Renovating Introductory Probability and Statistics at MIT

Jeremy Orloff

October 25, 2013

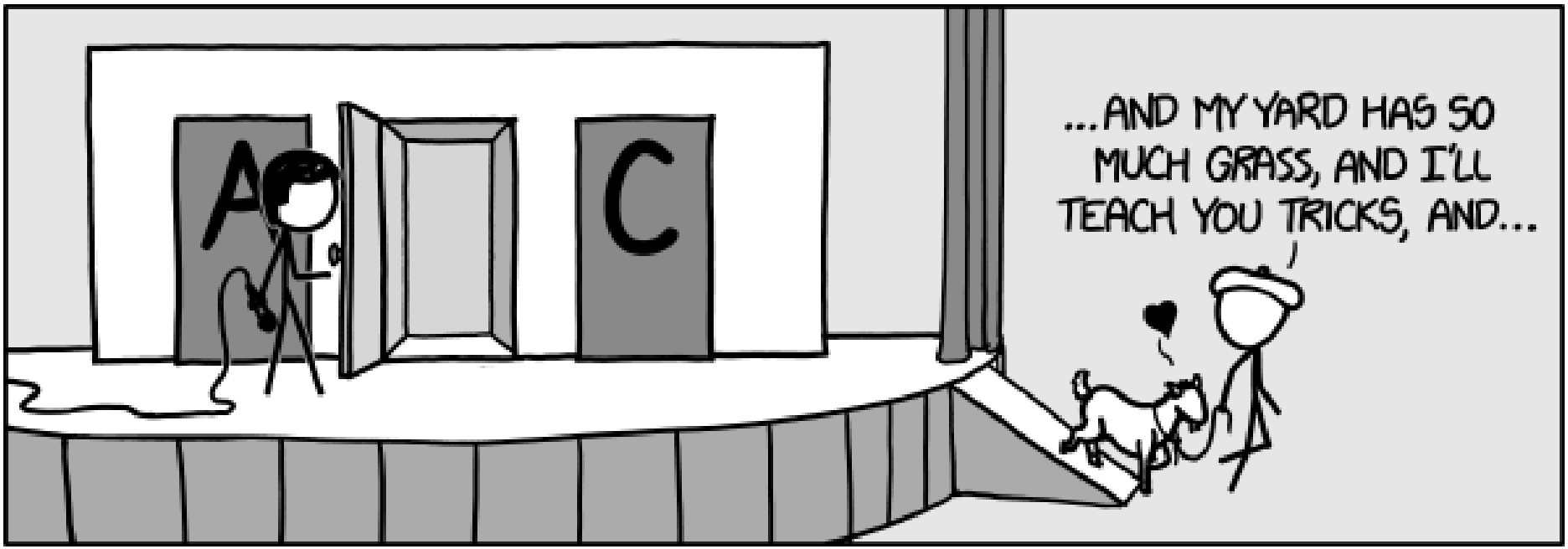
- Davis Foundation –2 year grant
- Haynes Miller –PI, visionary
- Jon Bloom and Jeremy Orloff –course development, teachers

Goals of the Project

Renovate MIT 18.05: Introduction to Probability and Statistics

- New pedagogy (active learning, flipped classroom)
- New curriculum (update course for the 21st century)
- Enhance with technology (pedagogy and curriculum)

Today's XKCD



Outline of talk

- What we inherited
- What we changed (everything)
- What we've learned
- What's next.

What We Inherited

- Lecture style class for non-math majors
- Old curriculum
- Dwindling enrollment
- Lack of faculty interest in teaching the class
- Mandate to raise enrollment
- Interest in active learning (Haynes Miller)
- Interest in online learning (The world)

We taught 18.05 in Spring 2012 in lecture format with the previous year's syllabus.

- Successful, but . . .

