SYMPOSIUM PP

Communicating Materials Science—Secondary Education for the 21st Century

November 28 - 30, 2004

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* Invited paper
This workshop is designed to showcase materials science demonstrations in order to improve the quality of science education worldwide. The targeted audience consists of scientists local to Seattle and the greater Seattle metropolitan region. Materials Science and Technology is a curriculum developed at the University of Washington, supported in part by the Advanced Technology Education program at the National Science Foundation. The curriculum is designed to engage students and teachers in the study of materials science and technology, and in encouraging them to use scientific inquiry to solve problems.

### SESSION PP1: Education, Curriculum and Teaching

#### Students

**Chair:** Fionn Goodchild

**Monday Morning, November 29, 2004**

**Back Bay B (Sheraton)**

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<th>8:30 AM</th>
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<td><strong>Citizen Scientists – Advocate Educator, Dennis M. Bartels</strong></td>
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<td>President, TERC, Cambridge, Massachusetts</td>
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Former NSF Director Neal Lane spoke eloquently for the need of a cadre of "Citizen Scientists" who actively engage the public in the important questions of science, ethics, and civic engagement. This talk will develop further Dr. Lane’s notion of the Citizen Scientist to elaborate on a special case, which for the sake of a term will be known as the Advocate Educator. A historic tension in science education is the seemingly dual goals of universal science literacy and building a seamless pipeline into scientific careers. Some current trends suggest we may be retreating from our commitment to universal science literacy. Dr. Bartels will develop an argument that these two goals are inextricably linked and to allow one to diminish the other will create a significant crisis for this country's scientific enterprise. Much of the leadership and care for the health of the entire K-20 science education system needs to come from scientists, but lies well beyond more mundane participation, like the model of a scientist in a classroom for a day. The idea of an Advocate Educator may better serve the set of possibilities for scientists who respond to this call.

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<th>9:00 AM</th>
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<td><strong>Materials Science and Technology: A Curriculum That Works, Tom Stoops</strong></td>
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<td>and John Rusin</td>
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<td>1Materials Science and Engineering, University of Washington, Seattle, Washington</td>
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<td>2Engineering, Edmonds Community College, Lynnwood, Washington</td>
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Materials Science and Technology is a curriculum that works at Battelle Pacific Northwest National Laboratories, which emphasizes hands-on, minds-on studies of materials science and technology. The curriculum has been taught to over 1000 middle and high school teachers nationwide in a series of week-long institute programs, and is used in classrooms in 17 states. Evaluations have shown that the curriculum is highly effective in getting students interested in science and technology, and in encouraging them to study more science. This paper will give the basics of the curriculum and its approach. It will also discuss the types of venues used for promoting the curriculum and the teaching methods used. Full evaluation results will be discussed, including the assessment of increased student interest and increased student involvement in their own learning. Means of adapting the program to a local situation will also be reviewed. This program is supported in part by the Advanced Technology Education program at the National Science Foundation. Teacher educational programs are supported by NSF and by the ASM Educational Foundation. The commercial version of the curriculum is available from Energy Concepts, Inc.

### 9:15 AM PP1.3


Materials Science, Lehigh University, Bethlehem, Pennsylvania.

Given an authentic and relevant problem, how do learners who are given the opportunity to construct sharable artifacts engage in scientific inquiry and process knowledge? As result of their opportunity to construct, analyze and present, do students feel more ownership of the problem, their solution, and their solution process? Do they apply scientific problem-solving techniques using their artifacts? Do they share artifacts for analysis and are their presentations stronger when using their constructed artifacts? In an effort to begin answering some of these questions, fourteen groups of 4-5 sixth-grade students from within a typical northeast, US suburban middle school environment were asked to use scientific inquiry to formulate a plan for containing the deadly West Nile Virus that has been found in their county and to demonstrate their solution in front of their classmates. Students had access to two Web-based tools for solving this problem: the Web-based Inquiry Science Environment (WISE) and ImagiNations. WISE (http://wise.berkeley.edu) is a Web-based inquiry science environment. Through WISE, students had access to fifteen researcher-selected newspaper clippings about the West Nile Virus and two Websites deemed relevant for analysis of the problem. ImagiNations (http://www.lehigh.edu/imagi) is part of an outreach program intended to introduce K-8 students to electron microscopy and nanotechnology. Over a 2-week period, four 45-minute class periods were allotted to the problem-solving activity. Teams were encouraged to discuss their problem solving outside of class through online discussion using WISE-based tools. Students were also asked to journal their daily thoughts and activities through drawings, writings, and photos. Students were observed for the extent to which they related the problem they were solving to their lives, interacted with each other to solve the problem, applied new knowledge to solve the problem, and shared their artifacts with one another. In addition, the researcher interviewed the student groups, inquiring about their perceived level of problem and solution ownership, construction of artifacts, and perceived strength of final presentation. The researcher also interviewed the teacher for his/her impressions about the students sense of problem and solution ownership, construction of resources, accuracy in the scientific inquiry process, and students justification skills during this project. Finally, on the last day of the problem-solving activity, the researcher collected students journals and videotaped the groups presentations for subsequent qualitative analysis. A web-based module will be developed to (i) outline the scope of the problem and the problem-solving activity, the researcher collected students journals and videotaped the groups presentations for subsequent qualitative analysis. A web-based module will be developed to (i) outline the scope of the problem and the problem-solving activity, the researcher collected students journals and videotaped the groups presentations for subsequent qualitative analysis. A web-based module will be developed to (i) outline the scope of the problem and the problem-solving activity, the researcher collected students journals and videotaped the groups presentations for subsequent qualitative analysis. A web-based module will be developed to (i) outline the scope of the problem and the problem-solving activity, the researcher collected students journals and videotaped the groups presentations for subsequent qualitative analysis. A web-based module will be developed to (ii) present and analyze the results obtained from the study.

