

## An Interactive and Adaptive Online Electron Microscopy Education Platform

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Electron microscopy skills are valuable in today's workforce, with increased demand anticipated in the near future. However, such skills are difficult to acquire due to the need to train on expensive equipment under instructor supervision. Existing online education approaches are limited by class size [1] or fail to support a full range of microscope operations [2]. Portland State University has developed web-based electron microscopy education software: the Online Electron Microscopy Platform (OEMP).

The OEMP is a website that uniquely integrates electron microscope simulators with more traditional classroom content, such as lectures and homework. There are no limits on how many users may access the OEMP at once. From the main page (Fig. 1), users can customize their syllabus, select a virtual specimen to view in a simulator, resume using a simulator with their last selected specimen, or contribute specimen data, specimen images, spectra data, or lectures. Currently students may only access the transmission electron microscope simulator, but other simulators are planned for future development.

The simulator (Fig. 2) display replicates the layout of actual electron microscope operation software while offering an unprecedented range of functionality. The simulator includes an interactive diagram of the microscope column, simulated controls and apertures, and educational content. Students can operate the microscope in imaging or diffraction modes and control attributes of the specimen stage, electron beam, and camera. Students may also perform alignments and analytic techniques such as energy-dispersive x-ray spectroscopy and electron energy loss spectroscopy. Imaging mode shows modified specimen images, while diffraction patterns and spectra are generated from models. Educational content includes presentations, quizzes, Q&A, animated examples, the student's syllabus, a notepad, group chat, help, and other guidance. The site supports dynamic content updates via user submissions.

To test the effectiveness of the OEMP as an educational tool, we made it available to students in a transmission electron microscopy class at Portland State University. We tracked usage and progress in the simulator and surveyed students on their experience using the OEMP. Students considered the OEMP to be helpful, with one stating that "the simulator greatly improved my learning outcome."

Future development includes improved support for multi-element specimens; simulators for other instruments; and case studies, where student perform experiments using specified techniques [3].

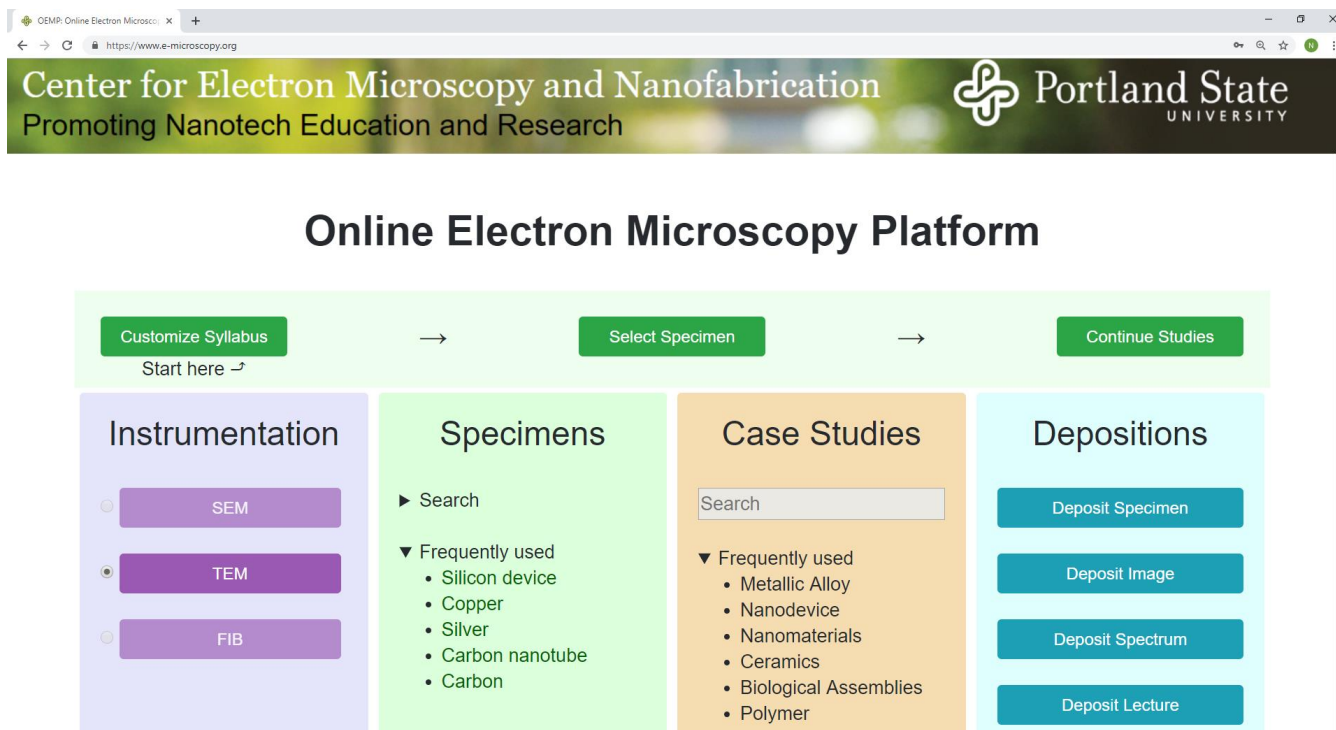
### References:

[1] DE Huber et al., *Microscopy Today* **26** (2018), p. 26.

