

Online Microscopy Lab Training Modules in an Academic Environment

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Introduction

The Applied Chemical and Morphological Analysis Laboratory (ACMAL) is a multi-user, multi-disciplinary characterization laboratory. ACMAL houses two scanning electron microscopes (SEM and FE-SEM), a transmission electron microscope (TEM), focused ion beam milling system (FIB), four X-ray diffractometers, and an X-ray fluorescence spectrometer [1]. ACMAL operates as a recharge center where users absorb facility operation cost through an hourly use fee. As such, we are keenly interested in encouraging broad access to the facility by lowering obstacles to users. Facility training enhancements provide the best pathway to productive and responsible facility usage.

Michigan Technological University (Michigan Tech) is a research-focused institution, drawing students from many countries into the graduate program. International students arrive at Michigan Tech with varying degrees of English language proficiency, as well as varying amounts of exposure to complex instrumentation. Even domestic students struggle with high level terminology and procedures associated with this equipment.

As a basic requirement for facility usage, academic training courses for credit are in place: Introduction to Scanning Electron Microscopy, Advanced Scanning Electron Microscopy, and Transmission Electron Microscopy. These focus on practical issues of instrument operation. Courses are offered to undergraduates in the fall semester, with an accelerated version for graduate students in the summer. Electron microscopy is inherently interdisciplinary. Registration flexibility allows for participation by students of different majors and aptitudes. We notice that students achieve varying degrees of success with these courses; some students excel while others struggle with basic operational steps. Furthermore, we observe a correlation between English language proficiency and successful completion of the training courses.

To help bridge the language gap, we are adopting more visual media to enhance learning, including photos, illustrations, charts, and diagrams. To reduce intimidating barriers associated with scientific and technical complexity, animated and interactive learning media are combined with the text content and still images [2]. This content is compiled into an online learning resource. The topics are referred to as eTraining modules. They are available informally and on demand as enhancements to the formal course learning. Having the option of building our own modules allows for accuracy specific to our lab environment [3] and permits updates as needed.

Involving Michigan Tech students in the module-building process allows our majors to develop high level technical communication skills.

The modules offer several advantages as virtual training tools. The self-paced exploration permits reinforcement of concepts, and the instant access speeds learning goals. Users gain confidence in practical areas, such as operating control panels, preparing samples, troubleshooting technical issues, and identifying scientific artifacts. User confidence is often a problem when lab access is limited. Successfully trained users lessen the burden on lab staff, leaving staff free to focus on applications support, equipment maintenance, and lab management. Providing interesting, publicly available content at a high school level may help attract college-bound students into STEM fields [4]. Finally, virtual tools of high academic quality and practical functionality attract attention that stimulates interest in our program and facility.

The Collaborative Process

To build the modules, we coordinate a working group which includes the facility director and electron optics engineer, a web media specialist, and several undergraduate students of varying majors. Students are generally recruited at the sophomore level, and they also serve as lab assistants. The project receives occasional feedback and oversight from faculty, graduate students, and external collaborators. The undergraduate students are called upon to assemble the raw content. They write procedural steps based on existing documentation in the labs. They take photos of instrument exteriors, interiors, and control panels. The students videotape procedures within the labs (Figure 1(a)), record voiceover narration, and capture software demonstrations.

Perhaps the most difficult stage of the collaboration is writing the introductory science background. This text is gathered from numerous sources and revised by several parties in the working group. Our initial efforts sometimes lacked a consistent procedure for revision. To ensure originality of content, we take advantage of the Michigan Tech's account with Turnitin, providers of plagiarism

