Computer Network Laboratory for Microscopy Education at the Materials Science and Engineering Department, The University of Arizona

Supapan Seraphin, Gary W. Chandler, and Michelle S. Switala

We report here on the first year of development of a novel teaching facility which incorporates new techniques designed to reach new audiences without diluting subject content. Interactive computer software coupled with rich scientific content of microscopic images provides a unique opportunity to help students learn science and technology. the laboratory is comprised of twenty student workstations networked to various microscopes, thus expanding the number of students capable of "hands-on" data acquisition and analysis by twenty times. Two scanning electron microscopes (SEM), a transmission electron microscope (TEM), and several light microscopes (LM) are interfaced through a server to the workstations. The laboratory is supported by the University of Arizona and the National Science Foundation, Undergraduate Education Division (Instrumentation and Laboratory Improvement Program) with generous donations of equipment and service from the following companies: Noran Instruments Inc., Sun Microsystems Inc., Nissei Sangyo America Ltd. (Hitachi), and Burr Brown Corporation.

University Efforts

Undergraduate and graduate courses are being developed at three levels of involvement: observational, analytical, and technical. In the observational level, in which the sample is the subject rather than the technique, exercises to convey the concepts of MAGNIFICATION and SCALE, and materials processing and materials selection are being developed. Already completed is a program simply titled *SEM Pictures*, which is a collection of SEM images of materials around us: human hair, Velcro, sweet&low, Stryrofoam, etc. The program is interactive in that users are asked to guess what some of the images are, and background is provided from a "materials science" perspective. Another program, *Donnelly*, incorporates images as part of an introduction to materials scientists and engineers and their activities by using the product line of a local company. Both software programs are also used as part of the outreach activities.

For the **analytical level** Noran x-ray and image analysis software is being used to develop exercises involving the microstructure and microanalysis of metal alloys, ceramics, polymers, composites, and glass. The major use within the department is a senior-level course on materials characterization which covers numerous techniques and will give students perspective on the principals, advantages, and limitations of each. A strength of the new approach is that techniques can easily be compared as all images, spectra, and their data is in similar format.

The **technical level** is designed for students who want to learn LM, SEM, TEM operation. The programs are also useful for students who took microscopy classes in the past and want to review operation procedure. Software program packages for SEM and TEM are designed to supplement hands-on sessions which familiarize students with the microscope controls and their corresponding functions. To facilitate learning and ease frustration, three features have been built into the programs: interaction opportunities, *Help* buttons, and animation sequences. Students are asked to interact by selecting or typing answers to questions throughout the programs. Students can then get immediate feedback to their responses by uncovering hidden answer fields by selecting appropriate "screen" buttons. *Help* buttons can also be selected to give more detailed information about current program topics, such as the physics behind the electromagnetic lenses. Finally, animation of processes observed on the microscopes, such as filament saturation, was added to make abstract concepts more concrete. While all of these features facilitate student learning, they are not the main reason students like learning microscopy in our computer lab. The students mostly like the fact that they can learn and practice whenever they want on the computers; they do not have to wait for microscope time or supervision.

The educational framework described above is flexible enough to also lend itself to fields outside materials science. Programs for anthropology, for K-12 education and for industrial education are being developed. The inherent appeal of

transferable images coupled with the technology of a current computer network is a major asset to educators at all levels. In the following section, we describe applications that have already been created for schools in the Tucson area.

Outreach Efforts

The American Association for the Advancement of Science's Project 2061 has published Benchmarks for Science Literacy, which is a tool for educators enabling them to design effective and necessary science curriculum. In Benchmarks, the AAAS makes recommendations for what students should be able to do in science, mathematics, and technology by the time they reach certain grade levels in order to obtain science literacy.[1] In the technology section, the teachers, administrators, and the Project 2061 staff of Benchmarks state: "The task ahead is to build technology education into the curriculum, as well as use technology to promote learning, so that all students become will informed about the nature, powers, and limitations of technology."[2] The computer Network Laboratory works towards accomplishing this task in three ways: creating Metacard and Hypercard "stacks" (programs that look like stacks of cards) on current local materials science research for high school students, training Tucson Unified School District (TUSD) science teachers to operate a scanning electron microscope and the computer software accompanying it, and designing activities and computer programs for groups of visiting middle- and high-school students.

Research done in Tucson is targeted for our high school stacks in order to demonstrate relevancy of subject matter and to help break scientist stereotypes. In each of these programs, a local industry or university product is examined from a basic science viewpoint and related to something the high school students are currently studying. For example, ions and electrochemistry were studied in relation to Donnelly Corporation's electrochromic glare-resistant rear-view car mirror; chemical bonding and isomers were studied in a stack concerning the fullerene research performed at the Materials Science and Engineering Department; and currents and thermal conductivity will be examined in a stack on Brush Wellman's Beryllium Oxide ceramics. The stacks are first written on Metacard and then rewritten on Hypercard, which can then be placed on disks and distributed to classroom computers. The stacks are filled with color and cartoons to illustrate processes, and are designed to make the presented material exciting to students.

The Science for All Americans' group feels that "anticipating the effects of technology is ... as important as advancing its capabilities."[3] The use of high powered microscopes and computer imaging and analysis is basic to many branches of science, and high school students should be exposed to such current, relevant, and widely used diagnostic techniques. To date, twenty TUSD science teachers have been trained in the operation of a Hitachi SEM and in the Noran software used to process images. During two summer workshops, these teachers obtained hands-on experience on the SEM, information and practice on capturing, processing, and storing images, and training on how to retrieve them from disks or over the network. The goal for the lab is real-time dialogue between a high school class and a microscope operator while the class manipulates their samples (through the operator) and captures their own images on the classroom computer.

The images the teachers took during their seminar were combined into a Metacard stack entitled "Summercamp," which is a colorful and interactive stack shown to groups of middle- and high- school and university students who toured the Computer Network Laboratory this spring and summer. A total of about 250 students visited the lab, from St. Peter and Paul School, Engineering Summer Camps, Academic Preparation for Excellence (APEX), and the Honor Center of the Learners Exploring Academic and Artistic Potential (LEAP), Research Experiences for Undergraduates (REU), and Pima Community College nursing students. The students were also given a mini lesson on the operation of a scanning electron microscope that employed a "working" model constructed of foam board, string, and rubber ball "electrons," given hands-on activities involving various materials, and shown another interactive Metacard stack on crystal structures.

Our research group shows women and minorities in strong positions and our activities make science relevant, fun, and accessible. We are committed to promoting science education and breaking stereotypes. ■

1 American Association for the Advancement of Science. Benchmarks for Science Literacy. Oxford University Press, Inc., 1993. page XI.
2 Ibid. pg. 42.
3 Ibid. pg. 41.