



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...**

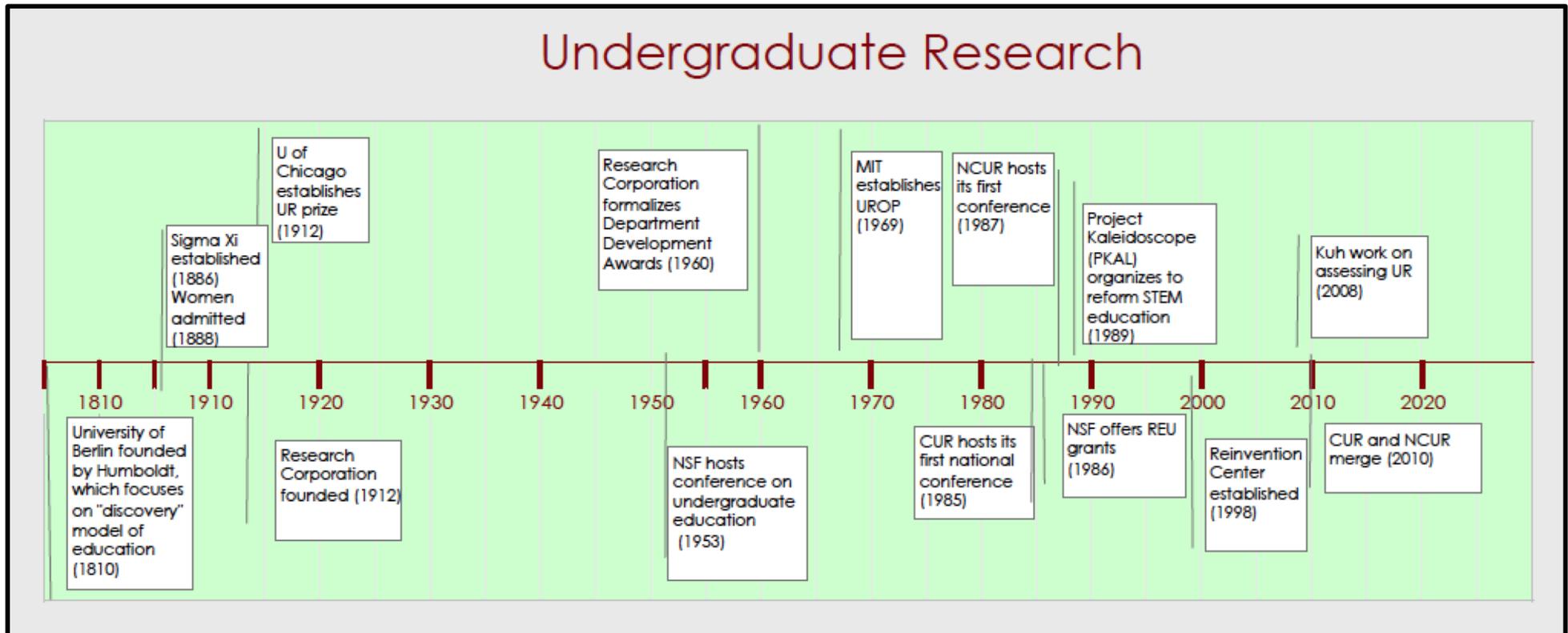


AAC&U (2007): **Undergraduate Research is one of 10 “high impact educational practices.”**



This is not new...

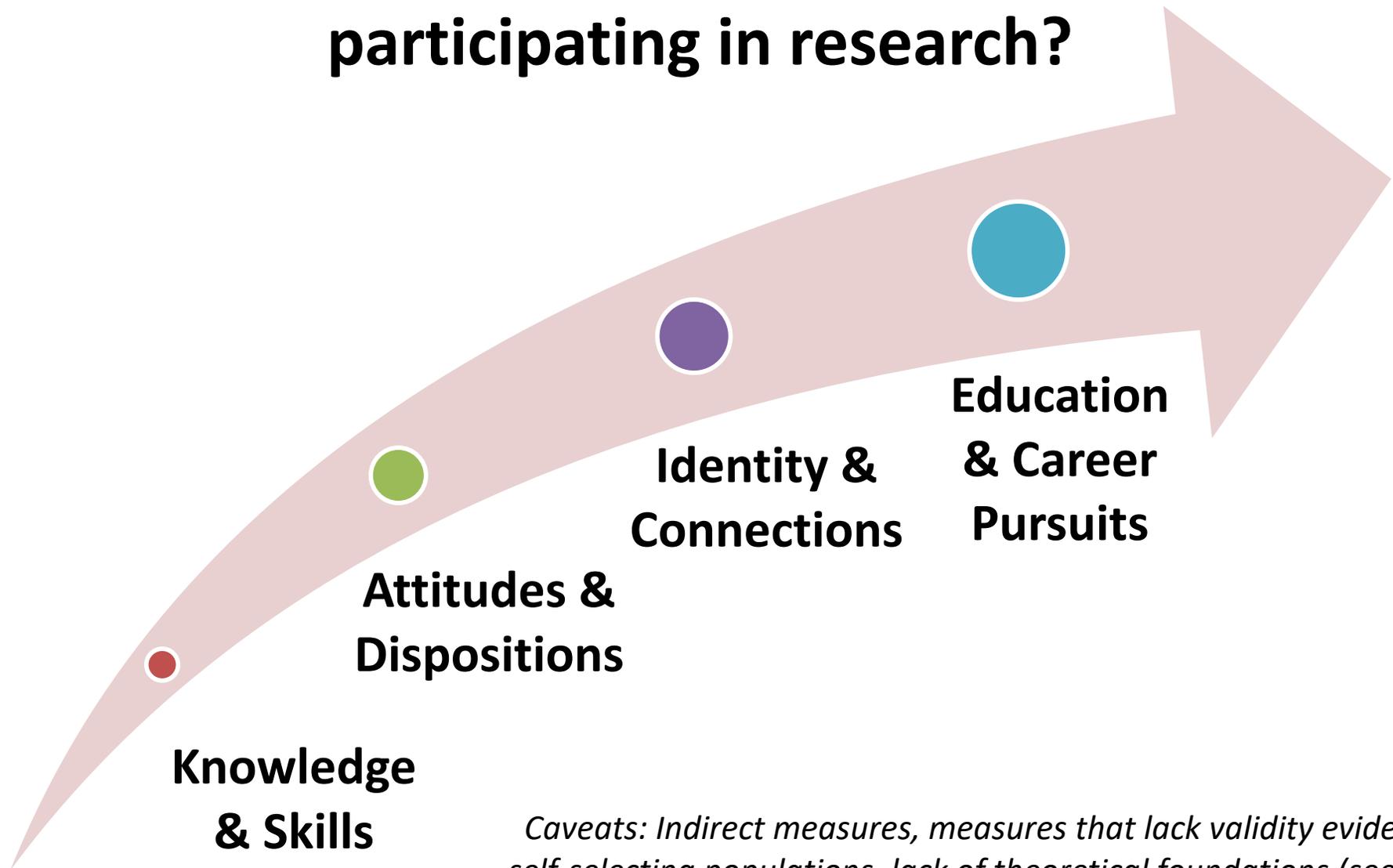
Undergraduate Research





For a comprehensive review and references, see
Corwin, Graham & Dolan, 2015, Dolan 2016

How do students benefit from participating in research?



