading system already in place at the College. The thread of competency assessments provides grading coherency for both faculty and students, and it provides students with valuable information concerning their development of nontraditional skills that they could use to identify shortcomings and further their learning. In this paper, we describe the innovative learning approaches in Olin's introductory materials science course, and we explain our implementation of the competency assessment system to measure student attainment of both materials science knowledge and broader skills such as teaming, communication, and experimental inquiry.

10:45 AM PP4.6
MIT's 3.091 and The Materials Digital Library: Investigating the Role of Digital Libraries in First-year Introductory Science Classes with No Lab Component. Donald R. Sadoway[1], Patrick E. Trapa[1] and Laura M. Bartolo[2]; [1]Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts; [2]College of Arts and Sciences, Kent State University, Kent, Ohio.

One example of the reality facing science educators is the practical impossibility of providing meaningful laboratory experience in large introductory undergraduate science classes. In 2001 the Accreditation Board for Engineering and Technology (ABET) and Sloan Foundation held a colloquy to understand the role of laboratories in engineering education as a first step towards experiments with alternative means of learning. Thirteen learning objectives were identified for laboratory experience over the entire undergraduate program. Under NSF sponsorship a study was conducted during the January 2005 intercession at the Massachusetts Institute of Technology to test the premise that a virtual laboratory (VL) could cultivate the majority of these learning objectives. The laboratory "experiments" were conducted in conjunction with data archived in the Materials Digital Library which also served as a repository for the reports and presentations authored by the students in the class. Self assessment surveys taken before and after indicate that for many of the ABET expressed laboratory learning objectives the experience gave students a greatly improved understanding of concepts and mastery of skills in lecture.

11:00 AM PANEL DISCUSSION II - Accreditation
Participants: Ronald Gibala (University of Michigan), Linda Vanasupa (California Polytechnic State University), G. Slade Cargill (Lehigh University). Moderator: M. Grant Norton (Washington State University).

SESSION PP5
Chairs: Katherine Chen and M. Grant Norton
Wednesday Afternoon, November 30, 2005
Berkeley (Sheraton)

1:30 PM *PP5.1
The Research Experiences for Undergraduates Program of the National Science Foundation. Carmen Huber, Division of Materials Research, National Science Foundation, Arlington, Virginia.

The National Science Foundation supports the participation of undergraduate students in materials research through several programs. The Research Experiences for Undergraduates (REU) Program is specifically designed to actively involve undergraduates in research activities. The REU program seeks to attract undergraduate students to and retain them in careers in science and engineering by making research opportunities widely available to interested and qualified students. A description of the REU Program is presented, including relevant program features and aspects of successful REU efforts. A brief overview of other NSF programs that support undergraduate research opportunities, either in association with individual or group research endeavors, is also presented.

2:00 PM *PP5.2
The Effectiveness of Active Undergraduate Research in Materials Science and Engineering. David F. Bahr, Mechanical and Materials Engineering, Washington State University, Pullman, Washington.

One of the issues that may limit the participation of undergraduates in active research programs is that there is a lack of significant data showing effective ways to have undergraduates play integral roles in research. Much of the "lore" of undergraduate research is based on anecdotal evidence and individual professor experiences with individual students. The Materials Science and Engineering program at Washington State University has developed and implemented four modes of involving undergraduates in research: a year long senior thesis required for all MSE students, paid part time research during the school year funded through external research grants, some students volunteer for carrying our research for credit, and full time research during the summer as part of an NSF funded Research Experience for Undergraduates. Over 100 students, ranging from freshmen to seniors, have participated in these programs over the past 8 years, including many MSE students at WSU as well as many visiting students from other institutions or majors through the REU program. Through a combination of survey responses and analysis of grades, time to graduation, and demographic data measures of the reasons for participation, the career choices of graduates, and the scholarly output of these undergraduate researchers has been cataloged and will be presented. Interesting trends, such as the fact that students with a GPA less than 3.0 tend to demonstrate an increase in GPA after participating in research suggest that active research projects should not be reserved for only "honors" students, but benefit the entire student population. The difference between the perceived benefits of presentation method between students and faculty (papers versus posters and presentations) will be addressed, as well as motivating factors in participation in the programs. Finally, some suggestions for incorporating undergraduate research into both summer and school year projects will be described.

3:30 PM PP5.3
Issues in Coordinating and Assessing an Interdisciplinary REU Program at a Primarily Undergraduate Institution. Chris Hughes[1], Gerald Taylor[1] and Brian H. Augustine[2]; [1]Physics, James Madison University, Harrisonburg, Virginia; [2]Chemistry, James Madison University, Harrisonburg, Virginia.

For the last five years, James Madison University has operated an interdisciplinary REU program in materials research using faculty and facilities from five different academic departments (Chemistry, Geology, Integrated Science and Technology, Mathematics, and Physics) spanning two colleges. Since this program relies in an intensely collaborative relationship across administrative structures and on the resources of a primarily undergraduate institution, it is somewhat unique among REU programs. This presentation will address some of the difficulties that an interdisciplinary REU faces and solutions that have been found to those problems. A brief summary of assessment strategies including the cooperation NSF-funded Research on Undergraduate Learning and Education (ROLE) team from Grinnell College will also be presented.

3:45 PM PP5.4

Polymer-Based Nanocomposites: An Internship Program for Deaf and Hard of Hearing Students. Peggy Cebe[1], Daniel Cherdack[1], Robert Guertin[1], Terry Haas[2], B. Seyhan Ince[1], James O'Leary[3] and Regina Valluzzi[4]; [1]Physics, Tufts University, Medford, Massachusetts; [2]Chemistry, Tufts University, Medford, Massachusetts; [3]Mechanical Engineering, Tufts University, Medford, Massachusetts; [4]Chemical and Biological Engineering, Tufts University, Medford, Massachusetts.

Over the past three summers, a total of ten deaf or hard of hearing undergraduates participated in six-week research internships at Tufts University, titled "Polymer-Based Nanocomposites." My colleagues and coauthors represent the interdisciplinary team of instructors in this program. The goal is to prepare the students for participation in the scientific community, and provide positive scientific experiences at a formative time in their educational lives. The program included course work in polymer materials science, writing workshop, and scientific ethics. Manual sign language interpreters were provided for the classroom sessions. Most of the students' time was spent working in the research laboratory of the Polymer Physics Group. After an initial period of instrument training and lab acclimatization, the students concentrated on different aspects of the project. These included: nanocomposite sample preparation and treatment, and characterization using wide angle X-ray diffraction, thermal analysis, light microscopy, infrared analysis, and mechanical property measurement. The benefits, difficulties, and outcomes of the program will be described along with best practices for managing communications with deaf and hard of hearing students in the lab. We thank the National Science Foundation, Polymers Program of the Division of Materials Research, for funding this program through DMR-0406127. A web-site reporting results of the internships can be viewed at: http://www.tufts.edu/~pcebe

4:00 PM PANEL DISCUSSION III - Undergraduate Research in Materials Science

Participants: Carmen Huber (National Science Foundation), David F. Bahr (Washington State University), Chris Hughes (James Madison University). Moderator: Katherine Chen (California Polytechnic State University).