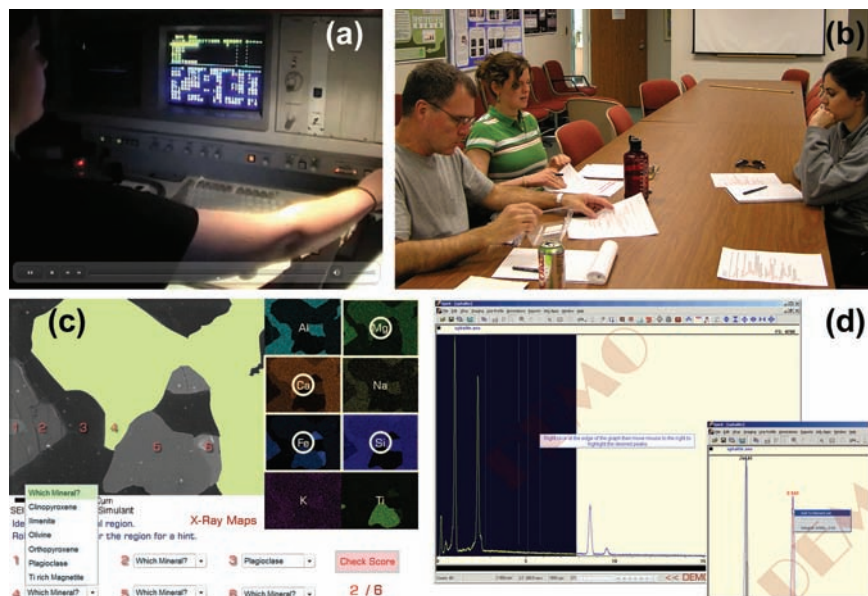
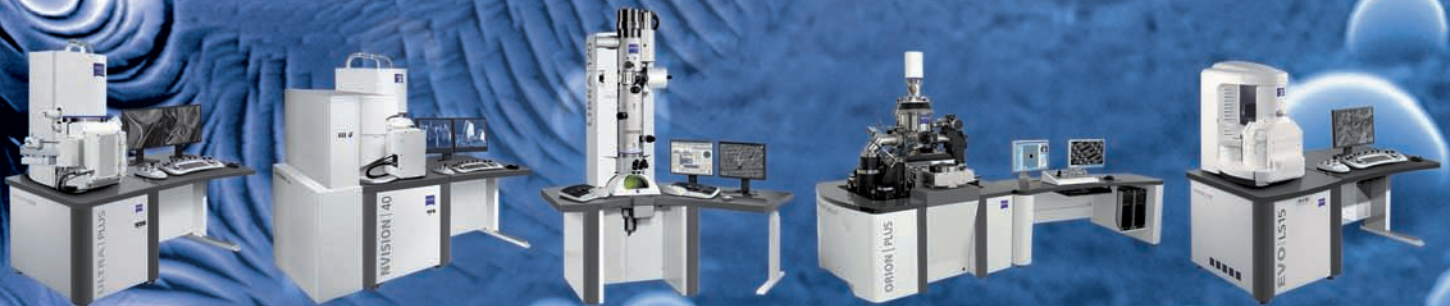


Figure 1. (a) Students videotape demonstrations on the JEOL-JSM 6400 SEM. (b) Working group meetings vary with the academic season. (c) An interactive challenge is provided for module user self-assessment. (d) A screen capture utility is used for demonstrating the spectrum analysis software Spirit.

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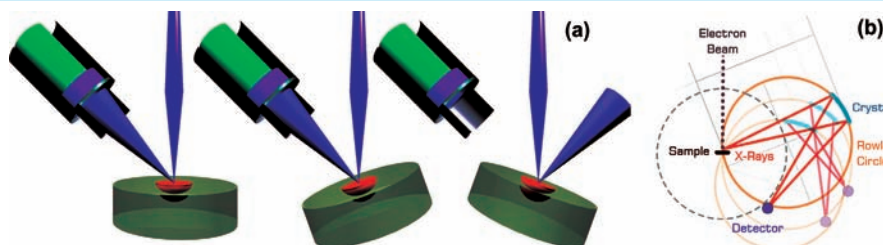


Figure 2. (a) Inexpensive 3D software is used to generate perspective views of the sample and detector, showing sample geometry impact on detection efficiency. Such illustrations are used in sections on troubleshooting and recommendations for analysis conditions. (b) Still capture overlays indicate an animated process used to clarify the detector configuration.

prevention software tools. The target reading level is high school, grades 9–12. We adopt the Flesch–Kincaid tests to check reading ease and grade level. Scientific and technical terms are replaced with their glossary definitions for this assessment. The Java utility Flesh 2.0 is used to analyze text documents and calculate their Flesch–Kincaid Grade Level and Reading Ease Score [5].

Owing to student turnover, the working group varies in size (Figure 1(b)). During peak collaboration sessions, we adopt a private online forum to readily post text for group revision. This is especially helpful in stockpiling glossary terms and definitions. It also serves as a style reference for scientific and technical spelling and nomenclature. Adoption of a style manual is recommended for longer-term projects.

Throughout the collaborative process, we strive to build consistency into both the revising procedure and the final product. Students are asked to assign meaningful titles, file names, revision dates, and authors to documents circulated within the group. Work is concretely tasked out to individuals at each stage, and target deadlines are proposed for every section of the build. This has been tremendously helpful in achieving responsible and rapid results. Timelines and regular work meetings help students to stay on track with their other academic commitments. The students excel, often producing graduate-level results. The team was able to deploy the first module within a few months of the first work group meeting.