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)

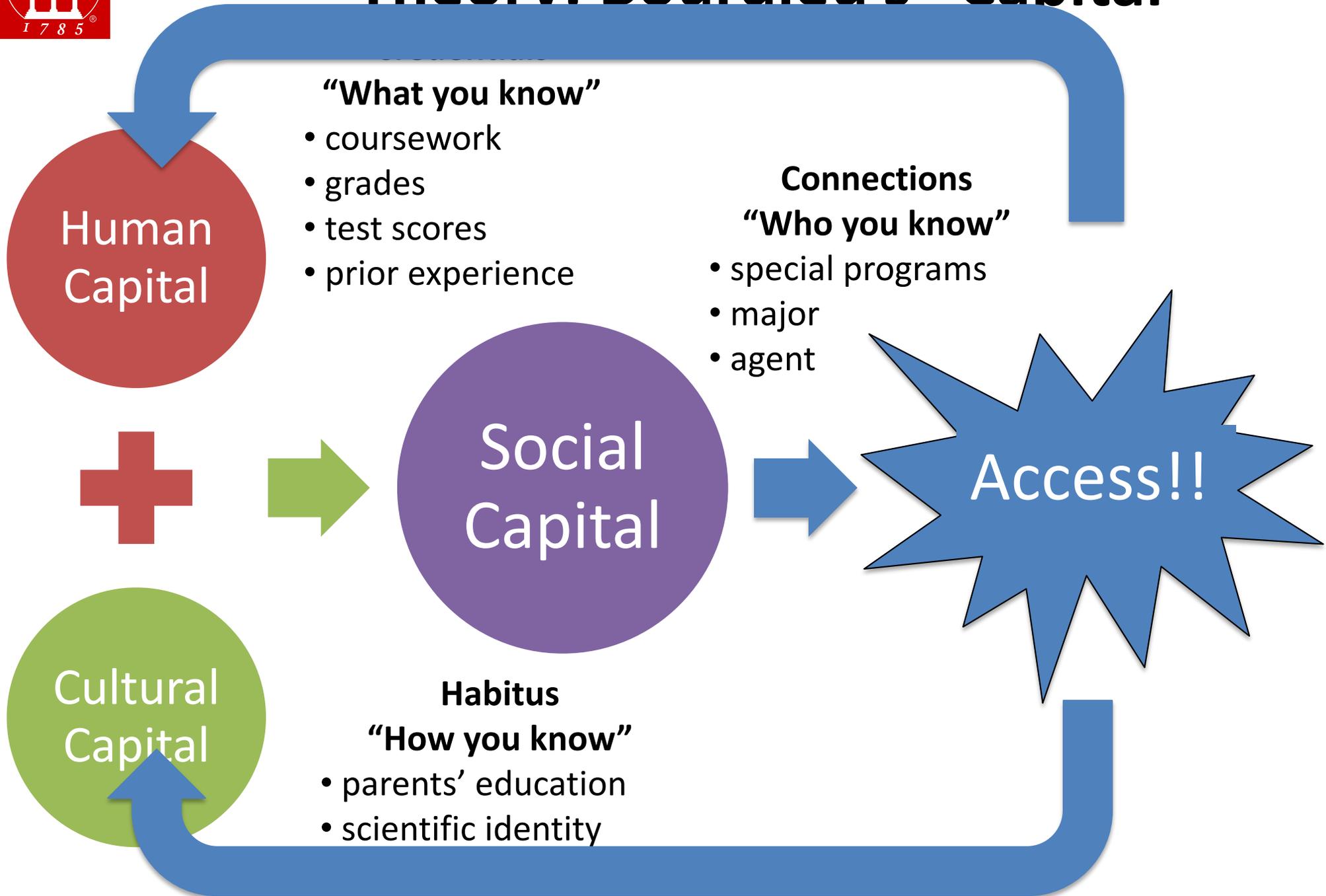


Which students get access to research experiences?

Consider how faculty find undergraduate researchers



Theory: Bourdieu's "Capital"





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



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

	CURE	Research internship
Scale	Many students	Few students
Structure	One to many	One to one
Enrollment	Open to all students in a course	Open to a selected or self-selecting few
Timing	Students invest time primary in class	Students invest time primarily outside of class
Setting	Teaching lab	Faculty research lab
Mentoring	Consistent / Structured	Varied

But does it “work”???

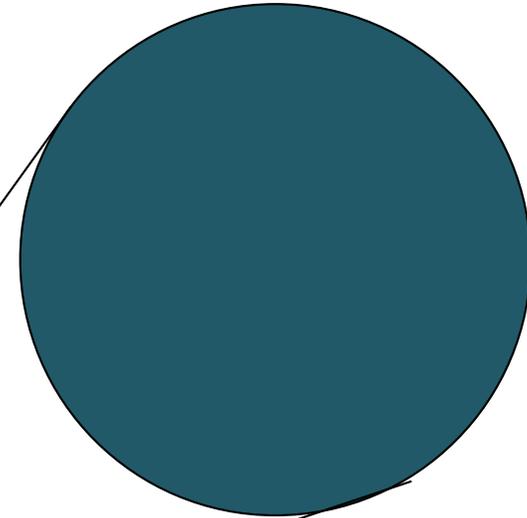
(Auchincloss et al., 2014)



Freshman Research Initiative

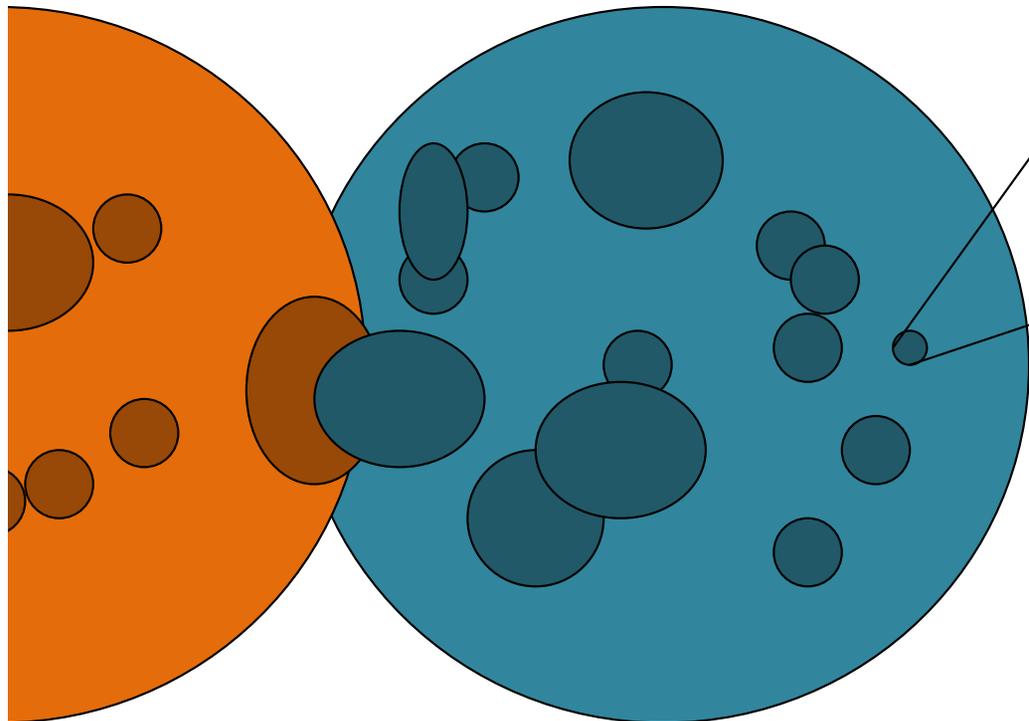
Research Program:

- 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

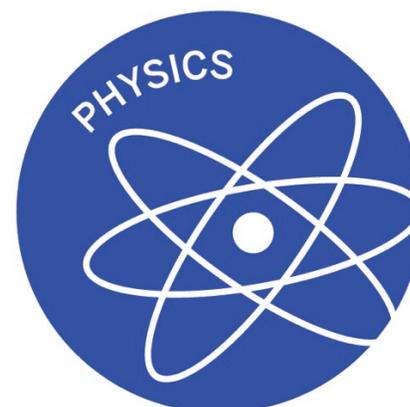
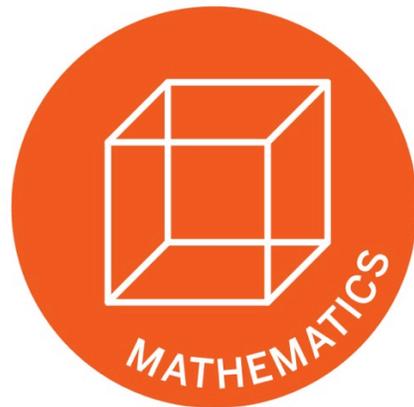
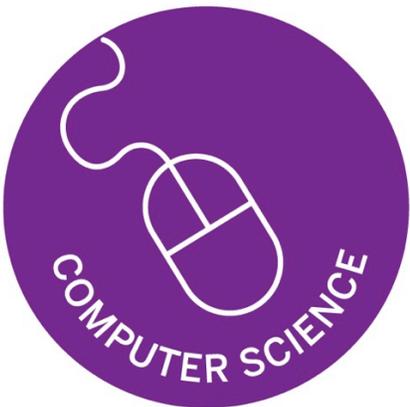
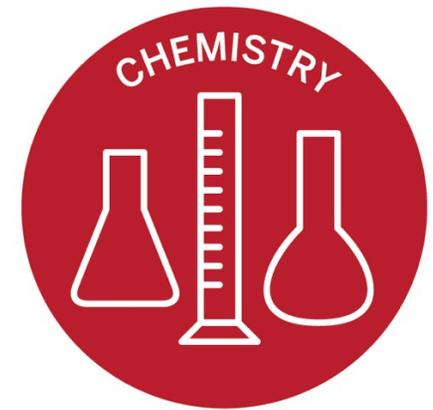
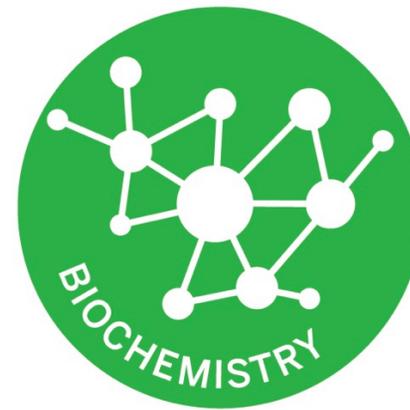
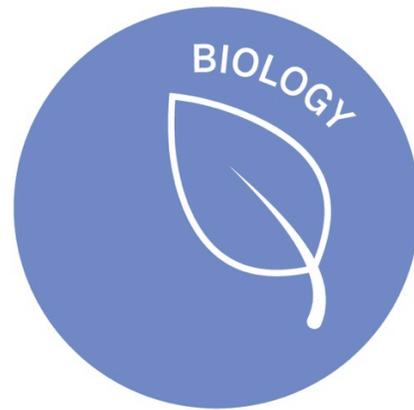




Example CURE program: UT Austin's *Freshman Research Initiative* **hhmi**



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

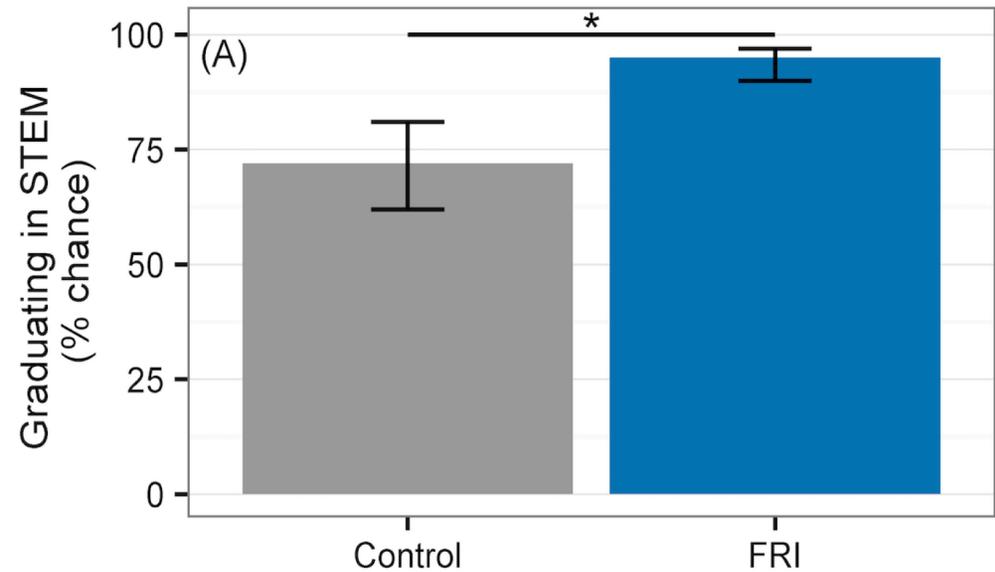
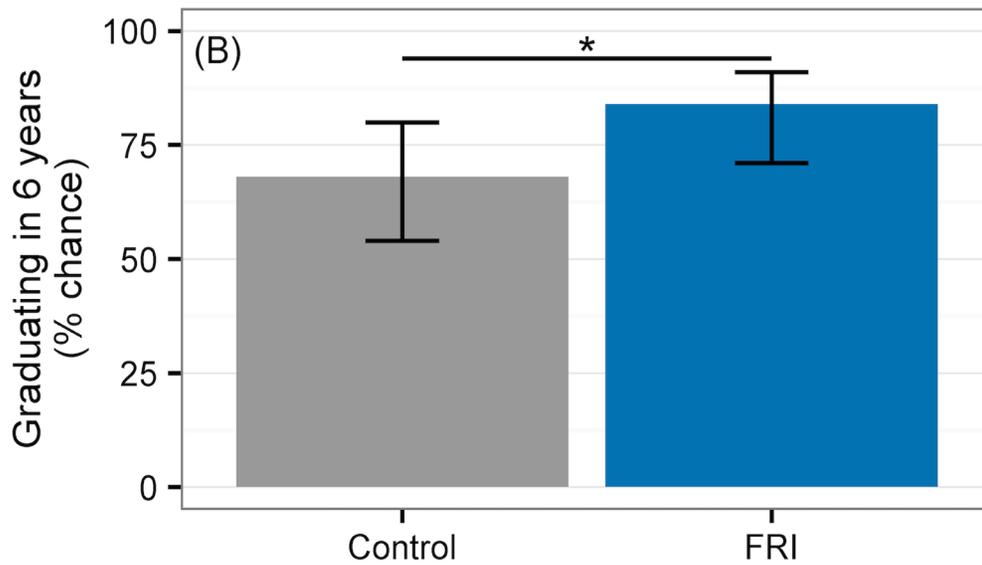


How does FRI affect students' graduation rates and completion of a STEM major?