### 9:30 AM PP1.4

**Teaching Materials Science and Engineering through the Writing and Use of "The World of Materials" Essays. Paul R. Homell** |

Materials Science and Engineering, Pennsylvania State University, University Park, Pennsylvania; 2Education Institute, College of Earth and Mineral Sciences, Pennsylvania State University, University Park, Pennsylvania.

The author has developed an essay-based approach for teaching and evaluating Materials Science and Engineering, centered on the writing, and use of thematic essays, which have the grand title, "The World of Materials". The essays concentrate on one material only, e.g., salt (or sodium chloride) will be my prototype; and each essay is constructed around the four elements of Materials and Science Education: structure, properties, processing and performance. However, each essay also contains relevant societal and historical information on the use and importance of that material. For example, the crucial role of salt in the development of various trading centers in Iron-Age Europe are explored in the essay on Salt. Where appropriate, biographical information on persons who are associated with that material is also included in the essay. The essay includes several functions including: 1. They may be used to teach Materials Science and Engineering through an in-depth description of particular materials (specificity) rather than by the traditional route, which describes particular materials but conceptually engender concepts (generality). 2. In any one essay, which is written by teacher
or student, a student will be exposed to a broad range of scientific concepts, related to materials, minerals and Earth Science. 3. Students can be encouraged to develop their critical thinking ability, and the students find the experience of the real scientific research activity of initial level. Development of problem-solving abilities makes it possible to increase rate and quality of teaching, and the students find the experience of the real scientific research activity of initial level. Development of problem-solving abilities.
flocked to the Princeton Scientist demonstrations and the scientists learned about materials science and the scientists became skilled at public interaction and had fun in the process.

3:30 PM PP2.3
Materials Matter: Demonstrating Material Science to the General Public. Beth Tinker1, Andrew Greenberg1,2, and Ronald D. Redwing1,4; 1Center for Nanoscience, Penn State University, University Park, Pennsylvania; 2The Franklin Institute, Philadelphia, Pennsylvania; 3Department of Chemistry, The Pennsylvania State University, University Park, Pennsylvania; 4Department of Physics, The Pennsylvania State University, University Park, Pennsylvania.

Through a partnership with Philadelphia’s nationally renowned science museum The Franklin Institute and Penn State University, "Materials Matter: It’s a Nanoworld After All" has been produced and distributed to 22 science museums nationwide. Also provided are demonstrational materials and supplies to equip a show for a year at each museum. This 60-minute cart-based interactive exploration has been viewed by an estimated 300,000 (many of them school-aged) visitors in 2003. The show includes demonstrations and micro-scale models that explore the "macro" mechanisms behind the unusual and surprising "macro" behavior of materials such as aerogels, shape-memory alloys, polymers, electronic ink, and zeolites. A development team consisting of graduate students and faculty members worked with five members of the program development staff at The Franklin Institute to develop the show. We are currently working to produce a second museum show on nanotechnology to be distributed in the spring of 2005.

3:00 PM **PP2.4
The NanoKids Project. James M. Tung1, CNST, Rice University, Houston, Texas.

