

Michigan State Integrates MATLAB into Engineering Curricula to Foster Student Proficiency in Problem-Solving Using Computational Tools



Dr. Daina Briedis with a student in the lab.

To solve engineering problems in industry, engineers need a strong technical background combined with the ability to apply computational tools. Undergraduate engineering curricula traditionally provide the former, paying less attention to the latter. As a result, not enough engineering students build confidence in their abilities to analyze and solve practical engineering problems computationally.

The College of Engineering at Michigan State University (MSU) recently worked to integrate MATLAB® more into the curriculum across several undergraduate engineering programs. In these programs, students now use MATLAB in at least one course per year, consistently building expertise. Because students are not spending time learning and relearning disparate general-purpose computing tools, professors can teach more and increasingly sophisticated engineering concepts.

“Our vision is to attract and develop passionate engineering students who are well-equipped to make a difference in the world,” notes Dr. Satish Udpa, dean of the College of Engineering at MSU. “That vision includes MATLAB integration throughout the entire engineering curriculum. This will enable a holistic teaching-and-learning approach where students can readily transfer skills within their coursework and beyond, into industry.”

The Challenge

During a recent program improvement assessment cycle, as required by ABET, Inc., faculty in the MSU chemical engineering program found that students showed

below-threshold performance in applying math and computing tools to problem-solving. Further investigation revealed that students did not see early computing and math courses as relevant to the engineering curriculum or to the engineering discipline they planned to pursue.

Variable use of computing tools throughout the engineering program made it difficult for students to develop confidence and consistent expertise. Students often resorted to cookbook approaches to assigned tasks, which are less effective in helping students apply their skills on authentic engineering problems. “Without systematic and repeated use of a computational tool throughout the undergraduate years, students spend additional time relearning the tool when solving a rich problem, instead of focusing on the concept the faculty member wants them to learn,” explains Dr. Daina Briedis, associate professor, Chemical Engineering and Materials Science, at MSU.

The Solution

Several faculty members in the chemical engineering program at MSU integrated MATLAB across the undergraduate curriculum, using it during required courses in all four years. Recognizing that curriculum changes require faculty support, MSU provided faculty with MATLAB training, video tutorials, and direct teaching assistant support for developing problem sets.

Integrated curricular changes build on the first-year course, Introduction to Engineering Modeling, which covers the basics of MATLAB and Symbolic Math

The Challenge

Help engineering students build confidence in their ability to apply computational tools and better prepare them for industry and postgraduate study

The Solution

Integrate MATLAB and Simulink throughout the engineering curricula, enabling students to consistently build upon their previous experiences

The Results

- Students better prepared to meet industry demands
- Program outcomes and student skills improved
- Teaching accelerated in higher-level courses

“Our environment of choice for problem-solving at the undergraduate level is MATLAB. We selected MATLAB because it is suitable for a broad range of problems and because it is becoming the de facto standard in many university engineering programs, reflecting the increasing use of MATLAB in industry.” —DR. JON STICKLEN, MSU

Toolbox™, including vectors, scalar computations, graphing in two and three dimensions, and solving symbolic math expressions. In this course, students also learn fundamental programming concepts such as functions, loops, and conditionals, which they use to create simple simulation models.

In Modeling and Analysis of Transport Phenomena, second-year students in chemical engineering use MATLAB to solve ordinary and partial differential equations, as well as to model the transport of energy, fluids, and momentum in a variety of systems. The third-year chemical engineering course Mass Transfer and Separations expands on the use of differential equations in MATLAB to model distillation, absorption, extraction, and multicomponent separation processes.

In Process Control, fourth-year students use Simulink® to learn the basics of control theory and system dynamics. They also plot root locus diagrams in MATLAB to analyze stability of their control systems. Students must also use MATLAB and Simulink during one of the course’s exams.

Based on the success in chemical engineering, and with support from the National Science Foundation’s CPATH Program (award number CNS 0939065), MSU is targeting the civil engineering and chemical engineering programs for the development of modules that enhance computational competencies of graduates. This effort is driven by input from industry and features the use of authentic problems.

The Results

Students better prepared to meet industry demands. “MATLAB enabled us to achieve our goal of producing graduates with better computational capabilities,” says Dr. Jon Sticklen, associate professor and director of the Center for Engineering Education Research at MSU. “Students are proud to cite their MATLAB experience on their résumés, because they know industry is looking for it.”

Program outcomes and student skills improved. “As we integrated MATLAB throughout the curriculum, the assessment scores for student work steadily improved until they met or exceeded our thresholds,” says Dr. Briedis. “The students also reported higher confidence levels in their abilities—and when students believe they can complete a task, they generally will.”

Teaching accelerated in higher-level courses. “The efficiency that I have now when teaching fourth-year students is incredible,” says Dr. Briedis. “MATLAB is a common language we all speak. I don’t have to waste time bringing them up to speed, and as a result I can get much deeper into the subject material than in years past.”

Industry

- Academia

Application Areas

- Data analysis
- Mathematical modeling
- System design and simulation
- Control systems

Products Used

- MATLAB®
- Simulink®
- Symbolic Math Toolbox™

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