In total, we use a group mailing list, periodic meetings, open source wiki and forum web technologies, and a simple web portal for assisting in organizing the work. The web portal organizes group projects, drafts, to-do lists, collaborators, and revision information. A course content management system would also serve as a useful collaboration sandbox for academic module authors.

Compilation

Raw content is turned over to a web media specialist for compilation into web format. The amazing spectrum of desktop software now available for media creation and editing allows educators to communicate in a realm once dominated by film and television industries. Scientific and technical illustrations and animations are created using the Adobe

Web Premium CS3 suite. Photos are edited and optimized for the web using Fireworks. Flash is used for designing animated schematics and processes and for constructing interactive demos. We have begun self-assessment for the learner with a Flash-based X-Ray Mapping Challenge (Figure 1(c)). More opportunities for self-assessment are planned for the topics. A separate Adobe product, Captivate, is employed for the creation of software demos (Figure 1(d)). The entire package is compiled with the use of helpdesk software, Adobe RoboHelp 7.

Flash is a tool of seemingly boundless functionality that probably lends the most engagement for users of all backgrounds. It requires a skill level that may be found amongst the computer science or technical communication majors. The simplest use of Flash is as an easy drawing tool for illustrations, which can be exported as still images. Adobe Illustrator also serves this purpose, and Electric Rain Swift 3D 5.0 is used for rendering static and animated 3D objects to a vector format. A sample illustration shows a colorful perspective view of a specimen in the Energy Dispersive Spectrometer (Figure 2(a)). We also create simple animations, such as the off-center pivot rotation of a crystal and detector around a Rowland Circle in the wavelength dispersive X-ray spectrometer (Figure 2(b)). It is perhaps the only animated version of this well-known diagram. More importantly, we are able to create interactive “tours” of the equipment using photos and illustrations of the instrumentation (Figure 3). Users can mouse over the images to see labels, descriptions, and a zoom view. They can change scenes to study the parts of the microscope or the panel controls.

Video is converted to the Flash video format (FLV) using Flash Video Encoder. That allows us to combine video, text, inset video for details, and vector illustration overlays in one interactive Flash exhibit. The FLV codecs constitute a high quality for the download file size. This is crucial for web dissemination, attracting a broader audience than can be obtained by publishing on disk. For software demonstrations, the students use Captivate to record screen activity and export it to the Flash format. Captivate does not require specialized animation skills.

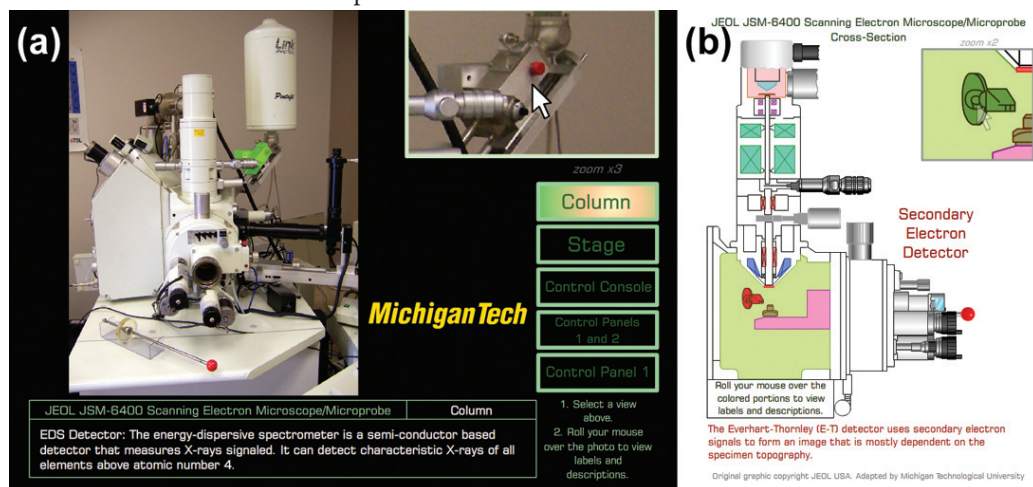


Figure 3. Interactive equipment “tours” allow users to explore components by mousing over images of parts. A text dialog and zoom window display details. (a) The photographic parts tour of the JEOL-JSM 6400 SEM has multiple scenes for the column, stage, control console, and control panels. (b) The illustrated cross-section tour of the SEM relies on color to highlight component areas. The diagram was reproduced from the instrument manual with the permission of the vendor.