The NanoKids Project answers an intense need for innovative instructional materials that inspire and motivate students in grades 6 - 12 to learn nanoscale science and engineering, and at the same time, nurtures collaboration between research scientists, science educators, and school district curriculum administrators to develop and implement these materials. Core concepts of chemistry, physics, molecular biology, and their application in materials engineering are presented in 3-D animated lesson/adventures with original contemporary music, and reinforced in the interactive digital student workbooks that include learning-based video games and exercises. A comprehensive teacher guide, bilingual parent guide, and support website round out a total immersion concept. Aligned with state and national standards, the materials are integrated into existing curricula, and specifically address issues of diversity in learning and teaching. Formative evaluation results garnered by an independent firm from the pilot testing of the NanoKids materials in 11 middle schools and two high schools will be included in this presentation.

3:30 PM PP2.5
Exploring Materials Science with LEGO® Brick Models. Dean James Campbell Chemisty and Biochemistry, Bradley University, Peoria, Illinois.

Various physical and chemical principles related to materials science and technology can be demonstrated with LEGO® models. Three-dimensional models are excellent tools for grasping structure-function relationships. Additionally, many people are familiar with LEGO® bricks, and most models can be built with a level of mechanical sophistication that does not intimidate or frustrate the user. LEGO® bricks typically have many connection sites, allowing tremendous flexibility in the structures that can be built. The bricks can be used to model the structures of materials and the techniques used to study them. Many models can be built with varying degrees of sophistication, even incorporating electronics, enabling the user to focus on relatively simple concepts or more subtle details. The variety of models available also enables LEGO® bricks to fit into a variety of curricula. This presentation will feature models of the structures of materials, including unit cells, discrete molecules, and polymers. It will also feature models of analytical tools used to study materials, including models of a scanning probe microscope and a transmission electron microscope. Details of these and other models are featured in the book "Exploring the Nanoworld with LEGO® Bricks". This book may be downloaded from the Internet at: http://mrsec.wisc.edu/edetc/LEGO/index.html.

3:45 PM SPECIAL PRESENTATION BY HIGH SCHOOL TEACHERS

SESSION PP3: Coupling Materials Science Education with Research and Technology

Tuesday Morning, November 30, 2004
Back Bay D (Sheraton)
9:45 AM PANEL DISCUSSION WITH HIGH SCHOOL TEACHERS

10:30 AM *PP3.3
Multilevel Education Activities in Polymer Science and Chemistry: Multimedia Materials, Teacher Workshops, Undergraduate Research Center and NSF-IGERT Program.
Lon J. Mathias, Department of Polymer Science, University of Southern Mississippi, Hattiesburg, Mississippi.

Education resources and programs in polymer science and related fields are extensive at the University of Southern Mississippi (USM). Resources consist of multimedia materials in print and web or CD. Periodic workshops are held both at USM and at national meetings. On-campus programs include a new course (Living in the Material World) aimed at non-science majors. An example of the on-line resource materials available in the Polymer Science Learning Center (PSLC). The PSLC provides entertaining, multimedia polymer and materials education modules for K-12 and college students. The modules are also being designed for use in high school curricula. The Macromedia movie buffs can find out how polymers have been used in the film industry. Learners interested in life in the oceans can amble over to the Polyplankton to learn about polymers from the sea. Visitors who feel like sloth can help the PSLC mosaic Paul Lemur investigate who is behind the burning of the Polyplankton Playhouse. PSLC visitors also can participate in virtual expeditions such as The Story of Kennedy and L.Scott Chumley3; RJ Lee Group, Monroeville, Pennsylvania; Materials Science and Engineering Department, Iowa State University, University Park, Pennsylvania; RJ Lee Group, Phoenix, Arizona; Metals and Ceramics, Iowa State University, Ames, Iowa.

11:15 AM PP3.7
On the Use of "Flash Movies" for Instruction and Assessment in High School Science Curriculum.
Ralph H. Locklin2, Andrew J. Wisener, Michael W. Fleen1, Ian R. Harrison1, Eric J. Spielvogel3 and Paul R. Howell1,2,* Materials Science and Engineering, Penn State University, University Park, Pennsylvania; Schreyer Institute for Teaching Excellence, The Pennsylvania State University, University Park, PA 16802, Pennsylvania; *E-Education Institute, College of Earth and Mineral Sciences, The Pennsylvania State University, University Park, PA 16802, Pennsylvania.

Over the past several years, the authors have been developing a series of flash modules and on-line quizzing tools for use in teaching and assessing the fundamentals of Materials Science and Engineering. The original thrust was aimed at non-science majors at university, but the modules are also being designed for use in high school curricula. In the current presentation, we shall present our philosophy for the presentation and assessment of materials-related subject material, by describing two particular modules. The first, on Historical Aspects of the science of materials, and the second, on Electronic Materials. We will also describe the application of an on-line quizzing tool Perceptions, which allows us to embed Flash movies in our assessment strategy. We shall present examples of Drag and Drop questions, and we will also show that the quizzing tool can be an integral part of the educational process by providing rich feedback on questions related to the materials contained in the Flash movies. Finally, we will show how the teaching and assessment tools could be integrated into a high school curriculum.

