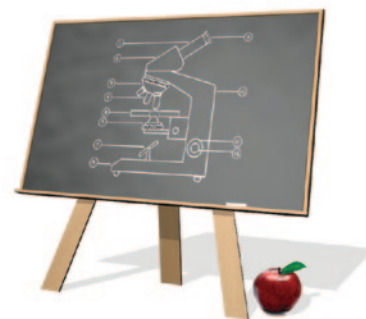


MicroscopyEducation

High School SEM Discussion Group: A Resource for Teachers and Microscopists

Margo Gill-Linscott, MSA Education Committee
RJLee Group, 530 McCormick Street, San Leandro, CA 94577, retired

Analytic.gilllinscott4@googlegroups.com



Introduction

Internationally, United States fifteen-year-olds scored 24th in science literacy and 28th in mathematics according to the Congressional Research Service March 2008 report.

Changes are occurring in high school education to address these issues. One component of this change, I believe, is that scanning electron microscopes (SEMs) are finding their way into middle and high school science programs through federal (NSF) and corporate sponsorship, university and community college partners, or parents and technical professionals (Figure 1).

Surveys conducted by the Air Force Research Laboratory, pre-1991, revealed that “teachers desired working with SEMs above any other scientific instrument” and that “students respond positively to hands-on work more than any other type” [1]. Since that time several SEM programs in schools were instituted, but they have been working in isolation. Now recent dialogue on the Microscopy Listserv [<http://www.microscopy.com>] has led to the organization of a discussion group, which reduces that isolation. The HS_SEM@googlegroup.com was established to provide a database of high schools with SEMs and

to encourage discussions between teachers, donors, mentors, advisors, and professional microscopists. Useful contact and resource lists are posted there as well.

Microscopy Programs in High Schools

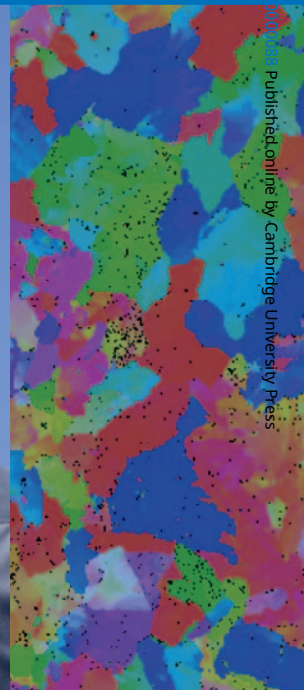
In-school programs involving microscopy with SEMs are promising, but they require funding and effort. As a first step, there are some virtual scanning electron microscope simulators (for example, <http://micro.magnet.fsu.edu/primer>, scroll to “virtual microscopy”). Although these simulators allow for interactive changes in magnification, focus, contrast, and brightness on a limited number of pre-recorded samples, they do not enable users to visualize their own samples and therefore cannot be used by students as part of inquiry-based projects. At many schools around the country, field trips, tutorials, short courses, web-based remote access, and mobile van and bus tours are currently providing an introduction to electron microscopy. The next step forward is the on-site electron microscope. We located several users of SEMs in high schools (Table 1), and most of these teachers and donors are now actively participating in the HS_SEM discussion group. Other schools with SEMs probably exist, and we would like to include them as well. To provide information about current SEM outreach programs, the following paragraphs describe some of the introductory programs based on- and off-campus.

Web-based programs. Universities with federal support, numerous corporations, and professional organizations have many K-12 outreach programs. Web-based programs have been popular. Examples are the WebSEM Project ExCEL (<http://websem.mse.iastate.edu>), Bugscope (<http://bugscope.beckman.illinois.edu/>), and the TelePresence Microscopy Collaboratory (TPMC) (<http://tpm.amc.anl.gov>). These programs provide a useful introduction to SEMs and are accessible to most high schools through internet connectivity. Control of a “remote-access” microscope such as WebSEM, Bugscope, or TPMC



Figure 1: June Poling's students from Valley Catholic Middle School in Beaverton, Oregon. Chandler Martin, 12; Abinaya Srikanthan, 13; Nivedita Mandal, 13; and Ryan Howerton, 12; are using their Hitachi 510 to create a mystery photo for a weekly school “Name the Object” competition.

