Training University Faculty to Improve Student Learning Outcomes in Quantitative Courses
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The University of North Carolina at Chapel Hill

Invited Address, Division 5: Quantitative and Qualitative Methods, American Psychological Association, Washington DC, Friday, August 4, 2017.
A Collaboration:
Department of Psychology and Neuroscience
Department of Biology
Department of Mathematics
Center for Faculty Excellence
Natural Science Faculty Members in the College of Arts & Sciences
What are important principles for teaching courses in statistics and quantitative methodology into the 21st century?
1. Train faculty members
   a. Encourage inclusive excellence
   b. Improve student learning
2. Assess teaching differently
Presentation Topics

Educational Context in 2017
   Who Are Our Undergraduates?
   Who Are Our Graduate Students?
   Who Are Our Faculty?

What STEM Education Research Tells Us

The Finish Line Project (Panter, PI)
   Curricular Redesign Studies
   Departmental Case Study
   Randomized Controlled Trial

Five Recommendations for the 21st Century
Educational Context in 2017

Think about your own spaces
Who Are Our Undergraduate Students?

N = 18,523

- Prior College Coursework: 79%
- First Generation: 19%
- Transfer: 15%
- Undecided Major: 43%
- NC Resident: 81%
- From N.C. Community College (Transfer): 35%
- Woman: 58%
- STEM-Interested: 30%
- Older than 22 Years: 21%
- Low Income: 22%
- Military: 10%
- Need-Based Aid: 37%

4-year graduation rate = 82%
6-year graduation rate = 91%
Who Are Our Graduate Students?

- **N = 8,427**
- **Masters 80%**
- **Psych Time To PhD 5.7 Years**
- **Woman 54%**
- **Wrote Grant 26%**
- **NC Resident 48%**
- **STEM-Interested 30%**
- **Support Finding Job 55%**
- **Older than 30 Years 36%**
- **Funded 78%**
- **Military 4.3%**
- **Funded 78%**
- **STEM Time to PhD = 5.3 Years**
- **Psychology Time to PhD = 5.7 Years**
Who Are Our Faculty?

Attributes
- Hired Competitively
- Generates Knowledge
- Collaborates with Students and Colleagues
- Designs Own Courses
- Motivated to Train the Next Generation
- Lifelong Learner
- Provides Advice about Careers
- Is Active on Campus and in Discipline
- May Lead a Center or Administrative Unit
Faculty Position Applicants and Hires, FY 2015-2016

<table>
<thead>
<tr>
<th></th>
<th>Applicants</th>
<th>Hires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenured</td>
<td>701</td>
<td>18 (2.6%)</td>
</tr>
<tr>
<td>Tenure Track</td>
<td>4,606</td>
<td>79 (1.7%)</td>
</tr>
<tr>
<td>Fixed Term</td>
<td>6,403</td>
<td>275 (4.3%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11,710</strong></td>
<td><strong>372 (3.2%)</strong></td>
</tr>
</tbody>
</table>

Q: Did the hiring committee consider the candidate’s promise to and/or ability to maximize student learning outcomes?
Sponsored Research (millions)

Source: Office of Institutional Research and Assessment, 7.18.17.
What STEM Educational Research Tells Us
“...increasing the retention of STEM majors from 40% to 50% would generate three quarters of the targeted 1 million additional STEM degrees over the next decade.”

**Recommendation 1.**
Catalyze widespread adoption of empirically validated teaching practices.

Catalyze Widespread Adoption of Empirically Validated Teaching Practices

1. Establish discipline focused programs funded by Federal research agencies, academic institutions, disciplinary societies, and foundations to train current and future faculty in evidence based teaching practices. [Emphasis added]

2. Create the “STEM Institutional Transformation Awards” competitive grants program at NSF.

3. Request that the National Academies develop metrics to evaluate STEM education. [Emphasis added]

President’s Council of Advisors on Science and Technology (2012), Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics, Executive Office of the President, files.eric.ed.gov/fulltext/ED541511.pdf
“Bloodletting was the medical treatment of choice for 2,000 years. It is the same thing. ...Look at the impact, though: You let some blood out, and go away and watch them, and they get well.”