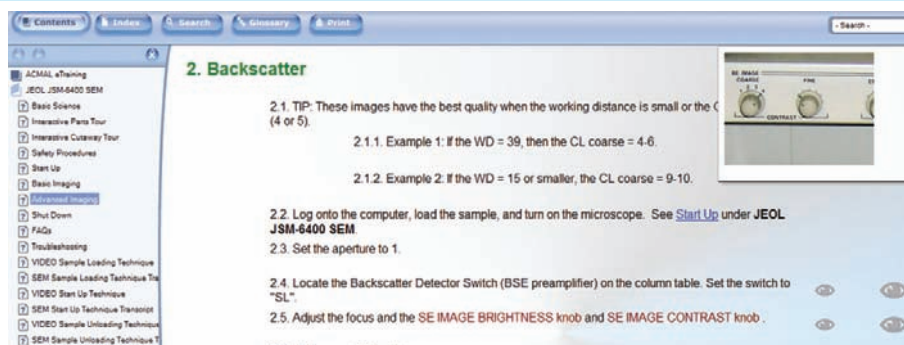


Figure 4. The RoboHelp interface shows the table of contents, dashboard panel, sample procedural steps, a popup image, a topical cross-link, and expandable glossary terms.

A major advantage to using the Flash format is its multi-platform browser plug-in. This allows us to reach a broader audience and to maintain the lightest client requirements. Wherever possible, basic alternative content is provided. This generally takes the form of a text transcript or screenshot.

The illustrations, photos, Flash animations, and text are all imported into web pages. In our case, helpdesk software was needed to keep track of an expanding set of glossary terms that is shared across the modules. We selected RoboHelp for this reason and also because of its flexible export options. Web editing experience is desirable but not necessary for learning RoboHelp. The primary format is a set of web pages with a Flash menu, referred to as Flash-Help. We also export a secondary format, WebHelp, which has a lighter interface. It can be downloaded and viewed offline. Other export formats are available.

The final package consists of a set of modules, each of which is composed of several topics (Figure 4). These constitute the table of contents. There is a shared standalone glossary, and glossary terms are also expandable within the text blocks on the page. Images are distributed throughout the text. For procedures which are text-based instructions, icons for popup images are positioned near most of the steps. The small icons don't interrupt the flow of the step sequence, which is often the case when procedural steps and screenshots are combined. Animations are embedded in the pages with the other content. RoboHelp has an index wizard, and the exported set of web pages is fully searchable. The topics are cross-linked as needed.

To aid the learner, we begin each module with a basic science introduction. They can then proceed sequentially through the tours and procedures, or jump to frequently asked questions or media demos. A support module is included to cover web client system requirements, lab safety procedures, alerts, disclaimers, and copyright information. The media components are released under a Creative Commons license [6] to help stimulate interest in electron microscopy by other educators.

Deployment

As these modules need to be compiled by RoboHelp, they are less readily updated than normal web pages. The group maintains a public version, posted on the facility website, and a draft version, posted on a demo website. Rapid communications for facility users are instead conveyed using the facility website or the facility wiki until that information can be absorbed into the next module version.

The modules are freely accessible by anyone. The target audience consists mainly of graduate students who are facility users on

campus. Beginners are able to study technical material on demand, without the pressure of a structured course timeline [7]. More experienced researchers with sporadic facility usage can get a refresher at any time. Younger students can access the material with a web search, giving them a sense of the world of microscopy as they begin to make career choices.

The first version was deployed in October 2006 after a summer of work by the group. It contained the JEOL JSM-6400 SEM and Support modules. The most recent version also has Microanalysis and Sample Preparation. Web traffic has grown steadily, attracting dozens of new visitors each month. Future modules are intended for the FE-SEM, FIB, and TEM instruments. More formal integration with the microscopy courses is being introduced. We have been receiving positive feedback from module users.

Conclusions

We have found a strategy for building lab training modules over a long term. Our method takes advantage of academic resources and works successfully within campus community cycles. The technical template is both modular and integrated, allowing for expansion of a cohesive set of training topics in electron microscopy. Student assistants learn a great deal about the equipment and its operation during the process of compiling training content. This increases their competency as lab staff as well as preparing them for graduate school or employment in the commercial sector. ■

Disclaimer

Michigan Tech is not affiliated with any of the software vendors mentioned in this article. Many alternative software solutions are available to the would-be module builder.

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