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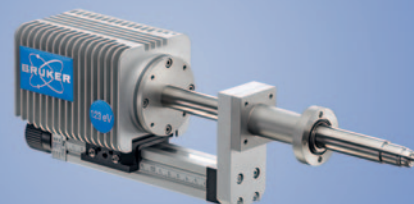
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Table 1: High schools known to have SEMs on campus.

High School Name	Town	State	SEM Make and Model	Approximate Instrument Age (years)
Arizona Agriculture & Equine Center (AA&EC)	Paradise Valley	Arizona	Cambridge 360	~22
Bergen County Academies	Hackensack	New Jersey	SEM: FEI Quanta 2003 D, (new) TEM: JEOL JEM2100, (new) Confocal: Leica TCS SP5 (new)	~2 ~2 ~2
Central	Philadelphia	Pennsylvania	FEI Phenom (new)	~2
Haldane Central	Cold Spring	New York	Zeiss DSM 940A	~16
Hudson's Bay	Vancouver	Washington	Amray 1000	~20+
Hunter	West Valley City	Utah	Amray 1200C	~14
Red Lion	Red Lion	Pennsylvania	ETEC Autoscan	~36
Lane & Douglas County	Drain	Oregon	FEI Phenom (new)	~2
Valley Catholic	Beaverton	Oregon	Hitachi S-510	~20
West Greene	Waynesburg	Pennsylvania	ASPEX eXpress (new)	~2

offers experience in moving the specimen stage, magnifying, and adjusting the various controls for focus, rotation, or tilt, through on-screen boxes, drop-down menus, and other screen directions.

Bugscope, one of the more successful programs, began in March 1999 and has interfaced to 200 schools with 300 sessions; 5000 students used it by 2005. They offer training and sessions in one-hour blocks. Sample preparation is performed by laboratory personnel, after receipt of the specimen by mail. Bugscope offers a “chat room” so users can ask questions about what they are seeing and has several libraries of SEM images available for review [2].

Issues with web-based access, such as connectivity, scheduling time, and the transitory nature of teacher jobs, still exist in this approach. The problems involved in using these programs have been discussed by Chumbley and Chumbley in a recent article in *Microscopy Today* [3]. Successful, long-term relationships do exist between Web-SEMs and high schools, which indicate that microscopy over the web will continue to be a resource for many schools in the future. The website <http://www.microscopy.info> has links to many of the web-based sites. Issues aside, this is a great first step.

Other programs. The Forensics Mentors Institute, Willow Grove, Pennsylvania, is a charitable foundation funded by grants from the American Chemical Society. It began operation in 1994 and has provided an eight-week summer “science adventure program” for disadvantaged students for the last 11 years. This hands-on exploration program, guided by advisors and mentors, uses the SEM for problem solving. This program reaches 12 high school students a year. Many of these students have gone on to colleges and universities as listed in their FMI 2007 Newsletter [4].

The Princeton Institute for Science and Technology of Materials in partnership with Rutgers University and AMS International (Association for Materials Science) is one of several institute/university affiliations that offer an intensive one-week course for teachers as an introductory overview to microscopy and its uses. Programs like this provide a critically important background for the few teachers who are able to attend.

After-school programs and SEM-bus program. Alfred University, in collaboration with the Air Force Research Laboratory, began a program called SEMED in 1991. This program provided students and teachers access to their SEM laboratory after school for two sessions a month. The students (grades 8–12) were required to prepare samples and operate the SEM under supervision during nine one-hour sessions. The program changed in 2005 due largely to the 9-11-2001 incidents: they now have a specially designed bus with multiple SEMs that they drive to various schools to continue their program [5].