“You give people lectures. And they go away and they learn the stuff. But it wasn’t because they learned it from the lecture. They learned it from homework, they learned it from the assignments.”

“When we measure how little they learn from lectures, it is very small.”

_A Nobel Laureate's Education Plea: Revolutionize Teaching_, National Public Radio, 4.14.16
High Structured, Active Learning: What Is It?

- **Shift certain course content** to outside of class time
  Design **engaging** small group activities for the classroom that stimulate critical thinking
- Devote class time **higher-level problem solving**
- Keep both student and instructor **accountable**
- Maximize **educational capital** of peers within a classroom
  “It is NOT your traditional lecture – beyond watching, listening, and taking notes” (Felder & Brent, 2009, p. 2)

In short, it

..."involves students in doing things and thinking about the things they are doing" (Bonwell & Eison, 1991, p. 2).
**Getting Under the Hood: How and for Whom Does Increasing Course Structure Work?**  
Eddy & Hogan (2014, Table 1)

<table>
<thead>
<tr>
<th>Course Structure</th>
<th>Graded Preparatory Assignments</th>
<th>Student In-Class Engagement</th>
<th>Graded Review Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low</strong> Traditional Lecture</td>
<td>None; &lt;1 per week</td>
<td>Talk &lt;15% of course time</td>
<td>None; &lt;1 per week</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td>1 per week</td>
<td>Talk 15–40% of course time</td>
<td>1 per week</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td>≥1 per week</td>
<td>Talk &gt;40% of course time</td>
<td>≥1 per week</td>
</tr>
</tbody>
</table>
Thinking Shifts (Instructor and Student)

1. Articulate Student Learning Outcomes
   - By the end of each course section
   - By the end of each course
   - Reverse engineer: Start with what you intend students to know and be able to do

2. Increase Student and Instructor Accountability
   - Before, during, after class session
   - Regularly measure student learning

3. Design Relevant Problem Solving Activities and Exercises that Prioritize Higher Levels of Bloom’s Taxonomy
   - Create, Analyze, Evaluate, Apply vs. Understand, Remember
Thinking Shifts (Instructor and Student)

4. Understand Directionality
   • One Directional = Profess, Lecture, Sage on the Stage
   • Bi-Directional = Cognitive Coach, Guide on the Side

5. Embrace Sound (Chatter, “Talk”) and Educational Social Capital
   • Decibel Analysis for Research in Teaching (DART)
   • Analyze classroom recordings
   • Predicts time spent on single voice (e.g., lecture), multiple voice (e.g., pair discussion), and no voice (e.g., clicker question thinking) activities
Key Papers


The Finish Line Project
The Finish Line Project [Panter, PI]

$3M, 2014-2019
First in the World Program, U. S. Department of Education

Focus on the experience of first generation college students

Randomized Controlled Trials in Different Areas
  • Curricular changes ("transition courses")
  • Course redesign in STEM
  • Faculty Learning Communities in STEM
  • Student supports
Curricular Redesign Studies

Case Study: Mathematics

Randomized Control Trial: STEM
In 2013 AAU awarded UNC a grant to conduct course redesigns in the Departments of Biology, Chemistry, Physics.

But, where was Math?

Math = “Grand Central Station” of undergraduate education.

Most undergraduates take math.
Path 1: Low score
Path 2: STEM major

The First Priority of the The Finish Line Project!!
Math Faculty Learning Community Design

Spring 2016, Fall 2016

N = 12 math professors (including department chair)
Facilitators = 4, specially selected

Payments = $5,000/faculty member
Sakai Site with Materials
Expectations: Attend, Read, Peer Visits, Meeting with Consultant, Present
RCT Faculty Learning Community Design

Call to faculty in all Natural Science Departments
Spring 2016, Fall 2016

\( N = 21 \text{ STEM professors} \): Marine Science, Biology, Computer Science, Geography, Geological Science, Math, Exercise and Sports Science, Environment and Ecology