Changes

- Curriculum –at end of slides, not in talk
- Pedagogy
  - Active Learning
  - Flipped classroom
- Used the MIT TEAL (physics) classroom
  - Specially built 3000 square foot room
- Technology
  - Used the MITx platform for online activities
  - Used clicker questions in class
  - Used Matlab for statistical simulation and visualization

Outside of Class (MITx)

- Online reading and reading questions
  Both class activities and grading reinforced the need to do this
- Traditional problem sets plus 'problem set checker'
- MITx is instrumented to allow for analytics on student use and performance
- Using MITx added a substantial amount of work to run the course.

Active Learning in the Classroom

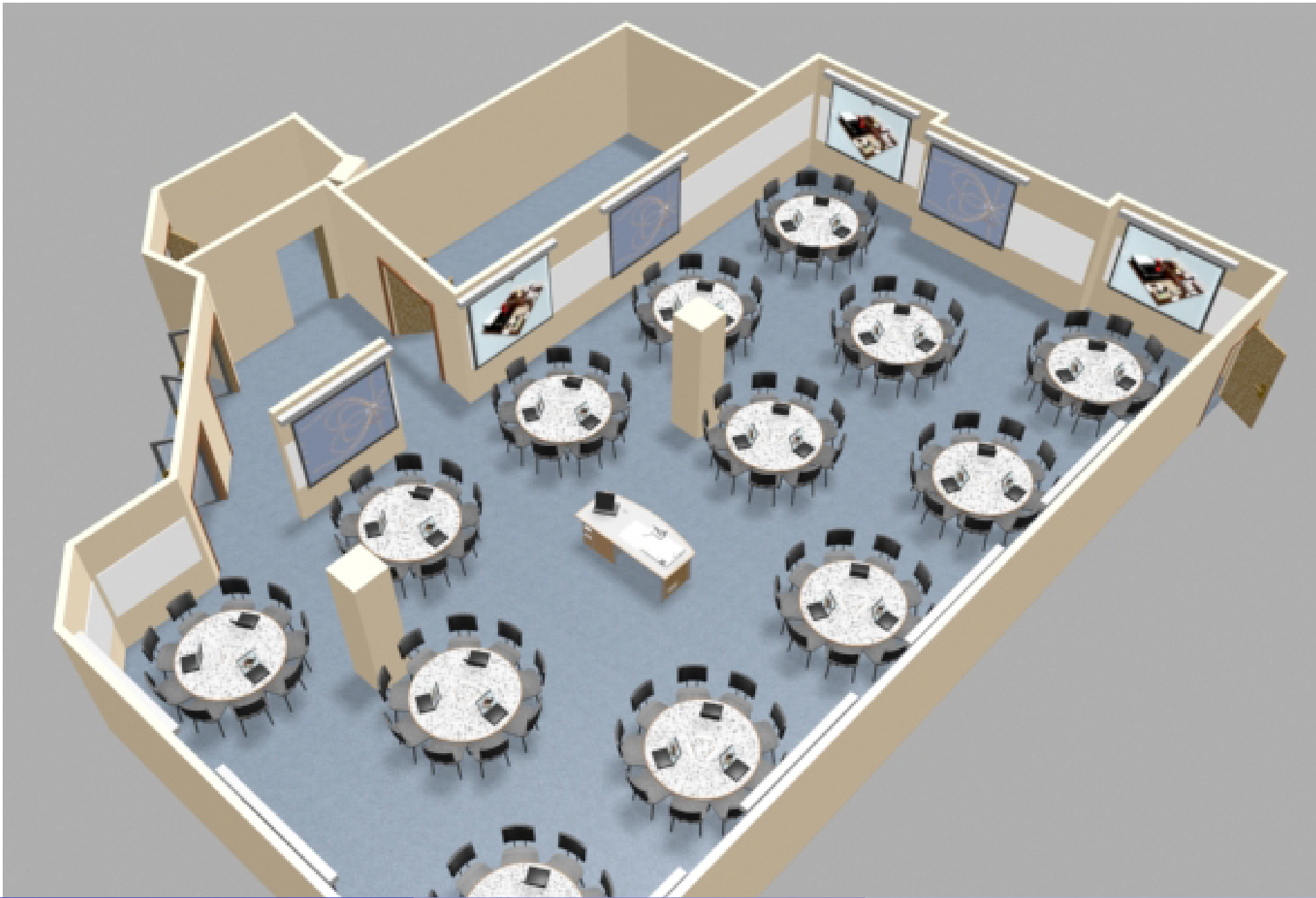
- 2 instructors, 2 TA's for 50 students
- 20-30 minutes of lecture spread throughout the 80 minutes
  - Does not cover everything
  - Few examples
  - Combination of white board and slides
- 3-6 clicker (concept) questions
- 2-4 board questions
- Occasional class discussions of papers, fallacies, statistics in the news
- Friday studio: more involved computer projects using Matlab