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

THE JOURNAL OF
PHYSICAL CHEMISTRY C

ARTICLE

pubs.acs.org/JPC

368 Journal of Chemical Education • Vol. 86 No. 3 March 2009 • www.JCE.DivCHED.org • ©Division of Chemical Education

In the Laboratory

Why Silver Nanoparticles Are Effective for Olefin/Paraffin Separations

Zachary D. Pozun, Kelly Tran, Anna Shi, Ryan H. Smith, and Graeme Henkelman*

EDGE ARTICLE

www.rsc.org/chemicalscience | Chemical Science

Discrimination of flavonoids and red wine varietals by arrays of differential peptidic sensors†

Alona P. Umali, Sarah E. LeBoet, Robert W. Newberry, Siwon Kim, Lee Tran, Whitney A. Rome, Tian Tian, David Tain, Jane Hong, Melissa Kwar, Hildegard Heymann, and Eric V. Anslyn***

Design, Synthesis, and Amplification of DNA Pools for In Vitro Selection

Bradley Hall, John M. Micheletti, Pooja Satya, Krystal Ogle,² Jack Pollard,³ and Andrew D. Ellington¹

¹Department of Chemistry and Biochemistry, University of Texas, Austin, Texas

²Freshman Research Initiative, University of Texas, Austin, Texas

³3rd Millennium Corporation, Cambridge, Massachusetts

Current Protocols in Molecular Biology 24.2.1-24.2.27, October 2009

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

Andrew D. Lellis · M. Leah Allen · Alice W. Aertke · Jonathan K. Tran · David M. Hillis · Courtney K. Harbin · Christian Caldwell · Daniel R. Gallie · Karen S. Browning

Synthesis and Catalytic Evaluation of Dendrimer-Encapsulated Cu Nanoparticles

An Undergraduate Experiment Exploring Catalytic Nanomaterials

Z. Vivian Feng,*† Jennifer L. Lyon, J. Sawyer Croley, Richard M. Crooks, David A. Vanden Bout, and Keith J. Stevenson

Freshman Research Initiative, Department of Chemistry and Biochemistry, University of Texas at Austin, Austin, TX 78712; *feng@augsb.org

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. Jhaveri,² and Andrew D. Ellington^{1,2}

¹Department of Chemistry and Biochemistry, University of Texas, Austin, Texas

²Freshman Research Initiative, University of Texas, Austin, Texas

³Nova Research, Inc., Alexandria, Virginia

Current Protocols in Molecular Biology 24.3.1-24.3.27, October 2009

Published online October 2009 in Wiley Interscience (www.interscience.wiley.com).

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J Chem Crystallogr (2010) 40:1060-1064

DOI 10.1007/s10870-010-9794-7

ORIGINAL PAPER

Synthesis and Crystal Structure of a New Heterotrimeric Schiff-Base Zn-Gd Complex

Andy Liao · Xiaoping Yang · Julie M. Stanley · Richard A. Jones · Bradley J. Holliday

(Examples from UT Austin Freshman Research Initiative)