Facilitators = 2
Randomly assigned to:
Condition 1: High Structure FLC
Condition 2: Low Structure (“Business as Usual”) FLC

Payments = $5,000/faculty member
Sakai Site with Materials
Expectations: Attend, Read, Peer Visits, Meeting with Consultant, Present
Faculty Learning Community Outcomes

**Immediate**
Increased knowledge
- active learning principles
- first generation college students
- pedagogical changes that can support active learning principles/FGCSs
Baseline course data
Sakai analytics

**Midterm (One Year)**
- Analysis of redesigned syllabus
- Scheduled to teach redesigned course
- Use of active learning principles in redesigned course

**Long-Term (2-3 Years)**
- Evaluations (mid-semester, final) of the course redesign
- Use of active learning principles across additional courses
- Redesign of additional courses
Why did you decide to participate in the STEM Faculty Learning Community study?

Were there specific goals that you were trying to accomplish?

- Hoped to improve teaching style
- Wanted an opportunity to set aside time to specifically focus on teaching
- Wanted to learn how to engage students
- Hoped to motivate colleagues to adopt more active learning styles
How, if at all, did the FLC affect how you plan for/will teach your courses in the future?

Were there specific goals that you were trying to accomplish?

- Yes, already made specific changes to their courses (most)
- Online/interactive components added
- More group activities
- More chance for students to give one another feedback
- Less lecturing overall
While in the FLC, what was it like for you to gather with your colleagues to discuss pedagogy and your undergraduate teaching?

How close or distant did you feel to the members of the community when discussing pedagogy? What do you consider to be key lessons learned about optimizing student learning in STEM courses?

• Really useful
• Very enjoyable
• Valuable -- a rare opportunity to discuss teaching with colleagues (i.e., instead of discussing research, specific student issues)
• Learned a lot from what others had tried
Thinking about your experience in the FLC Faculty, what aspects of the sessions, program, and the community did you find to be particularly useful and why?

What aspects did not work well or did you feel were not worth your time and why? [Give examples if you can.]

**Good**
- Able to discuss teaching with peers
- Inspiring to hear stories
- Classroom observations

**Not As Good (Condition 2)**
- Need for more structure/agenda during meetings
- “Faculty talk a lot”
- Transient group (i.e., some faculty had to miss multiple sessions); smaller groups might be better
Five Recommendations for the 21st Century
“University Learning” Needs to Happen
Bradforth et al. (2015), *Nature*

Faculty Members can:
• Increase scientific and reflective teaching
• Increase student engagement in learning

Senior Administration can:
• Recognize and reward good teaching
• Encourage faculty buy-in
• Centralize and make accessible data and analytics
• Use teaching improvement as a fund-raising lever

Colleges and Departments can:

• Articulate common learning objectives for introductory STEM courses
• Provide faculty with time and resources to improve teaching
• Encourage peer support and cross-departmental dialogue
• Evaluate teaching with meaningful metrics
• Make teaching count for promotion and tenure

1. Train PhD Students Differently

- If the career choice is teaching, a graduate program needs to provide relevant training.

- Future faculty fellows programs

- Create opportunities to teach undergraduates using high structure, active learning approaches.

- Graduate students often teach professors about teaching.
The [Department] at [University] seeks applicants for a permanent 9-month Lecturer position, effective [date]. The position involves assisting with innovative Science, Technology, Engineering, and Mathematics (STEM) course redesign of introductory [STEM] courses and **teaching 2-3 classes per semester** in courses such as [list of courses].

The successful candidates will also contribute to the implementation and evaluation of programs to bring evidence-based teaching methods to introductory courses, collaborate with faculty conducting [discipline] education research, and work closely with tenure-track faculty in their discipline. Applicants should have a Ph.D. in [discipline] or science education with at least one semester of full-time college teaching as instructor of record. **Candidates should have clearly demonstrated a commitment to using evidence-based teaching methods in the classroom and have strong interdisciplinary content knowledge.**
3. Train Faculty Differently

• Create and encourage faculty development and communities for discussion about student learning and pedagogy
  • Within department, across rank
  • Within general discipline

• Incentives
  • Celebrate teaching examples
  • Communicate value in personnel decisions
  • Provide stipends, consultant support
  • Break down rank/hierarchy barriers
  • Encourages professional self-development
4. Assess Teaching Differently

• It’s a Measurement Issue!!!

