Teaching in STEM at UM is generally excellent

• We have been leaders in implementing new methods:
  – Math: Nationally praised first year calculus
  – Chemistry: Organic-first, authentic research design
  – Biology: 174 – a precursor to flipped classrooms
  – Physics: technology in large courses - electronic response, Problem Roulette, E²Coach

• This work recognized on campus and off
  – Teaching Innovation Prizes
  – College-wide awards
  – Thurnau professorships
  – Career\PECASE winners
  – HHMI

• Mostly, we are responding to external change from a position of considerable strength
Why focus effort on rethinking teaching now?

• The learning sciences now provide better established guidance to teachers and learners
  – General results from cognitive science suggest general approaches
  – Specific results from discipline-based education research provide local guidance

• Education is now digital
  – Universal access to content: this frees us to do new, better things
  – Lots of data: allows us to see what is happening now and to learn what works best
  – Online courses: they can do some of what we used to do very cheaply

These generational shifts reinforce one another: we have a prime opportunity to make our teaching consistently evidence-based
Evidence from the literature: a few clear examples
Two general results

**Frequent testing is more effective than repeated study**


**Interleaved practice creates desirable difficulties and enhances recall**

Work specific to physics: Interactive Engagement

- “Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses”
- 62 courses at many levels, each classified as traditional or interactive engagement
  - Traditional: <g>=25%
  - Interactive: <g>=48%

\[
\langle g \rangle = \frac{\% \langle S_{\text{post}} \rangle - \% \langle S_{\text{pre}} \rangle}{100 - \% \langle S_{\text{pre}} \rangle}
\]

Hake, R., 1998, American Journal of Physics, 66, 64.
Active learning improves performance across STEM

- Freeman et al. 2014 meta-analysis of 224 active learning studies across fields in PNAS
  “The results raise questions about the continued use of traditional lecturing as a control in research studies, and support active learning as the preferred, empirically validated teaching practice in regular classrooms.”

- There are challenges for us: effects are smaller in larger classes

A few facts about our introductory courses
GPA in Other courses (GPAO): is the best predictor of grades, much better than SAT/ACT, HS GPA, or anything else...

Grade penalty = \(<\text{GPA} - \text{Grade}\rangle\)

\(<\text{GPA} - \text{Grade}\rangle\) All = 0.41
Intro STEM courses impose “grade penalties” ranging from 0.2-0.6 letter grades.
Intro STEM lecture courses *all* display substantial gendered performance gaps.
Intro STEM lecture courses all exhibit gendered performance differences from 0.1-0.3 letter grades.
Other large intro courses don’t exhibit these differences

- Number male = 4886
- Number female = 6243

\[ \langle \text{GPA} - \text{Grade} \rangle \text{ Male } = 0.19 \]
\[ \langle \text{GPA} - \text{Grade} \rangle \text{ Female } = 0.23 \]
\[ \langle \text{GPA} \rangle \text{ Male } = 3.23 \]
\[ \langle \text{GPA} \rangle \text{ Female } = 3.30 \]
\[ \langle \text{Grade} \rangle \text{ Male } = 3.03 \]
\[ \langle \text{Grade} \rangle \text{ Female } = 3.07 \]
Other large intro courses don’t exhibit these differences.
Data from 2000 – 2012 for all ‘giant’ classes, with average enrollments over 400

Large courses using timed examinations for the bulk of evaluation

What happens in other classes?
Data from 2000 – 2012 for all large introductory STEM lecture and lab courses

What about intro STEM classes?
An Opportunity to **REBUILD**
for UM’s Third Century

- Convergence creates a moment of opportunity for the reform we want
  - Research suggests ways courses might be improved
  - Data provide strong ways to test what we try
- REBUILD is a new $2M NSF project supporting collaboration among Physics, Chemistry, Both Biologies, and Math

**Goals for REBUILD**

1. Move to using evidence-based methods and a scholarly approach to teaching and learning
2. Seek support for reform from our Provost, Dean, and funding sources
3. Do this work in multigenerational research teams
REBUILD across departments

• Chemistry: Coppola, Wolfe, McNeil (+ 2 PDs)
  – Exploring student experience across their curriculum, authentic research design labs (HHMI grant)
• Biology: Olsen, Cadigan, Wittkopp (+ 1 PD)
  – Intro course reform, learning outcomes for courses, authentic research design labs (HHMI grant)
• Mathematics: DeBacker, Speyer (+1 PD)
  – Revamping 215 labs, improving training programs
• Physics: McKay, Pierce (+1 PD)
  – Intro courses, major recruiting, peer tournaments, Problem Roulette, E²Coach (NSF grants)

https://rebuild.lsa.umich.edu/
Our request from you

• The purpose of REBUILD is to encourage and support the changes we as a faculty want to make
  – One goal is to improve introductory courses
  – Another is to increase persistence and the number of STEM majors: upper level courses are important too

• We’d like to use this opportunity to gather input from you:
  1. What changes to teaching or assessment would you like to make in the next few years?
  2. What stands in the way of your doing this?
  3. What would help?
  4. What evidence will convince you of success?