Tips, Tools, and Resources for Teaching an Active-Learning (motivated) Differential Equations Course

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No Need to Copy

Download slides at:
`https://github.com/Pelonza/JMM16-ODE-Talk`

Background

Course

- Mixture of Engineering (Mech, ECE), Mathematics, and Meteorology students
- Typical class size 15-30
- Students have limited programming experience by this course

Teaching Goals

- Be able to use class-time as exploratory/active learning
- Integrate significant computational explorations (6-10 for the semester)
- Provide sufficient in-depth applications to motivate learning DEs

Textbook Choices

- *Differential Equations Laboratory Workbook*, Borrelli, Coleman, and Boyce
  Available on CODEE:
  `www.codee.org/library/projects/differential-equations-laboratory-workbook-1`
  - Lots(!!) of experiments
  - Originally from 1992, so specific software references very out-of-date
  - If planned well and/or updated can serve well as labs or homework activities.
- *Notes on Diffy Qs* by Jiří Lebel, 2013/2014
  Available at `http://www.jirka.org/diffyqs/`
  - Designed to work hand-in-hand with the IODE Software (more later)
  - Also available VERY cheap in bound versions (<$20)

Textbooks (cont)

- *Differential Equations with Linear Algebra, An inquiry based approach to learning*, by Ben Woodruff
  Available from github: `https://github.com/bmwoodruff/math316-IBL`
  - Includes a nice review section and linear algebra section (for combined courses)
  - Takes a constructivist/IBL approach to teaching with most key ideas 'discovered' by the students
  - Includes many links directly to Sage web-applets (or WolframAlpha) for answer checking
- Unpublished IBL Project from Chris Rasmussen (contact him for materials)

Project & Assignment Sources

- First, the two textbooks (non-IBL) include several project/worksheets
- IODE, again at `www.math.uiuc.edu/iode/`
  - Fairly stand-alone projects/labs - 6 total
  - Inclues Fourier Series and PDEs
  - Some small compatibility issues/updates
  - Key/Solutions not posted, but I received some from an Admin/have available
- The Connected Curriculum Project at `https://www.math.duke.edu/education/ccp`
  - 14 Labs/projects (for DEs), in Maple, Mathematic, and MATLAB formats
  - All are for OLD software versions, so try them first to revise some commands
  - This site actually has a LOT of awesome (other) stuff

Project & Assignment Sources 2

- CODEE at `www.codee.org`
  - Most important:
    The 2013 JMM Mini-Course workbook.
    `http://www.codee.org/jmm-2013-minicourse/jmm-2013-project-book/view`
    - This has a large breadth of projects of varying complexities and walk-through levels
    - Biggest Downside: No clear list of pre-requisite knowledge (or sometimes learning goals) for projects
  - Very nice 'Mathematical Modeling' process/diagram and activity
  - Lots of other projects and resources if you dig around
- MIT Open Courseware
  - Includes some web-based applets (Javascript anyone?)
  - Some problem-sets and solutions also available

(Free) Software

- Sage (Cloud) at `http://sagemath.org`
  - Available in the cloud or downloadable, free alternative to Mathematica, Maple (mostly), and MATLAB (also Octave)
- WolframAlpha at `http://wolframalpha.com`
  - Your students will use it. You should understand it.
  - Advantage/Disadvantage: mostly a one-line entry option
  - Don't forget additional applets or explorations that Wolfram has available
- IODE at `www.math.uiuc.edu/iode/`
  - Package for MATLAB/Octave
  - Includes several useful GUI exploration pieces

Assessment

- **S**tudent **A**ssessment of their **L**earning **G**ains (SALG) Found at `www.salgsite.org`
  - Learner focused, with heavily validated assessment questions
  - Recommended: SALG-M (Sage or Non-Sage) by Hassi & Laursen
    A SALG instrument developed and validated explicitly for IBL Mathematics courses
- Paper: *Students' Retention of Mathematical Knowledge and Skills in Differential Equations*, by Oh Nam Kwon, Karen Allen, and Chris Rasmussen, **School Science and Mathematics**, May 2005
  - Contains a short list of assessment items related to developing a Concept Inventory for DEs
- (Your idea here) – No (to my knowledge) definitive concept inventory.

General Tips

- Don't (dramatically) change approaches after the semester starts
  - Students really appreciate predictability
- If using IBL, go extra slow at the beginning
  - without that foundation, the rest will fall apart
  - Get support from the the Academy of Inquiry-Based Learning
    `www.inquirybasedlearning.org`

Reflections on Tools and Resources

- The IODE labs are well-written and reasonably easy to incorporate
  - Students really enjoyed these, and were generally successful
  - Some programming may need taught
- The CODEE/JMM2013 Projects are great, but are not really "plug and play"
  - Projects need a clearer identification of what tools/skills they need to have mastered before the project or to complete the project
  - Solutions are not always available, so may need solved by you first
  - Some of these are very challenging and indepth!

Big Thanks to Ben Woodruff for the textbook

also
Chris Rasmussen for his draft text and assessment questions,

and
Tom LoFaro, Michael Huber, and Ami Radunskaya for writing and sharing their modeling projects and many solutions via email.

Thank you for listening

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