11:30 AM PP3.8

RJ Lee Group (RJLG) is a small business that specializes in materials characterization including environmental, marine, and artificial forensics. RJLG has been developing the Schoolhouse Project combining the use of high-technology instrumentation and the problem-solving approach with the needs of science education. The objectives of the Schoolhouse Project include 1) providing students with hands-on experiences to pursue advanced education, especially in mathematics, computer sciences, engineering, and basic sciences; 2) providing technical assistance to teachers and students working on real world materials

952
students. Effective SEM simulation would retain the excitement of the science into the fourth and fifth grade science curriculum. The aim behind this approach is to increase the concepts is being conducted as part of a National Science Foundation of South Florida, Tampa, Florida; 3Department of Industrial and Management Systems, University of South Florida, Tampa, Florida.

An ongoing plan to integrate nanotechnology and material science concepts is being conducted as part of a National Science Foundation GK-12 project at the University of South Florida. The objective of GK-12 STARS (Students, Teachers and Research in Science) program is to foster systemic change in elementary by enriching math and science curricula and encouraging long-term professional development for teachers in the K-3rd. The program also aims to decrease the growing educational gap in science and math curricula prevalent among certain schools within the same school district, which is reflected in the outcome of the Florida Comprehensive Assessment Test (FCAT). The educational and material science module development and implementation in fourth and fifth grade. Both qualitative and quantitative assessments of the developed modules will be illustrated. Teacher training is a second aspect to the integration of this innovative approach. Teachers are scheduled for training sessions that introduce basic nanotechnology and material science concepts. The aim behind this approach is to increase the content knowledge of the participating teachers in cutting edge technology fields. The last program that aims at integrating nanotechnology and material science concepts in the proposed grades involves field trips to the university’s material research related laboratories (i.e. polymer chemistry, microscopy, nanotechnology, geotechnics) offered to students during the school’s periodic and research experience for teachers during the summer break. This paper summarizes findings compiled during the previous two years regarding the integration of nanotechnology and material science into the fourth and fifth grade science curriculum.


Tuesday Afternoon, November 30, 2004
Room 200 (Hynes)

1:30 PM **PP4.1 Improving Materials Science Education with Demonstrations. Amissa G. Ramirez and Amy Moll, 2Mechanical Engineering, Yale University, New Haven, Connecticut; 3Dept. of Mechanical Engineering, Boise State University, Boise, Idaho.
A collaboration between The Materials Research Science and Engineering Center (MRSEC) and the Integrated Science (IS) program run by the Center for Communication and Educational Technology (CCET) at The University of Alabama has been developing a computer game based approach to teaching Periodic Table concepts and facts to middle school students. We have targeted this audience because it is in the 5th-7th grade years that middle school students lose interest in science. The idea of using computer games as an instructional tool seemed a natural one given the popularity of such games with both genders in this age group. The team working on the project draws from MRSEC and CCET participants who provide content and direction for the designers and programmers. These teachers have been drawn from schools served by the Fall 2004 semester Plans for evaluation of the impact of the program on middle school students are currently in development and it is expected that a preliminary analysis of the evaluation data will be presented. Distribution to schools participating in the IS program will be through CCET. Meanwhile, distributing the program to other schools are still being developed.

3:45 PM PP5.3
Integrating Materials Science into the Uruguayan Curricula.
Lauren Forganc, Hector Espinoza and Gustavo Laborde; Compound Semiconductors Group, Faculty of Chemistry, Montevideo, Uruguay.