• Use appropriate assessment to document student learning in a course

  • Direct Measures of Student Learning: Common exam items, standardized concept assessments, student work rated by external raters with a well-designed rubric

  • What evidence exists should an instructor provide to demonstrate that specified student learning outcomes were achieved?
5. Reward Teaching Differently

Personnel Decisions, Typically

1. Teaching Portfolio (narrative, syllabi, course materials)
2. Course Evaluations
3. “Peer” Evaluations
   - Outside letters are about scholarship; cannot speak to teaching in a full way.

- Requires institutional commitment from the highest level from hiring and through the tenure and promotion of the faculty member
Questions, Comments?

panter@unc.edu
Extra Relevant Slides for Discussion
If Needed
Sample:
Peer Observation Form
(Personnel Decisions)
Methods Based Peer Visit Form

Adapted from the CCSSE "Classroom Observation Form" and FIRST IV Observation Rubric
I. PEDAGOGICAL APPROACH. How does the instructor’s approach to teaching support meaningful student learning?

1. Speaks clearly and audibly
2. Writes clearly and legibly (whiteboard, notes, document camera, etc.)
3. Shows enthusiasm for the subject matter and teaching
4. Encourages student questions and student participation
5. Gives students an adequate amount of time to respond to questions
6. Engages students with material through multiple modalities (presentation, hands-on activities, graphs, models, media, etc.)
7. Uses student groups to explore concepts, not just to practice what they learn
8. Uses web-based resources, PowerPoint, clickers or other technological tools fluently and in a manner appropriate for the purpose of the lesson

Comments:
II. APPROACH TO SUBJECT MATTER CONTENT. How does the instructor engage students with material to be learned?

1. Explains the learning objectives for the class session
2. Uses questions or activities to identify misconceptions
3. Shows how new concepts build on earlier concepts in the course or reflect larger themes in the discipline
4. Uses familiar examples to illustrate or explain concepts
5. Shows how concepts apply to “real world” situations
6. Ensures that major points are summarized at the end of the lesson

Comments:
III. INSTRUCTIONAL TECHNIQUES EMPLOYED. Does the lesson use a balance of techniques to foster student learning?

1. Lecture
2. Teacher-led discussion
3. Small group or paired activities/discussion
4. Teacher demonstration of a procedure
5. Working on practice problems
6. Formative assessment activities

Comments:
IV. ENGAGEMENT OF STUDENTS IN THE LEARNING. Are students actively and intellectually engaged with the content?

1. Instructor makes regular use of questions and activities to engage students with the material
2. Instructor poses questions that cause students to think (how? why?), not just recall (who? what?)
3. Instructor notices when particular students are not engaged and takes action to involve them in the class
4. High proportion of student talk vs. teacher talk
5. Students talk with each other about the material, as well as talking to the instructor
6. Students appear to see the relevance of what they are doing to what they are supposed to be learning

Comments:
V. MONITORING STUDENT LEARNING. How do the instructor and students know that students are learning?

1. Questions or activities provide opportunities for students to voice their current understanding.
2. Students prompted to explain their reasoning for their answers.
3. Students receive immediate or timely constructive feedback.
4. Students have opportunities to reflect on their learning.
5. Instructor probes for student understanding even if they do not ask questions.
6. Students explain what they learn in their own words.
7. Classroom Response System questions (clicker, polling, etc.) require more than factual recall or facilitate direct discussion.

Comments:
VI. LEARNING COMMUNITY. Are the instructor and students engaged in a positive, productive learning community?

