



Improving **U**ndergraduate **S**TEM **E**ducation **Initiative**



Implementing Active Learning in Undergraduate STEM Courses

Jessica Rosenberg, Ph.D.
Wendy Smith, Ph.D.




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AAAS IUSE Initiative

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WORKSHOP



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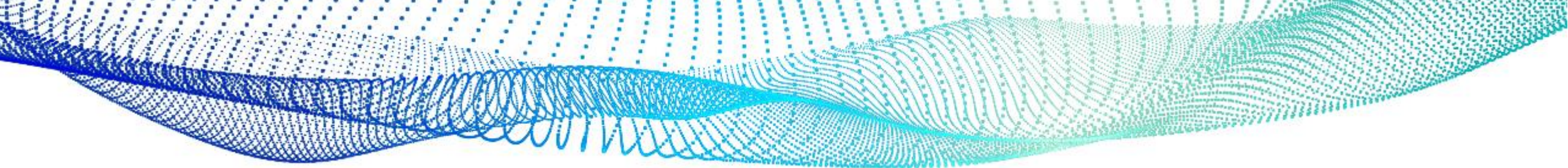
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The AAAS-IUSE initiative supports faculty, students, and the greater undergraduate STEM education community by disseminating research and knowledge about STEM teaching, learning, equity and institutional transformation.

Check out our website to learn more and view: <https://aaas-iuse.org>

- Blog
- Workshops
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WORKSHOP

Implementing Active Learning in Undergraduate STEM Courses



Jessica Rosenberg

George Mason University

NSF IUSE ICT 1821589: Building a Culture of Active Learning through Course-Based Communities of Transformation