In a similar way than in other Latin-American countries, science, technology and innovation have played a less significant role in the Uruguayan development than in other regions. Historical, social and economical factors have brought out in the country a more humanistic than scientific oriented society. This fact had influenced in a variety of items, included the education. The Uruguayan curricula have a wider contribution of sciences, related to other Latin-American countries ones. However, basic sciences predominate in the high school curricula, in several university careers and also in the research activities (with some exceptions such as health and natural resources fields). There are only a few references to Materials Science in the academic work is being performed directly from one of the research institutions. The presentation will focus on the SJSU program, including computer modeling of protein folding, optical physics, quantum cryptography, and materials characterization. During the summer each intern becomes a member of a mentor's research group, does publishable research, attends a weekly seminar on research frontiers, attends an undergraduate summer school and an undergraduate internship program for undergraduates and teachers, many of whom are at ARC. These interns are joined by those from two other programs, one in partnership with the American Physical Society for Undergraduate Women) and one with the National Society of Black Engineers (Student Research Award IBM Research). Materials related research activities at ARC include: polymer synthesis, photolithography, thin film magnetism and polymer structures. There are only a few references to Materials Science in the program for undergraduates and teachers, many of whom are at ARC. These internships are being performed directly from one of the research activities. Over the last years, Masters in Technological Sciences have been integrated into the undergraduate curricula. They are usually immersed in other educational work is being performed directly from one of the research institutions. The games allow students to request hints, which provide a further avenue for the students to learn about the material. The game is currently approaching a beta version which will be tested on groups of middle school students during the current curricula and the proposal of the introduction of material science oriented to science education are being implemented in the schools.

4:30 PM PP5.5
Broadening Middle-School Student Images of Science and Scientists. Diandra Leslie-Pelecky,1,2, Shirley J. Mills3 and Gayle A. Buck1; 1Department of Physics, University of Nebraska, Lincoln, Nebraska; 2Department of Teaching, Learning and Teacher Education, University of Nebraska, Lincoln, Nebraska; 3Project Fulcrum, University of Nebraska, Lincoln, Nebraska.

One factor influencing K-12 students' decisions not to study science and engineering is the common perceptions of what scientists and scientific careers are really like. The 'mad scientist' stereotype is alive and well - and not an image most kids can (or want to) identify with. Project Fulcrum is a NSF GK-12 program that teams science, math, engineering, and technology (SMET) graduate students with middle-school 'Lead Teachers'. The program is designed to help future researchers understand the challenges of K-12 education and their place in addressing those challenges. The Role Model Project addresses the goal of broadening student images of science and scientists. Although teachers often do have scientists visit their classrooms, this project asked the teacher/students to gather information specific to their own classroom (and curriculum) that they felt would help narrow the gap. Along with the results of a pre-survey of student attitudes, to design their projects. Although all of the activities involved student visits, the implementation and the activities surrounding the visits were different so as to address the various student profiles. At one school wrote that "all scientists do is work," so the team had the students investigate the visiting scientists' hobbies and other outside interests. Students at another school felt that all scientists are 'nerds' or 'geeks'. These students were asked to guess whether classroom visitors were scientists and explain their reasoning in writing. These answers provided interesting information about the variety of student stereotypes. For example, one scientist was identified as a non-scientist because he was an engineer who had seen students sports injury and 'all scientists don't play sports'! Assessments developed by the teachers included having students make Venn diagrams that compare their interests and skills with those of the visiting scientists. Other teachers had students design posters comparing and contrasting the different types of scientists. Teachers wrote up their activities and reflected on how their assessments suggested changes for future activities. The Role Model Project provided an excellent opportunity for participants from the University of Nebraska MRSEC to share their research, as well as their personalities and outside interests, with middle-school students. Participating in the context of a broader project allows researchers' contributions, increases university/K-12 school contact, and allows assessment of the researchers' participation. This work was supported in part by the MRSEC Program of the National Science Foundation under Award No DMR-0213808 and the GK-12 program under DGE-0608358

4:45 PM PP5.6
"The Alchemist's Potions: A Journey into the Nanoworld." A Nanoscience Camp for 5th-8th Grade Students.

954
Using current interest in Harry Potter and Lord of the Rings as a portal into the magical world of nanoscience, student participants will discover the secrets of the Apprentice’s Stone. Ancient philosophers sought the wisdom of the Apprentice’s Stone recognizing it as the key to unlocking the connections between Art, History and Science. Each day at the Penn State Center for Nanoscale Science Department of Chemistry’s “School of Potions and Wizardry,” the Professors and Prefects in our prestigious Chemistry Houses guide students as they explore a different property of the stone through a set of related hands-on laboratory activities. Day 1: “What we see is not necessarily all that is there.” Activities: Putting the nanoscale in perspective Paints extracted from natural products Day 2: “Knowledge can induce change” Activities: Make magic wands using materials that change color when heated or exposed to UV radiation Create a mosaic and fresco from their own paints and natural materials Build polariscopes Day 3: “The power of attraction” Activities: Make a magnetic “etch-a-sketch” Build nanoscale motors using photolithography Day 4: “The power of selection” Activities: Growing mega zeolites Chromatography Day 5: Reversibility and Irreversibility” Activities: Creating scratch and sniff paint using microencapsulation Shifting shapes with shape-memory metals inks of invisibility