1. Instructor respects and encourages student contributions
2. Students appear at ease asking questions and interacting with the instructor
3. Instructor (and/or TAs) moves throughout classroom, interacting with individual students and student groups
4. When in groups, students work collaboratively to accomplish tasks
5. Students exchange ideas, listen critically, and respectfully challenge each other
6. Instructor asks students to explain ideas to each other

Comments:
### STEM Attrition among Undergraduates

<table>
<thead>
<tr>
<th>“STEM-Interested”</th>
<th>Attrition %</th>
<th>Why? Left College</th>
<th>Why? Left STEM Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>65.3</td>
<td>29.3</td>
<td>36.0</td>
</tr>
<tr>
<td>First Generation</td>
<td>58.9</td>
<td>30.1</td>
<td>28.8</td>
</tr>
<tr>
<td>Hispanic/Latinx</td>
<td>49.5</td>
<td>23.1</td>
<td>26.4</td>
</tr>
<tr>
<td>Men</td>
<td>49.2</td>
<td>23.7</td>
<td>25.5</td>
</tr>
<tr>
<td>Total</td>
<td>48.3</td>
<td>20.2</td>
<td>28.1</td>
</tr>
<tr>
<td>White</td>
<td>47.9</td>
<td>19.8</td>
<td>28.1</td>
</tr>
<tr>
<td>Women</td>
<td>46.6</td>
<td>14.2</td>
<td>32.4</td>
</tr>
<tr>
<td>Other Race</td>
<td>45.9</td>
<td>20.5</td>
<td>25.4</td>
</tr>
<tr>
<td>Asian</td>
<td>32.4</td>
<td>9.8</td>
<td>22.6</td>
</tr>
</tbody>
</table>

Department of Education, National Center for Educational Statistics, 2014
Shifting Tides: Course Redesign

- Large STEM gateways: “tried and true”
- Re-think course focusing on research on student-centered pedagogy
- Frequent assessments: Student, instructor, content, climate, learning
- Accountability before class
- Class time is special – e.g., problem solving
- Teaching assistants facilitate
- Many types of resources offered
Course Redesign Does Not Just Happen

The University Commits
- Hiring scientists who teach well
- Faculty Learning Communities
- Course releases (“buy-outs”)
- Small grants: Teaching/Learning Centers

External Agencies Commit
- Association of American Universities
- U.S. Department of Education
- Howard Hughes Medical Institute
- National Science Foundation
## Graduation Rates: 2009 Entering First-Year Cohort

<table>
<thead>
<tr>
<th>Institution</th>
<th>4-Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virginia</td>
<td>87.2%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>87.1%</td>
</tr>
<tr>
<td>Johns Hopkins</td>
<td>86.9%</td>
</tr>
<tr>
<td>Duke</td>
<td>86.2%</td>
</tr>
<tr>
<td>Northwestern</td>
<td>82.4%</td>
</tr>
<tr>
<td>UNC-Chapel Hill</td>
<td>81.3%</td>
</tr>
<tr>
<td>So. California</td>
<td>76.8%</td>
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<tr>
<td>Michigan</td>
<td>74.8%</td>
</tr>
<tr>
<td>UCLA</td>
<td>73.6%</td>
</tr>
<tr>
<td>Berkeley</td>
<td>73.4%</td>
</tr>
<tr>
<td>Maryland</td>
<td>69.5%</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>64.0%</td>
</tr>
<tr>
<td>Washington</td>
<td>63.0%</td>
</tr>
<tr>
<td>Minnesota</td>
<td>59.2%</td>
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<tr>
<td>Wisconsin</td>
<td>56.0%</td>
</tr>
<tr>
<td>Texas</td>
<td>52.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Institution</th>
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</tr>
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<tr>
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<td>Virginia</td>
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<td>81.7%</td>
</tr>
<tr>
<td>Texas</td>
<td>79.6%</td>
</tr>
<tr>
<td>Minnesota</td>
<td>77.2%</td>
</tr>
</tbody>
</table>

Prepared by: Office of Institutional Research and Assessment (OIRA), March 28, 2017
Graduation Rates Disaggregated
First Generation Students, Low Income Students
(2010 First Year Cohort)