Novel findings that have broad relevance: Database entries or Community reports

New Release: FB2015_03, released June 26th, 2015

FB2015_03, released June 26, 2015



Home Tools Files Species Documents Resources News

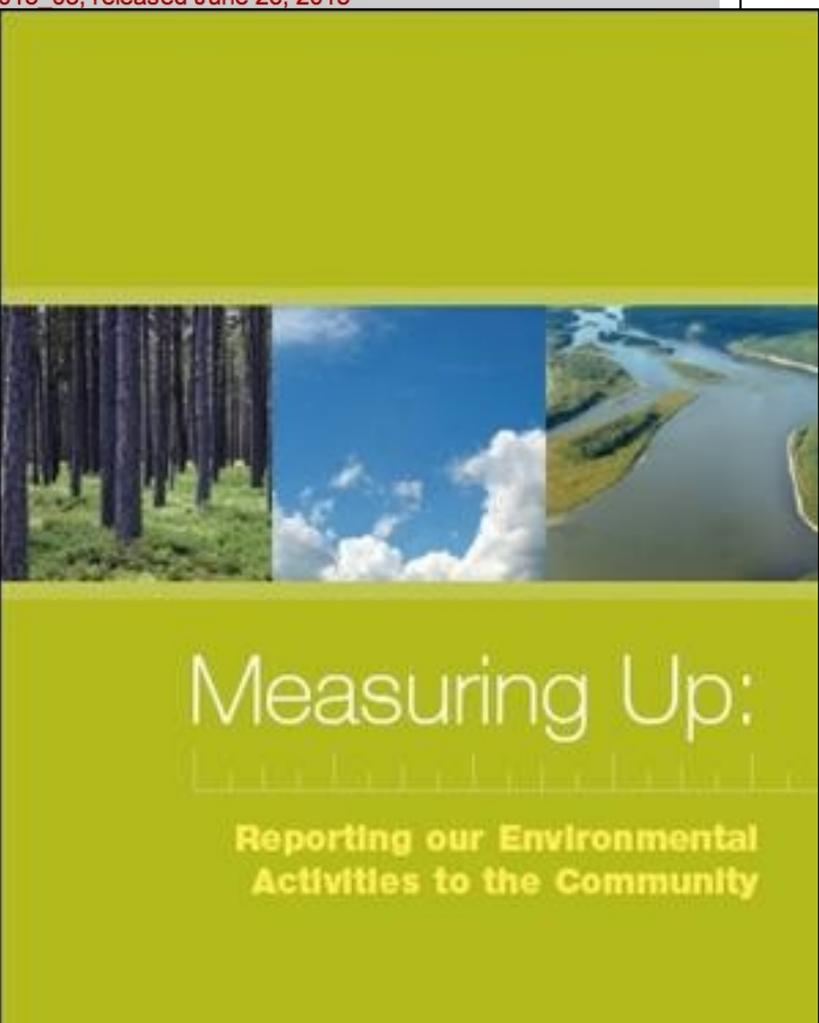
D.melanogaster
D.virilis
A.mellifera

BLAST GBrowse QueryBuilder RNA-Seq Search

Fast-Track Your Paper
FlyBase Forum
Find a Fly Person

QuickSearch ?
Simple Expression Phenotype GO Prot

Species: include non-Dmel
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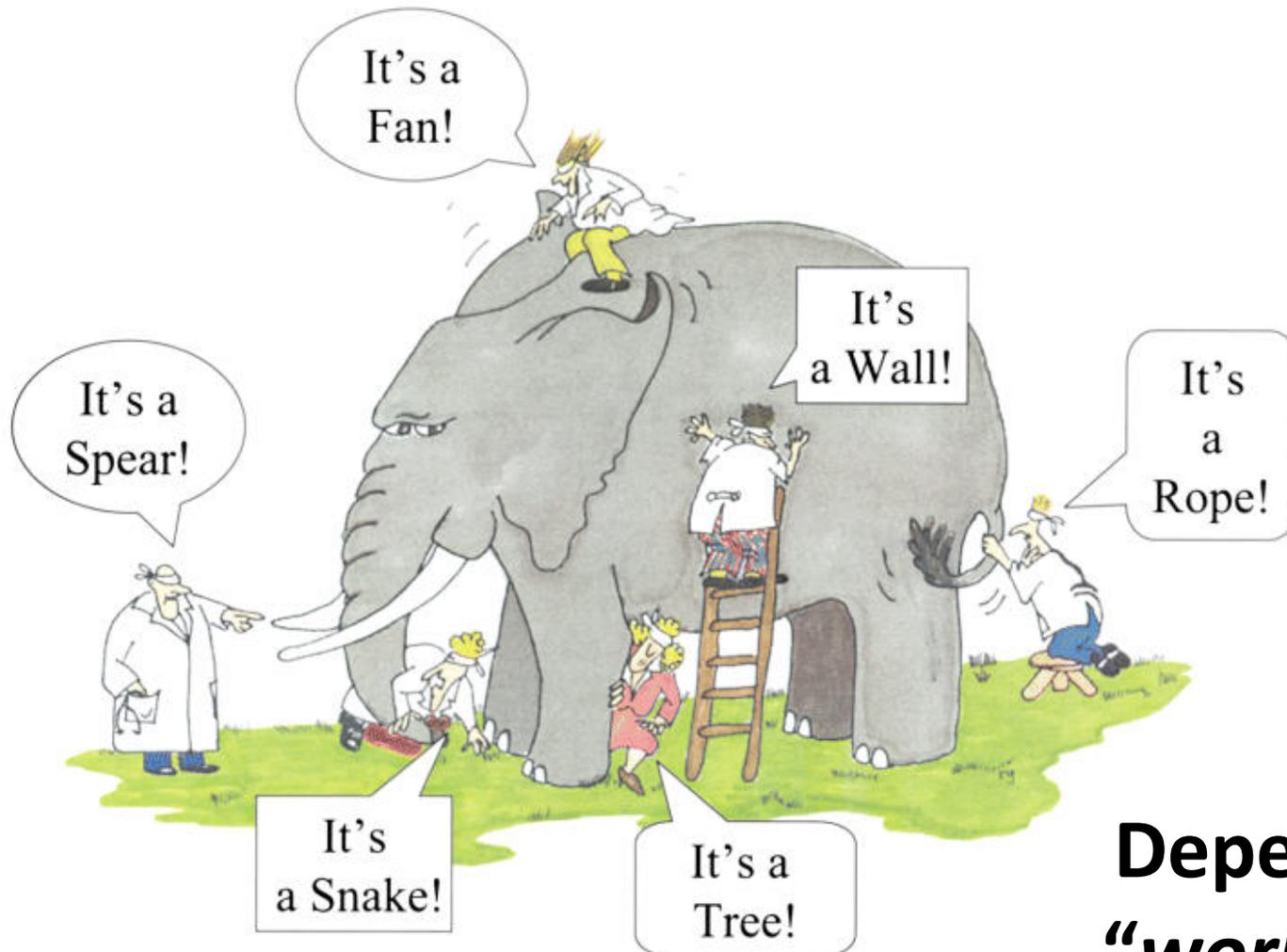
Measuring Up:
Reporting our Environmental
Activities to the Community

Examples from NRC Report (2016):
Integrating Discovery-based Research into the
Undergraduate Curriculum



What makes FRI or other research experiences work?

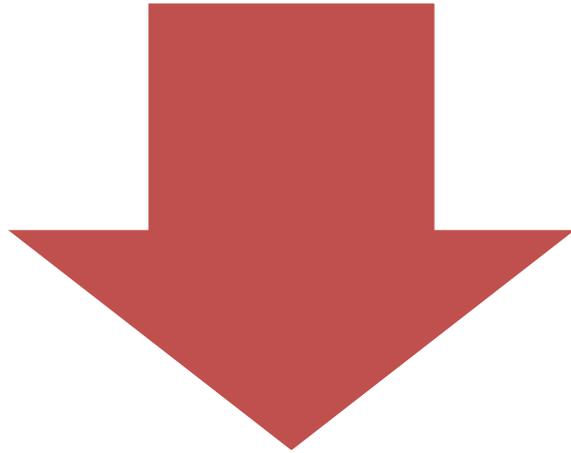
In other words, what are the key features?



**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?



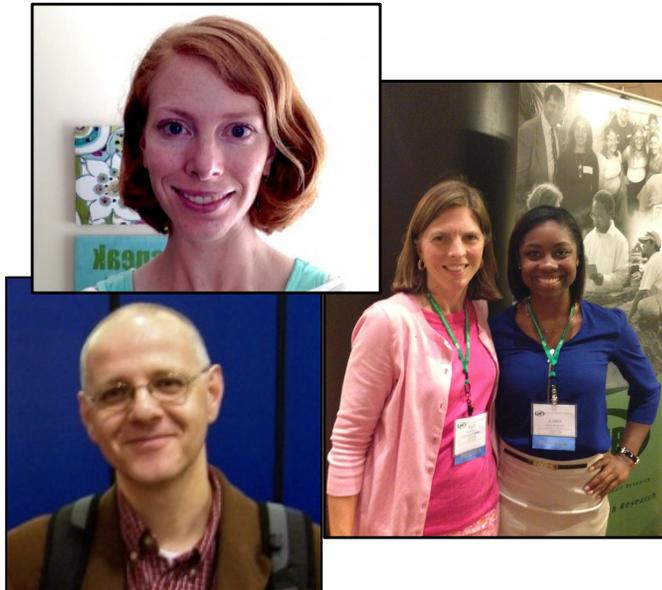


What happens during a research experience (FRI, CUREs, internships/UREs, etc.) that makes it effective for students?

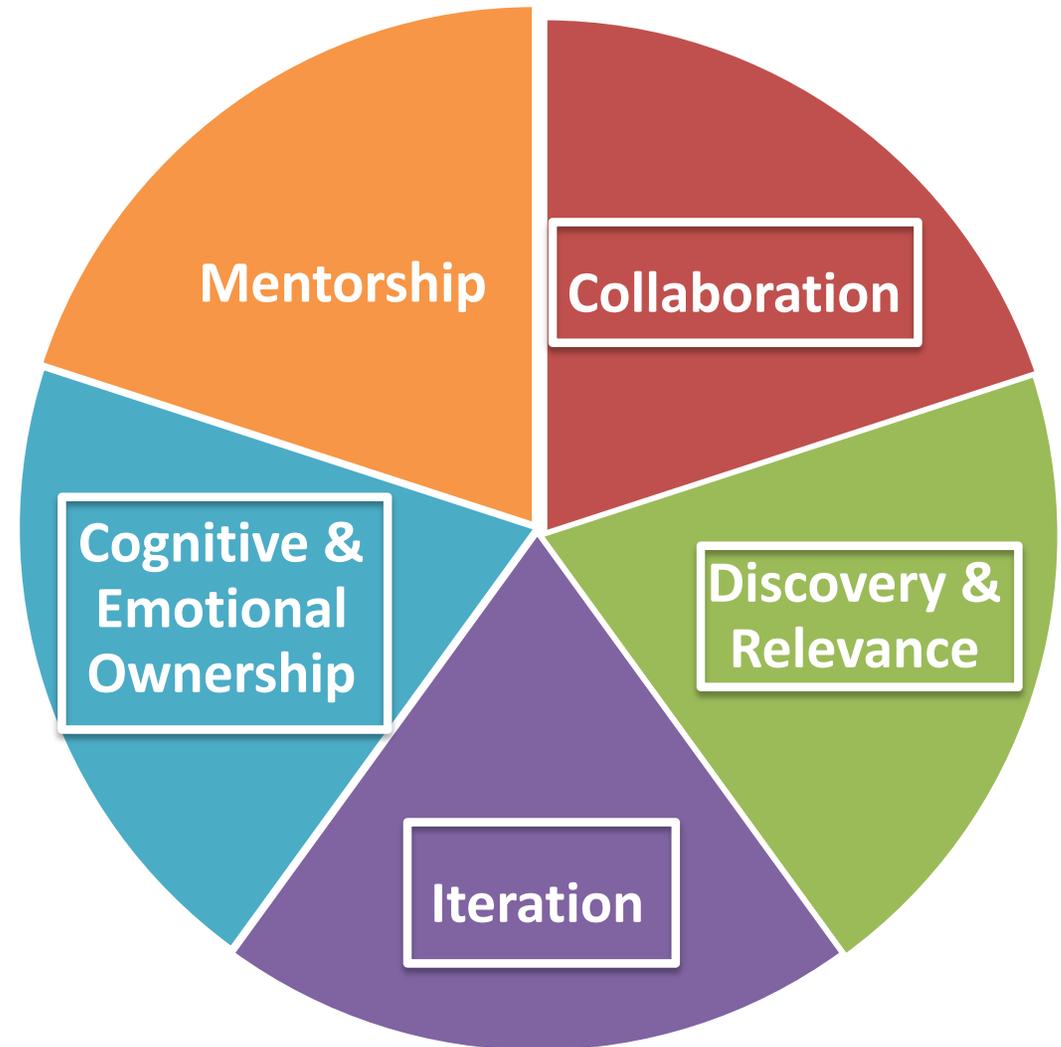
What do you hypothesize are the *key features*?