The Classroom

- Space and setup of the classroom is critical for facilitating interaction
- Technology (computers and projectors) are useful, but less important

- Expensive to create on campus
- Hard to replicate online

Classroom Schematic



Classroom Picture

General Observations

Glenda Stump of the MIT Teaching and Learning Laboratory (TLL) is studying our course. Some of these observations come from her.

- We successfully demanded a lot more of our students than in previous years
- Creating the class from scratch was an enormous amount of work
- We'd recommend having more experience teaching the subject before embarking on a project like this
- It's easy to be too ambitious before you learn the limits of this format

Observations (MITx)

- Students loved the problem set checker
- The checker caused students to reflect on their work
- Graded online reading questions were enough incentive to get most students to do the reading ahead of time
- Worked well in combination with the active classroom
- There is some evidence students *prefer* reading to video
- Needed an ancillary website
- The discussion forums were not used (students felt no need)
- MITx added substantially to the amount of time needed to prepare the class.

Observations (Active Classroom)

The active classroom enhanced student learning and satisfaction

- Simply standing up increases learning
- The physical space is of critical importance
- Both peer and teacher instruction
- Students got to know their teachers well
- Multiple levels of interaction between everyone involved
- Covered more material to a greater depth
- Students get to evaluate their understanding immediately
- Teachers get to see student errors and misconceptions immediately

Observations 4

Teacher satisfaction was also increased

- Co-teaching was more fun
- Co-teaching led to better teaching
- More positive interaction with students

What's next

- Revise and rerun the class this spring
- See if we can promote use of the discussion forum
- OCW Educator
- edX and MOOC
- Transition to a new teacher
- Other classes

Broad Course Goals

- Learn the language and core concepts of probability theory
- Understand basic principles of statistical inference (Bayesian, frequentist, bootstrap)
- Build a starter statistical toolbox with appreciation for both utility and limitations
- Use software and simulation to do statistics (Matlab).
- Become an informed consumer of statistical information (paper analysis).
- Prepare for further coursework or on-the-job study (active learning).

Curriculum

Traditional course:

- Probability: counting, random variables, gallery of distributions, central limit theorem.

- Statistics: linear regression, estimation, confidence intervals, p-values, NHST, bootstrapping

Changes:

- A unit on Bayesian inference
- A much heavier use of computers for simulation and visualization
- A course arc to smooth the transition from probability to statistics and improve understanding of the relationship between them

Course Arc

- Probability:
(uncertain world, perfect knowledge of the uncertainty)
  - Basics of probability: counting, independence, conditional probability
- Statistics I: pure applied probability:
(data in an uncertain world, perfect knowledge of the uncertainty)
  - Bayesian inference with known priors
- Statistics II: applied probability:
(data in an uncertain world, imperfect knowledge of the uncertainty)
  - Bayesian inference with unknown priors
  - Frequentist confidence intervals and significance tests
  - Resampling methods: bootstrapping
  - Discussion of scientific papers

- Computation, simulation and visualization using Matlab and applets was used throughout the course.