Leadership Team

Jessica Rosenberg

Physics and Astronomy

Jill Nelson

Electrical and Computer Engineering

Jaime Lester

College of Humanities and Social Sciences

Bob Sachs

Mathematics

Mark Snyder

Computer Science

PhD Students

Julie Shank

Higher Education Program

Kat Fernandez

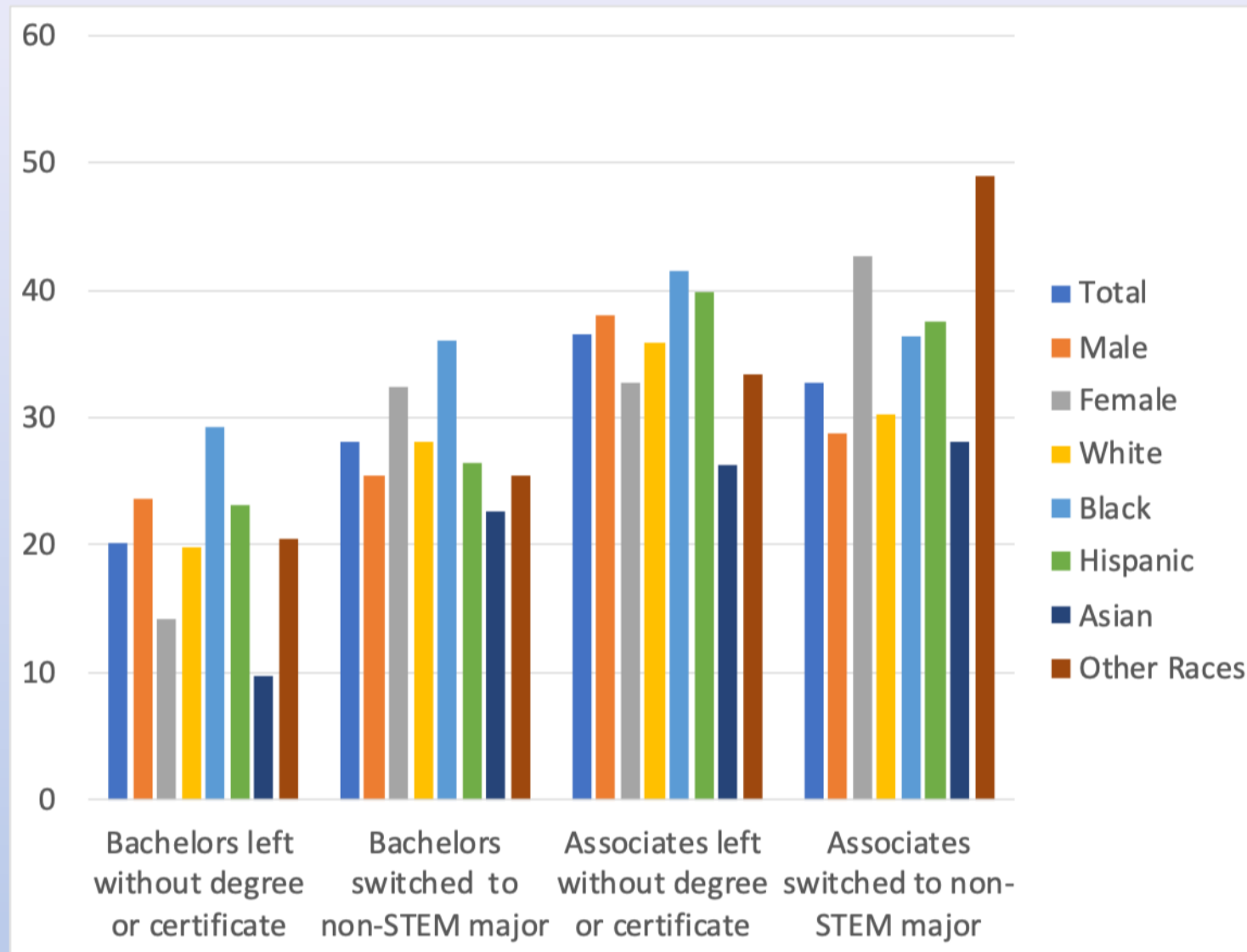
Physics and Astronomy

Phoebe McClincy

Physics and Astronomy

Program Manager: Melinda Ryan

A Large Fraction of Students Leave STEM



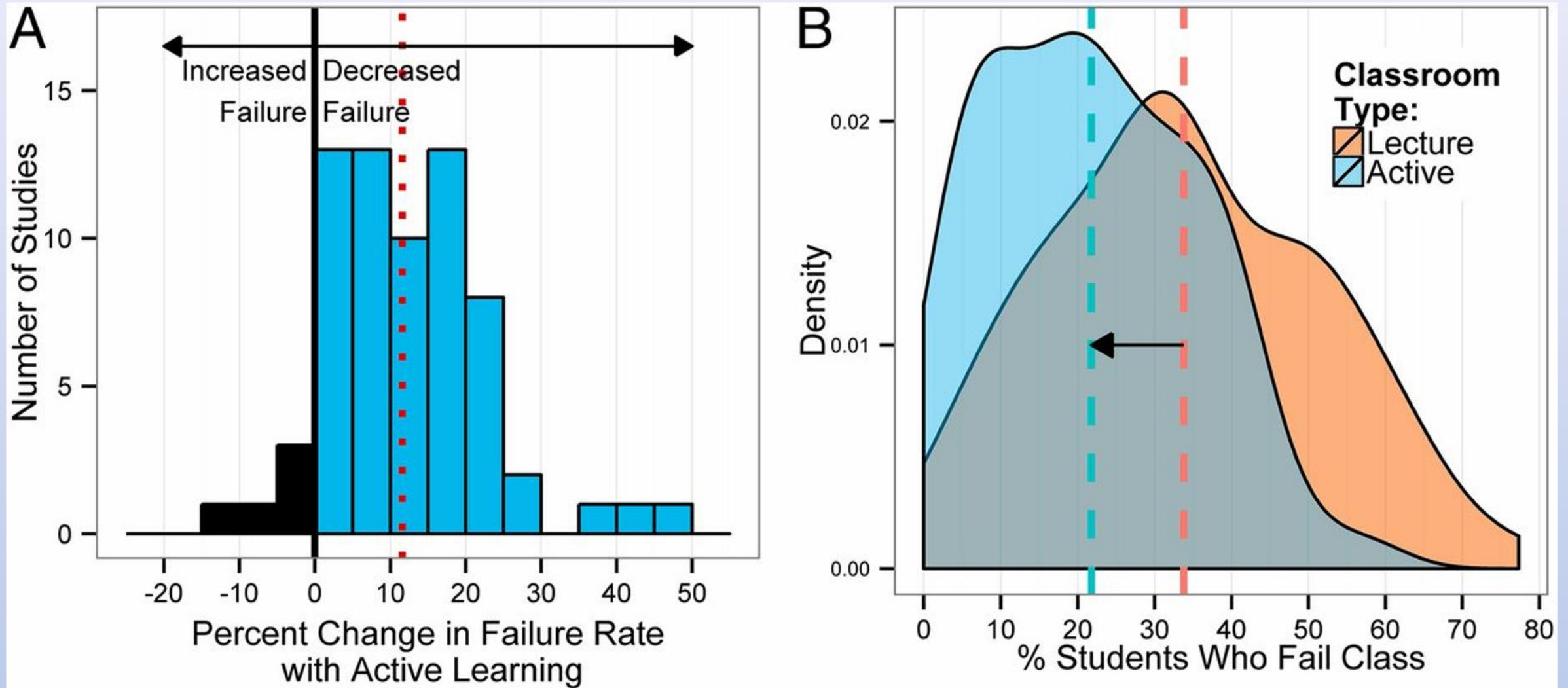
A Large Fraction of Students Leave STEM

NOW: *Talking about Leaving Revisited (2016): What Factors Contribute to Switching Decisions?*