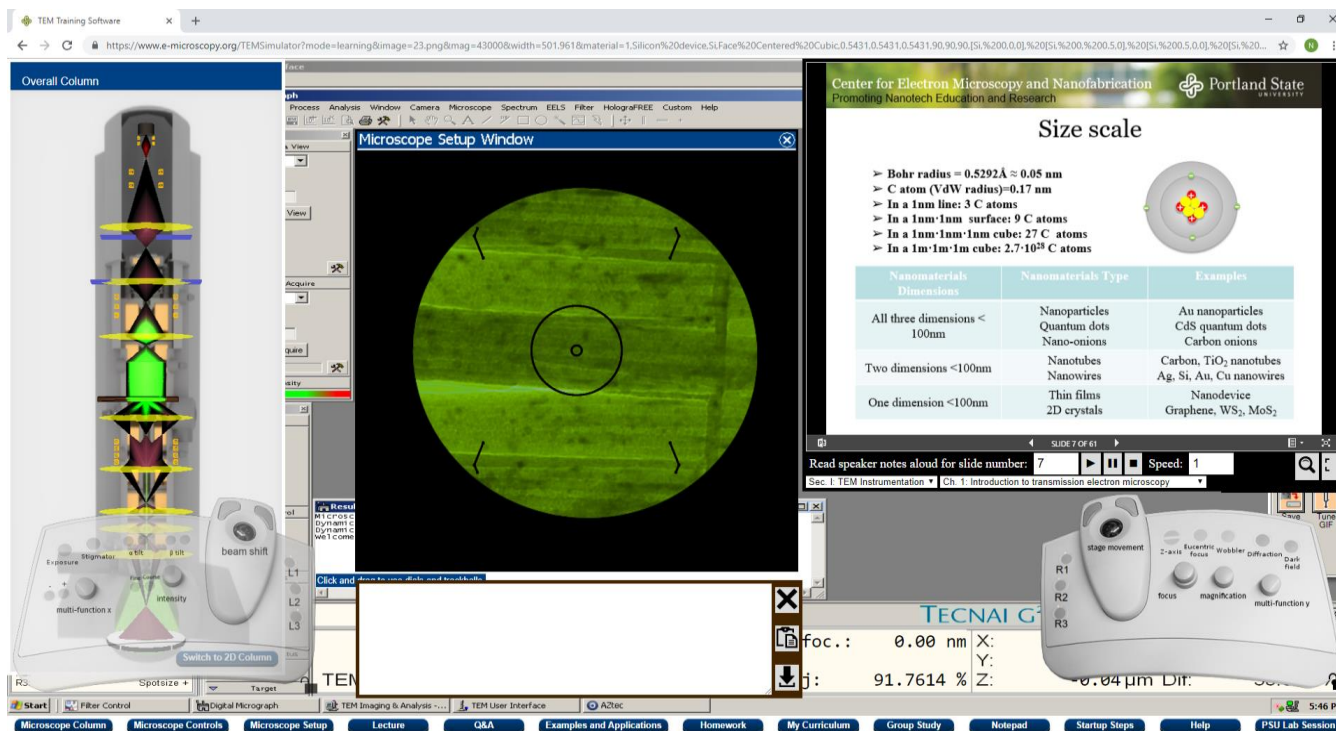
[2] Virtual TEM – Diffraction and advanced imaging | MyScope,

<https://myscope.training/legacy/tem/practice/virtualtem/advanced.php> (accessed February 11, 2019).

[3] The authors acknowledge funding from the W. M. Keck Foundation and thank Thermo Fisher Scientific (formerly FEI), Oxford Instruments, and Gatan for their support.



**Figure 1.** Main page of the Online Electron Microscopy Platform website. From here, users can customize their syllabus, select (or search for) a virtual specimen to view in a simulator, resume using a simulator with their last selected specimen, or contribute depositions to the platform.



**Figure 2.** Transmission electron microscope simulator page. Visible user interface elements include Microscope Column, Microscope Controls, Microscope Setup, Lecture, My Curriculum, and Notepad. Interface elements may be opened, closed, and moved. Lecture window includes search and audio notes.