Hypothesized Distinctive Features of CUREs



Lisa Corwin, David Hanauer,
Aspen Robinson, et al.





Bottom-up: Cross-course comparison



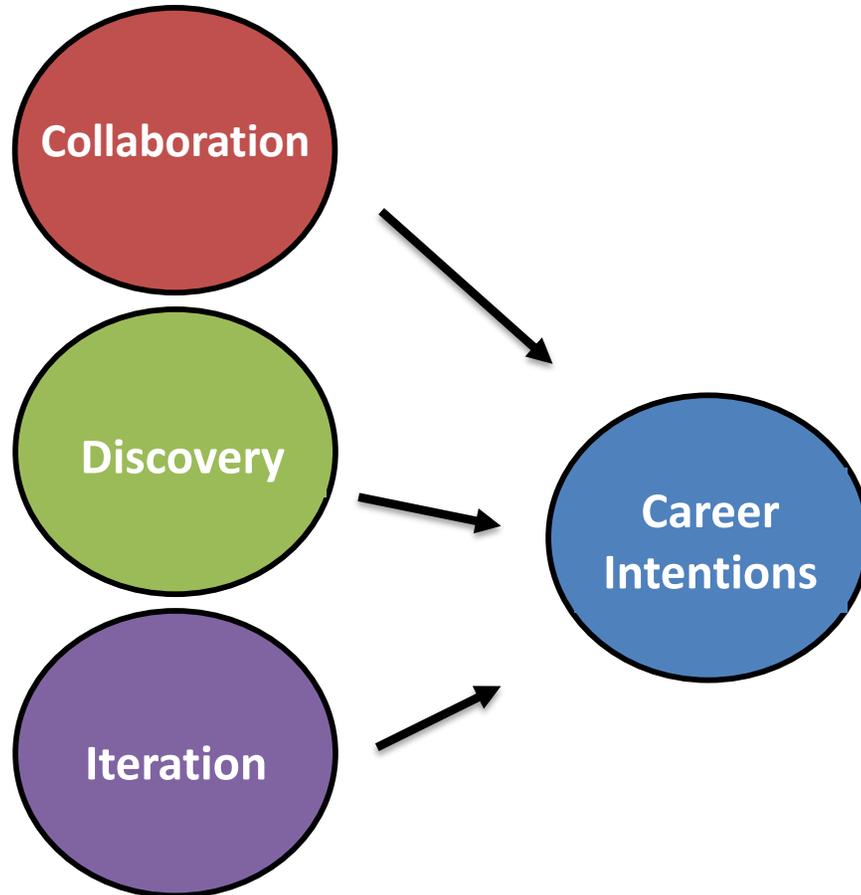
Lisa Corwin, Chris Runyon,
Stacia Rodenbusch, et al.

- 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)

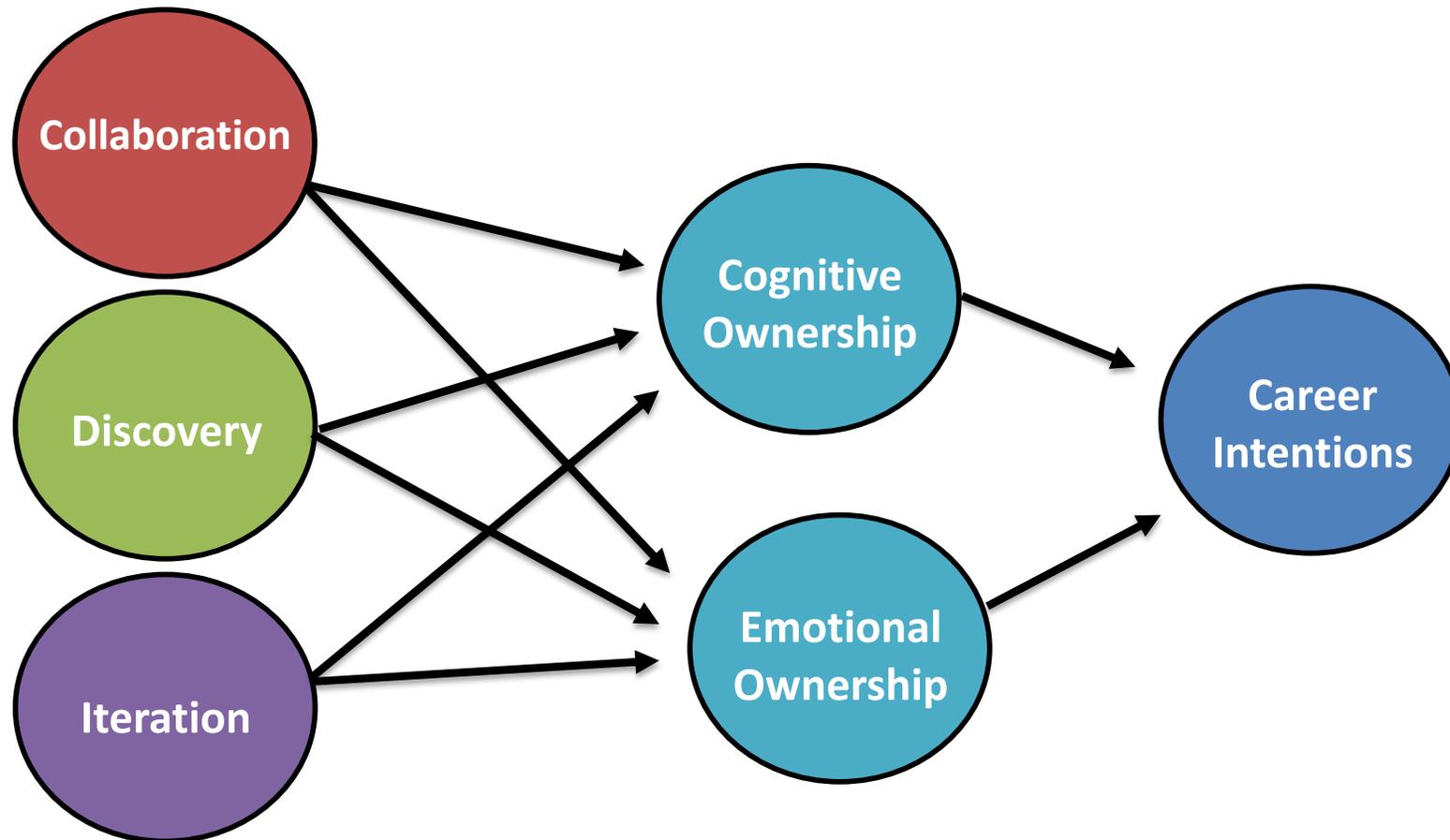


Do course features *predict* Δ career intentions?