<i>Factors Contributing to Students' Decisions to Switch from a STEM Major that also Affect Non-switchers</i>	<i>% Switchers (N=96)</i>	<i>% Non-switchers (N=250)</i>
Poor grades	61%	14%
Lost interest in or disappointed by STEM major	61%	5%
Lacks sense of belonging, negative culture of STEM	52%	8%
Problems with classroom learning experiences (too fast pace, course pitched too high; poor alignment between course elements)	51%	16%
“Weed-out” effects from gateway STEM courses	33%	15%
Under-informed, wrong choice of STEM major	42%	6%
Poor high school preparation, difficult transition to college	38%	3%
Career-choice limitations	33%	4%
STEM major too narrow: Wants to broaden education	26%	2%
Problems with poor quality of teaching	25%	2%
Difficulties getting help	21%	8%
Working a lot of hours/full-time makes succeeding in a STEM major too difficult	3%	0%

Anne-Barrie Hunter, Heather Thiry, Dana Holland, Raquel Harper, Elaine Seymour

Why Aim to Increase Active Learning?



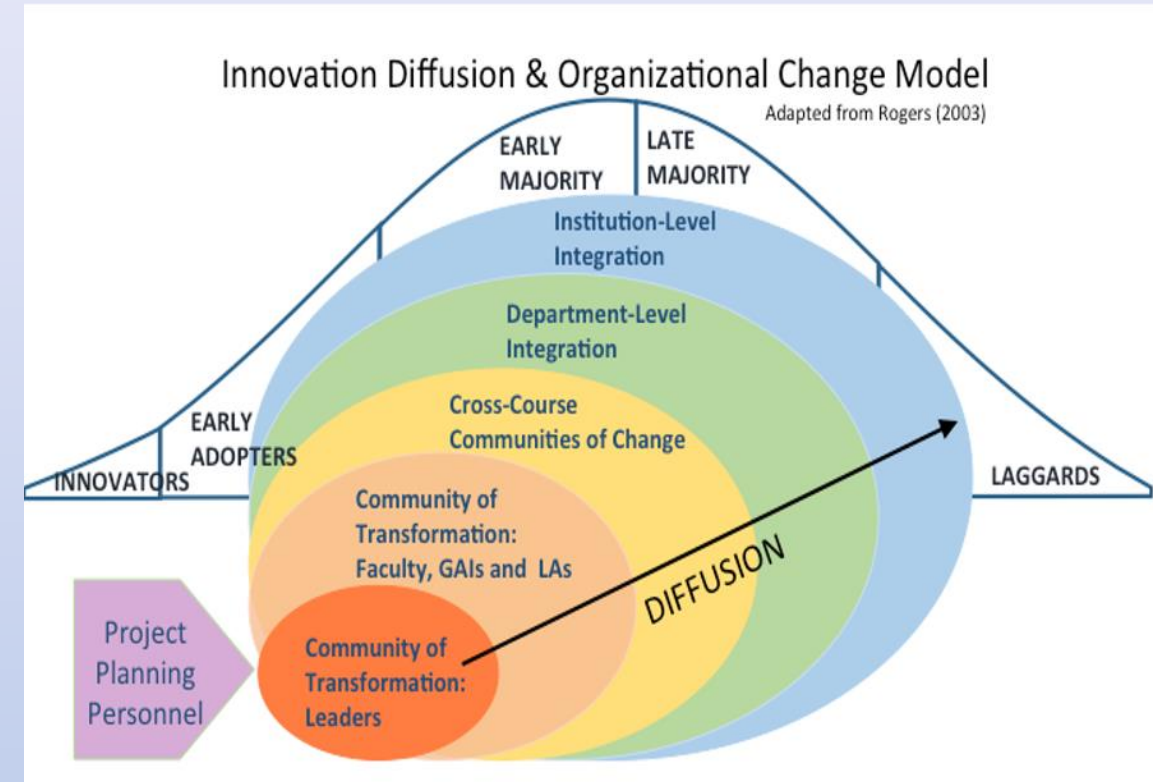
Active learning increases student performance in science, engineering, and mathematics 2014, Freeman, Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., Wenderoth, M. P., PNAS, 111, 8410

Project Goals

- Use multi-generational teams to spread the culture of active learning within the STEM faculty and facilitate broad adoption.
- Develop an understanding of how a faculty-driven grassroots approach, combined with institutional support, can build a culture of active learning.
- Study strategies to remove barriers for faculty implementing new evidence-based teaching methods.
- Prepare the next generation of STEM educators by involving graduate and undergraduate students in the implementation of active learning in the classroom.

