

Mathematics Undergraduate Students at the University of Oxford Use MATLAB for Symbolic Computation and Problem Solving



Dr. Catherine Wilkins with a student.

Students at the University of Oxford's Mathematical Institute are expected to demonstrate the capacity to absorb and apply new ideas, as well as the ability to think and work independently. The first-year course Exploring Mathematics with MuPAD provides students with an early introduction to self-directed learning while building foundational knowledge they will need in their other math and science courses.

Taught using MATLAB® and Symbolic Math Toolbox™ with its MuPAD® notebook interface, the two-term course introduces students to the use of symbolic computation in modern math. "We feel it's important for all maths undergraduates to have experience using a computer algebra system, regardless of what branch of maths they might specialize in," notes Dr. Catherine Wilkins, course director at Oxford. "An immediate benefit of taking this course in the first year is that students can use the MuPAD notebook to solve problems and check their answers in other courses. In the longer term, exposure to MATLAB and MuPAD is beneficial for students in their third- and fourth-year projects, in their postgraduate research, and as a skill to highlight on their CVs."

The Challenge

With about 200 students taking the course each year, a primary challenge is to promote independent learning while still providing each student with the resources, structure, and guidance they need to succeed. "The course is designed so that ideally the students learn by themselves and become more autonomous," explains Dr. Wilkins. "For this

approach to work well, students need access to the required software from their own laptops as well as access to someone who can provide guidance should they need it."

Student motivation is also critical in helping students achieve their goals. "I'm always looking for ways to increase the students' enthusiasm for the course work and to show them how it is relevant to their other courses," Dr. Wilkins adds. To engage pure and applied math students, the course has to provide a basis for interactively solving problems across a range of mathematics disciplines.

The Solution

The University of Oxford had previously acquired a campus-wide license, which gives students access to MATLAB and dozens of companion products. Dr. Wilkins took advantage of this access when she began teaching Exploring Mathematics with MuPAD using MATLAB and Symbolic Math Toolbox.

The course consists of two eight-week terms, each with just two lectures. In the first lecture, Dr. Wilkins introduces students to the MuPAD notebook.

Students then work independently for the remainder of the term. Every two weeks they work through the course manual, meeting in small group sessions at which a course demonstrator (or teaching assistant) is available to answer questions.

Early exercises teach students how to use elementary functions and generate plots and

The Challenge

Provide first-year mathematics students with a foundation in solving symbolic math problems computationally

The Solution

Use Symbolic Math Toolbox and its MuPAD notebook interface to teach a year-long course with projects that are tied to other coursework

The Results

- Self-directed learning enabled
- Course changes streamlined
- Transferable skills learned

“When students solve wave problems using the MuPAD notebook they can see, for example, the waves being reflected and how varying the parameters changes the behavior of the solution. That visualization reinforces their understanding and is particularly helpful in self-directed learning.” —DR. CATHERINE WILKINS, UNIVERSITY OF OXFORD

graphs. They also learn how to evaluate expressions, solve equations symbolically, and perform differentiation and integration.

Students later focus on ordinary differential equations and programming structures such as loops, conditionals, and procedures.

Dr. Wilkins asks lecturers of other first-year courses to assign problems for the students to solve using Symbolic Math Toolbox, which encourages students to apply the material they’re learning in different classes.

In the second term, students complete two projects and submit MuPAD notebook files electronically for evaluation toward their end-of-year grade. The first project involves solving a linear algebra problem, for example, using Gaussian elimination.

For their second project, students have four options, which typically include number theory, Fourier series, and wave motion problems drawn from other courses they are attending.

Third-year students may opt to take a structured project course, in which they use MATLAB and Symbolic Math Toolbox to reproduce and extend published research results in fields such as oceanography, finance, and biology.

The Results

Self-directed learning enabled. “With the campus-wide license, students can work on their assignments in their own rooms or wherever they take their laptops. The course would not run nearly as well without it,” says Dr. Wilkins. “Assignments are submitted online as MuPAD notebook files, which enables students and instructors alike to work remotely.”

Course changes streamlined. “When we converted the course to Symbolic Math Toolbox from another software package, the support we received from MathWorks was invaluable,” notes Dr. Wilkins. “MathWorks application engineers were very approachable, and they helped me translate the course manual for use with the MuPAD notebook.”

Transferable skills learned. “At the end of the year we ask students if they intend to use symbolic math computation in the rest of their studies and if they found that it reinforced their learning experience,” notes Dr. Wilkins. “The feedback has been very positive. Many students cite their work with MATLAB when pursuing positions in industry.”

Industry

- Academia

Application Areas

- Mathematical modeling
- Algorithm development

Products Used

- MATLAB®
- Symbolic Math Toolbox™

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