Undergraduate Research at Scale: Why, what, and how?
@curenet1 #CUREinstitutes #CUREnet2
Undergraduate research experiences

NSF, AAAS, NIH, HHMI Vision and Change (2011): Introduce research experiences as an integral component of biology education for all students...

AAC&U (2007): Undergraduate Research is one of 10 “high impact educational practices.”
This is not new...

(Kinkead, 2012)
How do students benefit from participating in research?

Knowledge & Skills

Attitudes & Dispositions

Identity & Connections

Education & Career Pursuits

Caveats: Indirect measures, measures that lack validity evidence, self-selecting populations, lack of theoretical foundations (see Linn, Palmer, Baranger, Gerard, & Stone (2015) and Gentile et al., 2017)

For a comprehensive review and references, see Corwin, Graham & Dolan, 2015, Dolan 2016
Which students get access to research experiences?

Consider how faculty find undergraduate researchers
Theory: Bourdieu’s “Capital”

Human Capital
- “What you know”
  - coursework
  - grades
  - test scores
  - prior experience

Connections
- “Who you know”
  - special programs
  - major
  - agent

Social Capital
- Habitus
  - “How you know”
  - parents’ education
  - scientific identity

Cultural Capital

Access!!
Students who come to college primed for careers in science are most likely to persist and succeed.

Recapitulates the status quo: Not enough, not everyone.

Reason 1: CUREs can broaden participation in research.

Access based on capital → Research Experience → More capital
Course-based Undergraduate Research Experiences

When whole classes of students address a research question or problem that is of interest to the scientific community
What is a CURE? Lots of different names

• Course-based research experience (CRE)
• Authentic Laboratory Undergraduate Research Experience (ALURE)
• Discovery-based research in the curriculum
• Research courses
## CUREs versus Research Internships

<table>
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<th>CURE</th>
<th>Research internship</th>
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<tr>
<td><strong>Scale</strong></td>
<td>Many students</td>
<td>Few students</td>
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<tr>
<td><strong>Structure</strong></td>
<td>One to many</td>
<td>One to one</td>
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<td><strong>Enrollment</strong></td>
<td>Open to all students in a course</td>
<td>Open to a selected or self-selecting few</td>
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<td><strong>Timing</strong></td>
<td>Students invest time primary in class</td>
<td>Students invest time primarily outside of class</td>
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<td><strong>Setting</strong></td>
<td>Teaching lab</td>
<td>Faculty research lab</td>
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<tr>
<td><strong>Mentoring</strong></td>
<td>Consistent / Structured</td>
<td>Varied</td>
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**But does it “work”?**

(Auchincloss et al., 2014)
Freshman Research Initiative

Research Program:
- A faculty member’s body of work
- Interrelated, ongoing, usually with a common thread
- Sometime overlapping with other faculty collaborators
- Many different projects led by post-docs, grad students

Research Stream:
- Allows expansion of a subset of the research program by providing:
  - More minds and hands
  - Exploration of large variable space
  - Lower risk (a dissertation doesn’t have to result)
- Has its own potential to spawn other projects and research collaborations
Example CURE program: UT Austin’s *Freshman Research Initiative*
Two-semester CURE courses: Research Streams
More than 6,000 students have participated in FRI, and more than 4,000 have had at least six years to graduate.

How does FRI affect students’ graduation rates and completion of a STEM major?

*How would you figure out the effect of FRI on students’ graduation rates and likelihood of completing STEM majors?*
FRI students more likely to graduate college and more likely to graduate with a STEM degree

Effect is the same for students from ALL backgrounds

Reason 2: Students benefit from CUREs

* Significant difference; error bars represent 98.75% confidence intervals
NOTE: 38.6% = National STEM 6-year graduation rate (Rodenbusch et al., 2016)
Reason 3: Faculty benefits

Shortlidge et al (2016) Interview study (N=38):

- Connect teaching and research (76%)
- Enjoyment (74%)
- Promotion and tenure (74%)
- Publications (61%)
- Research productivity (61%)
- Personal satisfaction (47%)
Novel findings that have broad relevance: Publications

**Why Silver Nanoparticles Are Effective for Olefin/Paraffin Separations**
Zachary D. Pozza, Kelly Tran, Anna Shi, Ryan H. Smith, and Graeme Henkelman