Future thinking innovation. A breathtakingly innovative school, Bergen County Academies High School in Hackensack, New Jersey, is a well-funded regional science and technology “magnet” school, and it is showing other schools, administrators, and students a way to proceed in the future. This school is organized to address frontier technologies such as nano-technology and stem-cell research [<http://bcts.bergen.org/stemcell/>]. Training students with state-of-the-art equipment, this school houses an advanced dual-beam FIB/SEM, a TEM, and a confocal light microscope, in addition to other tools required for current research. The school partners with Fairleigh Dickinson University, is funded through county and Perkins Grants, and collaborates with the Sloane-Kettering Medical Institute for Stem Cell Research. It doesn’t charge for instrument time but requires student involvement in all efforts. The laboratory is staffed by medical professionals. Students are engaged, they are excited, and they are learning to manage real-world responsibility and opportunity. These students will be well-prepared for the next step in their education.

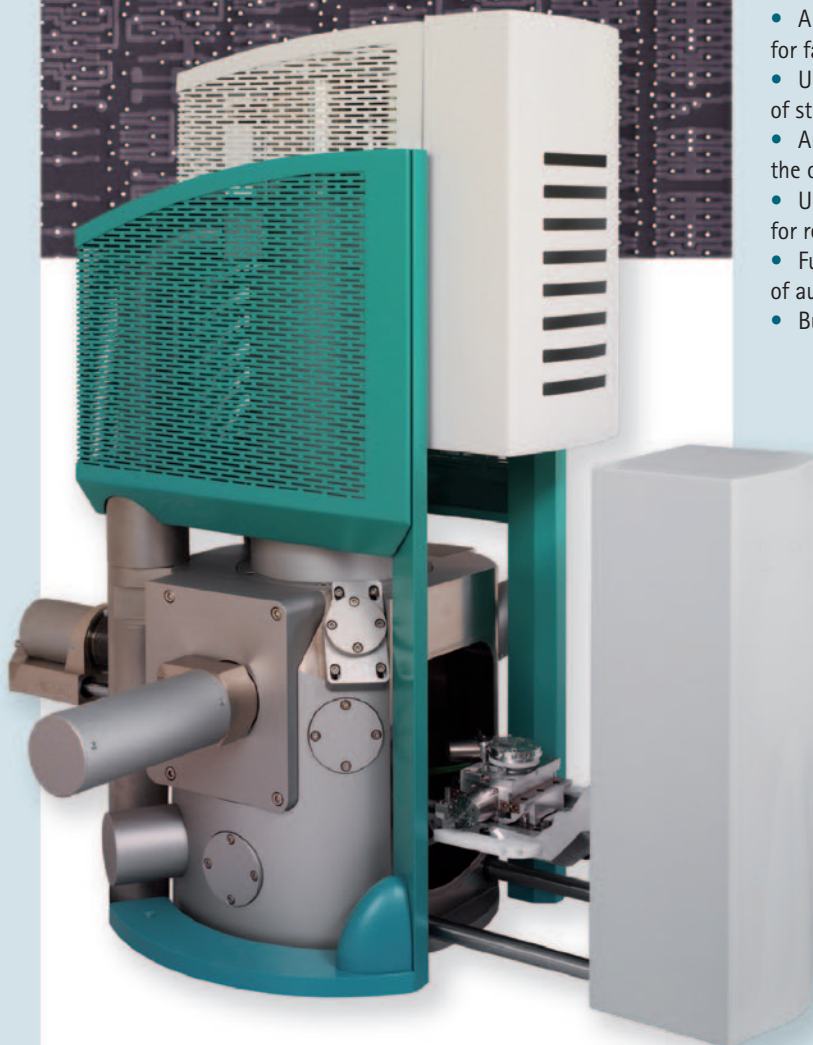
Are we there yet? In the last 20 years, there have been many microscopy education sponsors and many separate start-up programs from web-based SEMs to SEMs on a bus. We know that images of an “other world” capture the imagination and ignite a spark of curiosity. But are we reaching enough schools and students? The short answer is: NO! We aren’t reaching nearly enough of them! How can we extend programs like this to reach more of the 16,637,400 students [6] in the 26,500 secondary schools (2006–07) in the United States?