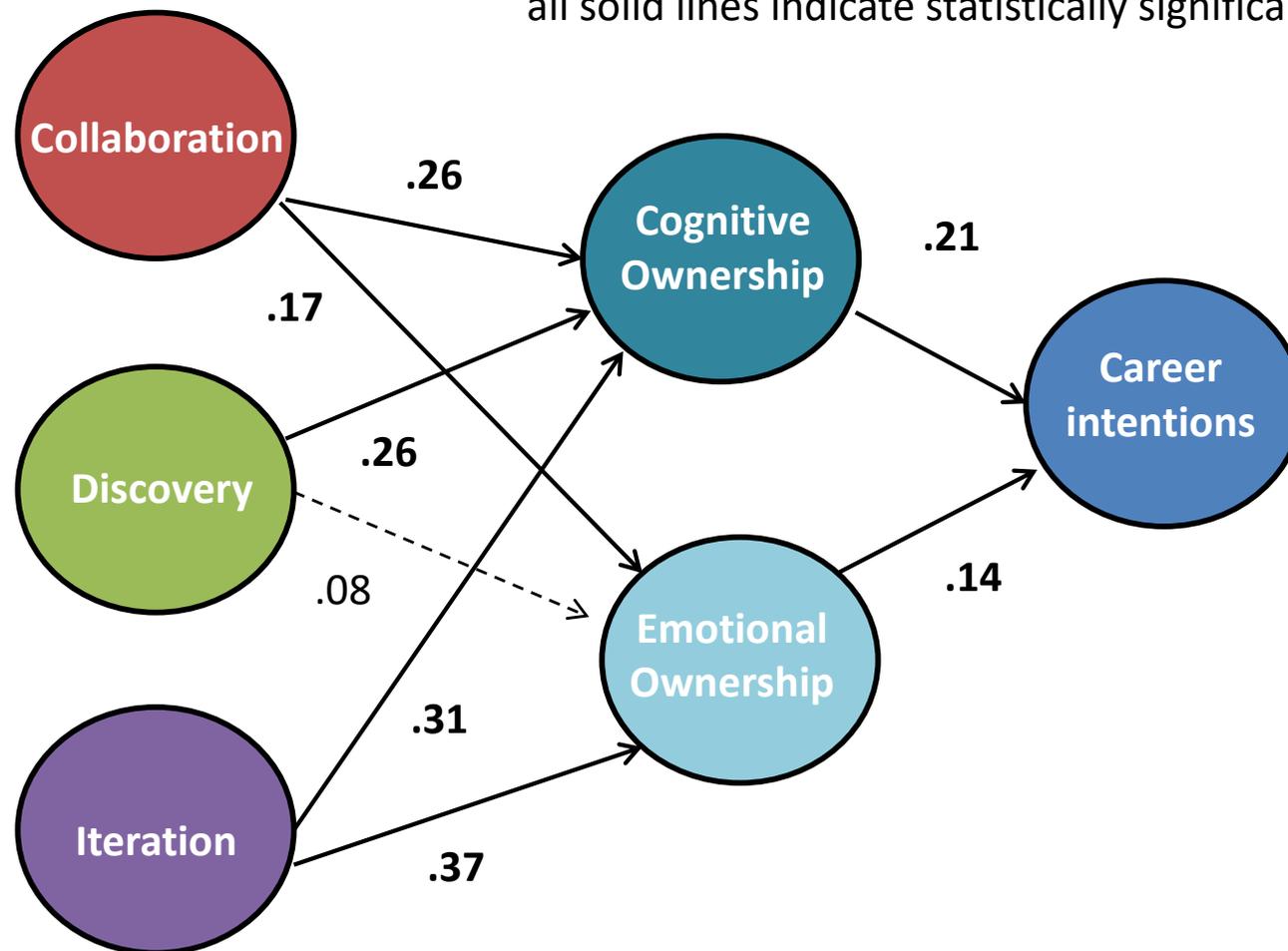


Are any observed relationships mediated by ownership?





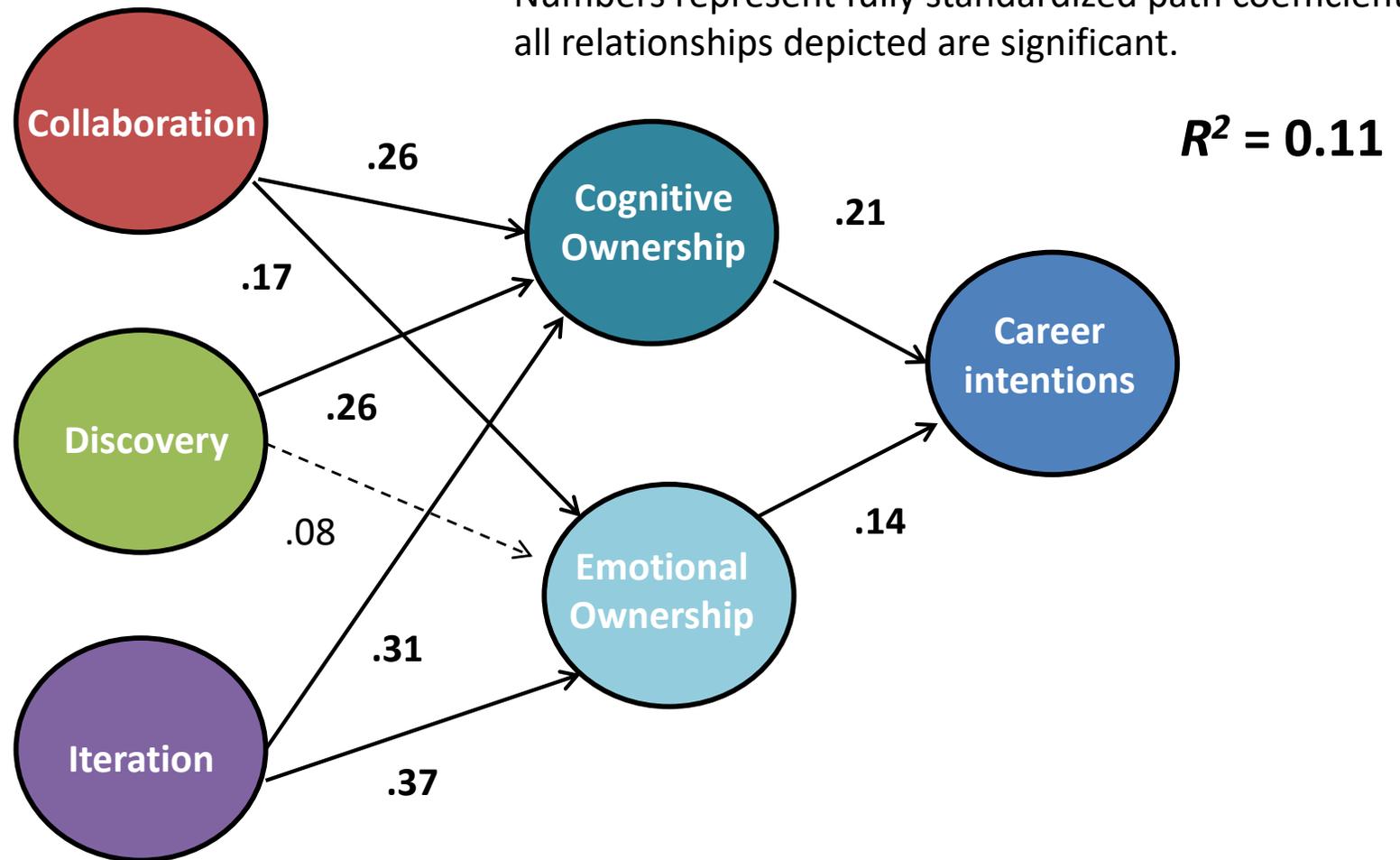
Numbers represent fully standardized path coefficients; all solid lines indicate statistically significant relationships.