**Discrimination of flavonoids and red wine varietals by arrays of differential peptidic sensors**
Alona P. Umali, Sarah E. LeBoeuf, Robert W. Newberry, Siwon Kim, Lee Tran, Whitney A. Rome, Tian Tia, David Tait, Jane Hong, Melissa Kwak, Hildegarde Heymann, and Eric V. Anslyn

**Design, Synthesis, and Amplification of DNA Pools for In Vitro Selection**
Bradley Hall, John M. Micheletti, Pooja Satya, Krystal Ogl, Jack Pollard, and Andrew D. Ellington

**Synthesis and Catalytic Evaluation of Dendrimer-Encapsulated Cu Nanoparticles**
Freshman Research Initiative, Department of Chemistry and Biochemistry, University of Texas at Austin, Austin, TX 78712; *feng@texas.edu

**In Vitro Selection of RNA Aptamers to a Protein Target by Filter Immobilization**
Bradley Hall, Seyed Arshad, Kyunghyun Seo, Catherine Bowman, Meredith Corley,*† Sulay D. Juwett,* and Andrew D. Ellington,‡

1 Department of Chemistry and Biochemistry, University of Texas, Austin, Texas
2 Freshman Research Initiative, University of Texas, Austin, Texas
3 Nova Research, Inc., Alexandria, Virginia

**Deletion of the eIFiso4G subunit of the Arabidopsis eIFiso4F translation initiation complex impairs health and viability**

(Examples from UT Austin Freshman Research Initiative)
Novel findings that have broad relevance: Database entries or Community reports

Examples from NRC Report (2016):
Integrating Discovery-based Research into the Undergraduate Curriculum
What makes FRI or other research experiences work?
In other words, what are the key features?

Depends on what “working” means!
Two approaches

**Top down:** What do social science and education theories predict should be happening?

**Bottom up:** What is happening during research experiences?
What happens during a research experience (FRI, CUREs, internships/UREs, etc.) that makes it effective for students?

What do you hypothesize are the key features?
Hypothesized Distinctive Features of CUREs


Lisa Corwin, David Hanauer, Aspen Robinson, et al.
Bottom-up: Cross-course comparison

• Sample of ~800 students from 23 different inquiry and CURE courses at various institution types (2-yr and 4-yr colleges, comprehensive and research universities):

• Surveyed about:
  – course design features: discovery, iteration, collaboration
  – ownership
  – intentions to pursue a science research related career (pre/post)

• Used structural equation modeling to determine...

(Corwin et al., 2018)
Do course features *predict* \( \Delta \) career intentions?

(Corwin et al., 2018)
Are any observed relationships mediated by ownership?

Collaboration

Discovery

Iteration

Cognitive Ownership

Emotional Ownership

Career Intentions

(Corwin et al., 2018)
Course features have a small but significant effect on students’ career intentions.

Effects of course features on students’ intentions fully mediated by ownership.

Iteration (not discovery!) has the largest effect on ownership.
Numbers represent fully standardized path coefficients; all relationships depicted are significant.

What about theory ("top-down" approach)?

*Not entirely atheoretical...*

Focus on persistence - theories of motivation
Self-Determination Theory of Motivation
(Ryan and Deci, 1985, 1991)

Self-determination

Purpose
Discovery?

Autonomy
Ownership? Culturally bound?

Relatedness
Collaboration?

Self-determination

Plus theories related to career development, equity, cognition, etc...
Tip of the iceberg!

**Cognitive Development**
- Knowledge, skills, abilities
- Expertise development

**Psychosocial Development**
- Ownership
- Self-efficacy
- Sense of belonging
- Scientific identity

**Affective Development**
- Mindset
- Perseverance / Grit
- Values

**Career Pursuits**
- Interests
- Expectations
- Choice points
- Pathways in, out, through

And this is only from the student perspective!

**Research perspective**

**Scientist/Educator perspective**

**Societal perspective**
Discuss with a neighbor: Which of the following scenarios would classify as a CURE?

**Scenario #1:** If the answer to the research question is unknown to the student, but the scientific community knows the answer.

**Scenario #2:** If students use primary literature to come up with only “thought experiments” that are novel.

**Scenario #3:** If students identify whether Maria or Kate has more bacteria on her shoes.

**Scenario #4:** If students try to characterize a novel mutant version of a protein, but they get negative results.

(Brownell, 2016)
Which is a CURE?

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X

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Find a neighbor and discuss...

• Why are you interested in teaching a CURE?

• If you plan to teach a CURE, what goals do you hope to achieve with your CURE?

• How will you know you have achieved those goals?