Teaching an ODE Course with CoCalc, Sage, Jupyter Notebooks, and LaTeX

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UTMOST 1.0

The first UTMOST (**U**ndergraduate **T**eaching in **M**athematics with **O**pen **S**oftware and **T**extbooks) project was a National Science Foundation CCLI Type 2 grant (2010–2014) that promoted open-source software and open-source curriculum in the undergraduate mathematics classroom.

- American Institute of Mathematics (DUE–1022574)
- Drake University (DUE–1022036)
- Stephen F. Austin State University (DUE–1020957)
- University of Colorado Boulder (DUE–1020687)
- University of Washington (DUE–1020378)
- University of California, San Diego

Highlights of UTMOST 1.0

The products of the first UTMOST grant included:

- CoCalc (formerly SageMathCloud)—A comprehensive cloud computing environment for education and scientific computing.
- Sage Cell Server—A mechanism to embed live computations into any webpage.
- PreTeXt (formerly MathBook XML)—A framework for writing mathematics that can be published in a variety of formats.
- Sage Education Workshops—Workshops for learning how to use Sage for the teaching and learning of mathematics.
- AIM Open Textbook Initiative—An editorial board to identify and support quality open-source textbooks.

UTMOST 2.0

The second phase of UTMOST was launched in Fall 2016 and supported by the National Science Foundation as a two-year IUSE grant. The players were:

- American Institute of Mathematics (DUE–1626455): Rob Beezer, David Farmer, Kent Morrison
- Stephen F. Austin State University (DUE–1625223): Thomas Judson
- University of Colorado Boulder (DUE–1624998): Susan Lynds
- University of Michigan (DUE–1624634): Vilma Mesa, Angeliki Mali

Highlights of UTMOST 2.0

- We investigated how students and faculty use textbooks, especially dynamic textbooks.
- We continued the development of PreTeXt, including an author's workshop in May 2017.
- We advanced the AIM open textbook initiative.
- We developed an online repository of Sage cells.

UTMOST 3.0

UTMOST 3.0 was launched in Fall 2018 and supported by the National Science Foundation as a four-year IUSE grant. This project is a continuation of the work begun in UTMOST 2.0.

- American Institute of Mathematics (DUE–1821706): Rob Beezer, David Farmer, Kent Morrison
- Stephen F. Austin State University (DUE–1821329): Thomas Judson
- University of Colorado Boulder (DUE–1821114): Susan Lynds
- University of Michigan (DUE–1821509): Vilma Mesa

Sage, an Open-Source Alternative

- William Stein founded SageMath in 2005. Rather than reinventing the wheel, Sage (which is written mostly in Python and Cython) integrates many specialized mathematics software packages into a common interface, for which a user needs to know only Python.
- The Sage community has been the driving force for developing Sage. Developers include both students and professionals.
- The philosophy of SageMath is to use existing open-source libraries wherever they exist, including Maxima, R, GAP, and NumPy to name only a few.
- In 2013, Stein launched SageMathCloud (now CoCalc), a web-based cloud computing and course management platform for computational mathematics.

Teaching an ODE Course with Technology

- The use of technology for the teaching and learning of ordinary differential equations is now widely accepted. Software (Sage, MatLab, Maple, Mathematica) that can be used to find and plot solutions to equations or systems of equations.
- The 2001 Park City Mathematics Institute undergraduate faculty program, *Teaching Ordinary Differential Equations*—Paul Blanchard (Boston University) and John Polking (Rice University).
- I had the opportunity to develop my own ODE course, first at Harvard University as a preceptor and then at Stephen F. Austin State University.
- *The Ordinary Differential Equations Project* (http://faculty.sfasu.edu/judsontw/ode/index.html)—an open source textbook.

The Needs of a Modern ODE Course

- The instructor needs to be able manage the course and the assignments in an efficient manner.
- Students need to be able to write good mathematics (preferably LaTeX or Markdown).
- Students need to be able to seamlessly incorporate technology into their assignments.
- There needs to be an opportunity for students and the instructor to collaborate online.

CoCalc and the Jupyter Notebook

- CoCalc (https://cocalc.com), a web-based cloud computing and course management platform for computational mathematics, can be used as an efficient method to provide examples and manage assignments.
- Using the Jupyter Notebook, students can write their solutions in LaTeX and incorporate Sage computations into a single document.
- Since students only need to write their solutions in a Markdown cell, many of the barriers to learning LaTeX are removed.
- Students can write executable Sage commands in the Jupyter Notebook.
- CoCalc makes it easy to collect, grade, and return assignments.

Resources

- PreTeXt—https://pretextbook.org.
- CoCalc—https://cocalc.com.
- The Sage cell repository—http://utmost-sage-cell.org
- SageMath—http://www.sagemath.org.
- UTMOST— http://utmost.aimath.org/.
- Project Jupyter—https://jupyter.org.
- The AIM Open Textbook Initiative —https://aimath.org/textbooks/.

Thank You for Listening

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