- 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)?

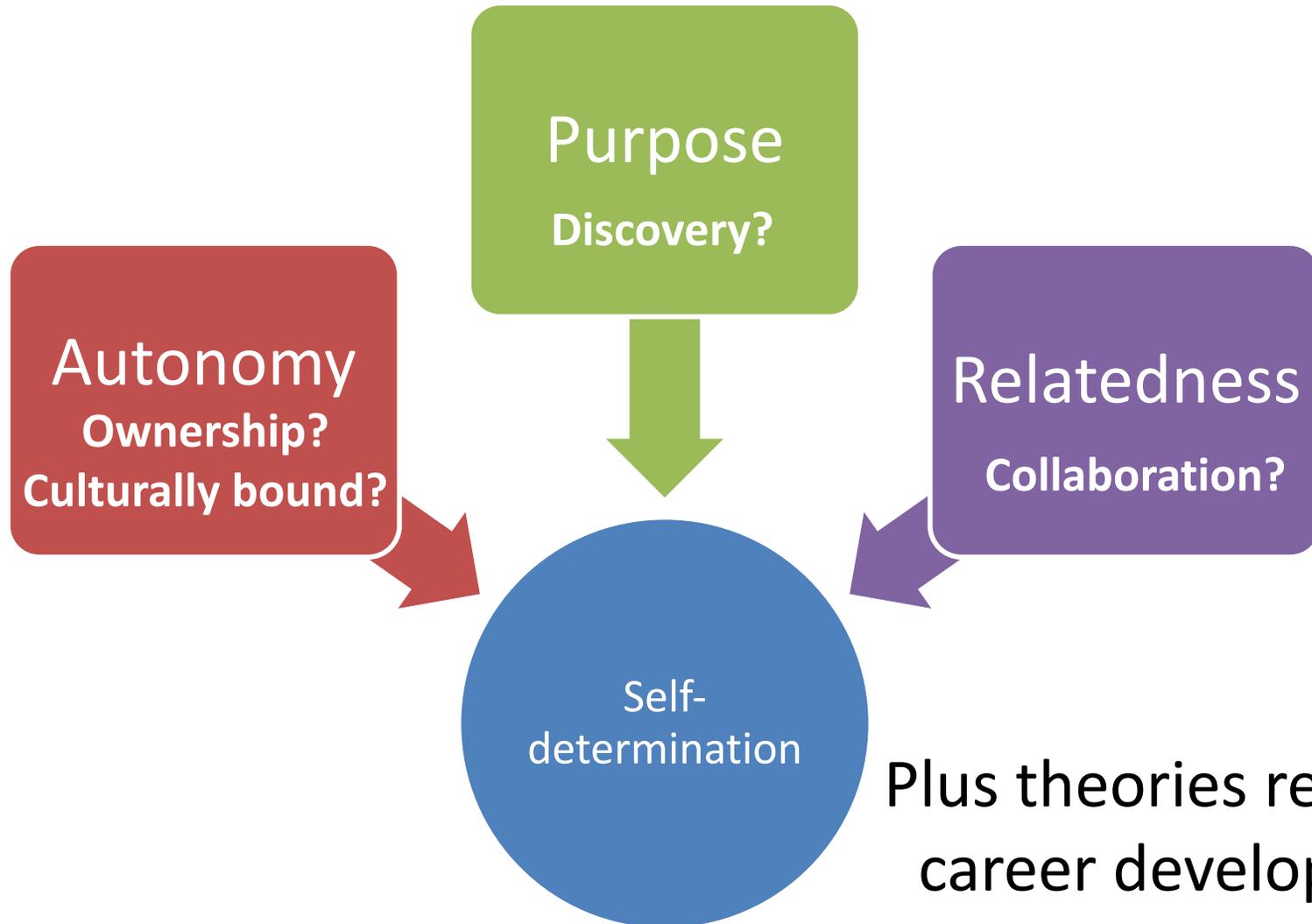
Not entirely atheoretical...

Focus on persistence - theories of motivation



Self-Determination Theory of Motivation

(Ryan and Deci, 1985, 1991)



Plus theories related to
career development,
equity, cognition, etc...

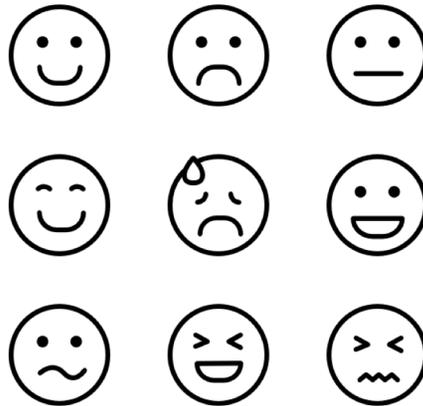


Tip of the iceberg!



Psychosocial Development

- Ownership
- Self-efficacy
- Sense of belonging
- Scientific identity



Affective Development

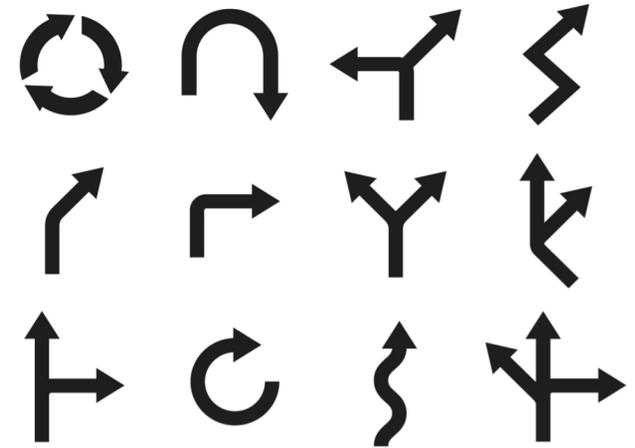
- Mindset
- Perseverance / Grit
- Values

Cognitive Development

- Knowledge, skills, abilities
- Expertise development

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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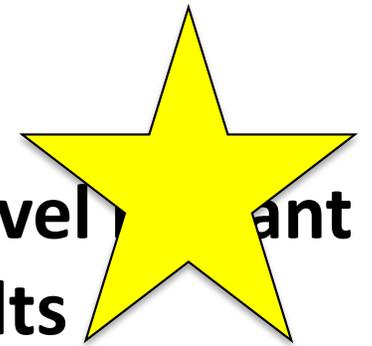
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Find a neighbor and discuss...

- 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?
-