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The HS_SEM Group Outreach

Member survey results. As an introduction to the information-gathering process for the HS_SEM discussion group, a survey was issued to incoming members to establish a baseline of experience and needs. Seven responses were received representing four schools. All reported that their SEMs are used primarily in biology but are available for anyone with basic operational training. In Cold Spring, New York, for example, the SEM programs centers on forensics. Survey responses stated that even for the older machines only routine maintenance has been required.

Scanning electron microscopes are used extensively in science fair projects. The Paradise Valley, Arizona, high school has a full-semester program on microscopy according to Mike Brown, science department director (Figure 2). Several of their students recently presented posters at the International Plant & Animal Genome XVIII Conference in San Diego, California. (January 13, 2010). Bergen County participates in and has had seven finalists in the prestigious Intel International Science and Engineering Fair, and one of their students presented an SEM poster paper at M&M '09 in Richmond, Virginia. Heather Fogell, Red Lion, Pennsylvania, is seeking to exchange the use of her SEM with a college that might need access to an SEM, allowing her students to experience research firsthand.

Invitation to join. If you are a teacher currently involved in using an SEM, are interested in expanding your high school program to include an SEM, or are a microscopist and would like to contribute to a high school program, please join the HS_SEM google group [Group address: hs_sem@google.com; URL: http://groups.google.com/group/hs_sem/].

Conclusion

The number of high school students being reached through current SEM programs is very small relative to the total student population and number of secondary schools in the US.

If the leaders of this country are really serious about changing the way we teach technology, we need to take revolutionary steps and become innovative—not just for one school, but for all.



Figure 2: Mike Brown's student, Jessica Keller, from AA&EC High School, Paradise Valley, Arizona, using a Cambridge 360 SEM.

References

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- [2] Bugscope: <http://bugscope.beckman.illinois.edu/>, Imaging Technology Group, 2007. (The Imaging Technology Group is part of the Beckman Institute for Advanced Science and Technology at the University of Illinois.)
- [3] A Chumbley and LS Chumbley, *Microscopy Today* 18(1) (2010) 42–45.
- [4] The Forensic Mentors Institute (summer 2007): <http://www.frfoundation.org/newsletters.html> (2300 Stratford Ave. Willow Grove, PA 19090, 215-784-9281, frfoundation@verizon.net)
- [5] <http://www.egr.msu.edu/~boehlert/SEMED/Boehlert.pdf>, CJ Boehlert, "Materials Engineering Education through Service Learning Involving Scanning Electron Microscopy Education", Michigan State University, Department of Chemical Engineering and Materials Science, *Proceedings of the 2005 ASEE North Central Conference*, 2005.
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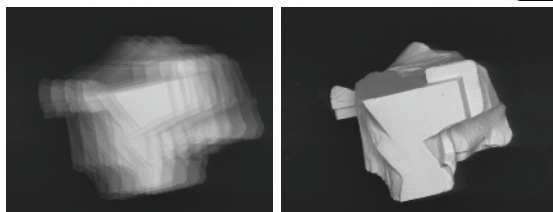
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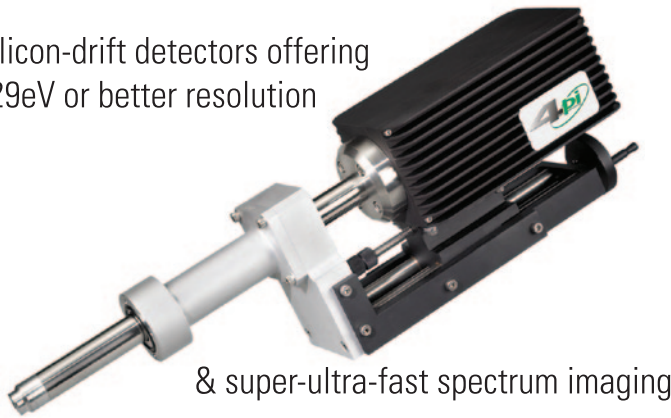
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