Grassroots Change

- Grassroots leaders seek to change their institutions from within
- Effective tactics include organizing intellectual opportunities, professional development opportunities, leveraging curricula and classroom as a forum (Kezar and Lester 2011)
- Change requires altering individual mindsets or perspectives, including those of campus leadership (diffusion)

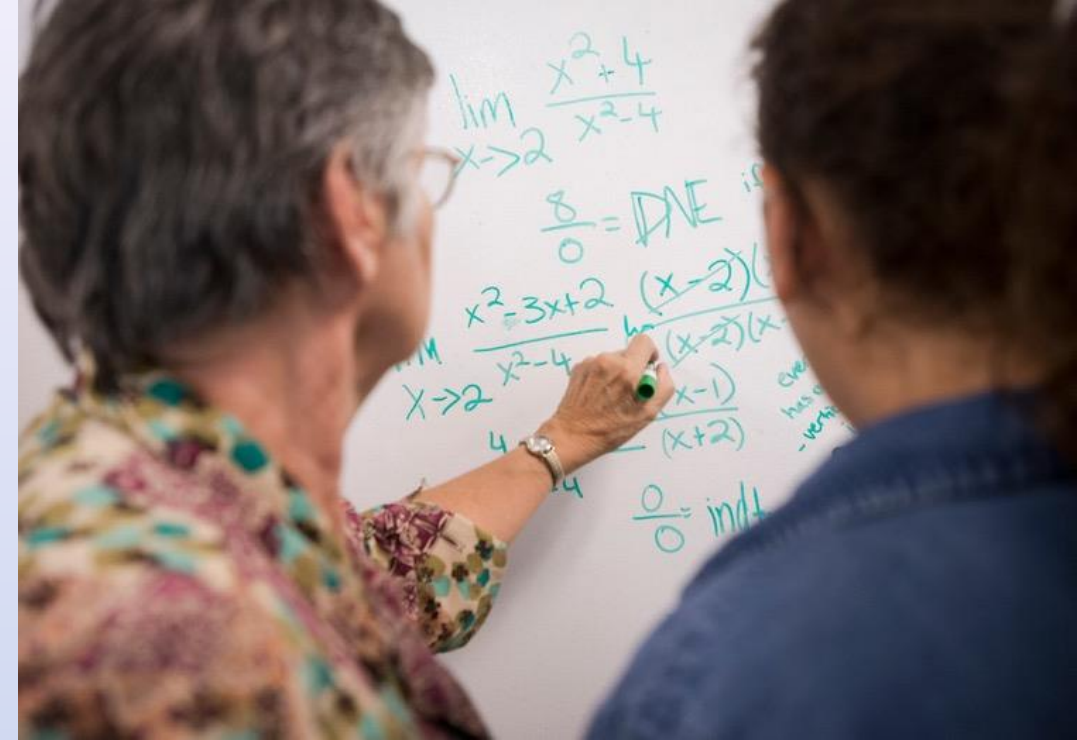


Who are your change leaders?

- What are the most important qualities of a change leader?

Project Implementation

- Mason is a large (38,000), public, very high research activity university
- Focused on large-enrollment intro. courses
- Implementation in Math (Calc I & II), Physics (University Physics I & II), and Computer Science (Intro)
 - Math: Launched Early 2019
 - Physics: Launched Fall 2020
 - Computer Science: Launched Fall 2021
- Faculty determine active learning emphasis (grassroots)
- Disciplinary leads facilitate efforts



Project Implementation: Launch workshop

- All-day workshop
- Morning: setting the institutional stage and explaining why active learning is important in the discipline
- Afternoon: faculty collaboration and planning change efforts



Common Themes

- Restructure recitations to make them student-centered
- Improve course coordination
- Build or borrow materials that will support active learning
- Provide GTA training/support



Which of these themes are most resonant for you, in your circumstances?

Prepare the next generation of STEM educators by involving graduate and undergraduate students in the implementation of active learning in the classroom

- Physics GTA seminar

Structure: Weekly seminar written into the contracts for all physics and astronomy GTAs. First-year graduate students meet weekly to discuss issues in their classes, learn more about active learning, and build a community and a discourse on teaching. Faculty led.

- Math GTA training

Structure: Weekly meeting of Calc I & II GTAs to check in, discuss issues in their classes, learn more about active learning, and build a community and a discourse on teaching. Two GTA leaders facilitated discussion

- Learning assistant seminar

Structure: Weekly meeting of new LAs across College of Science to discuss issues in their classes, learn more about active learning, and build a community and a discourse on teaching.

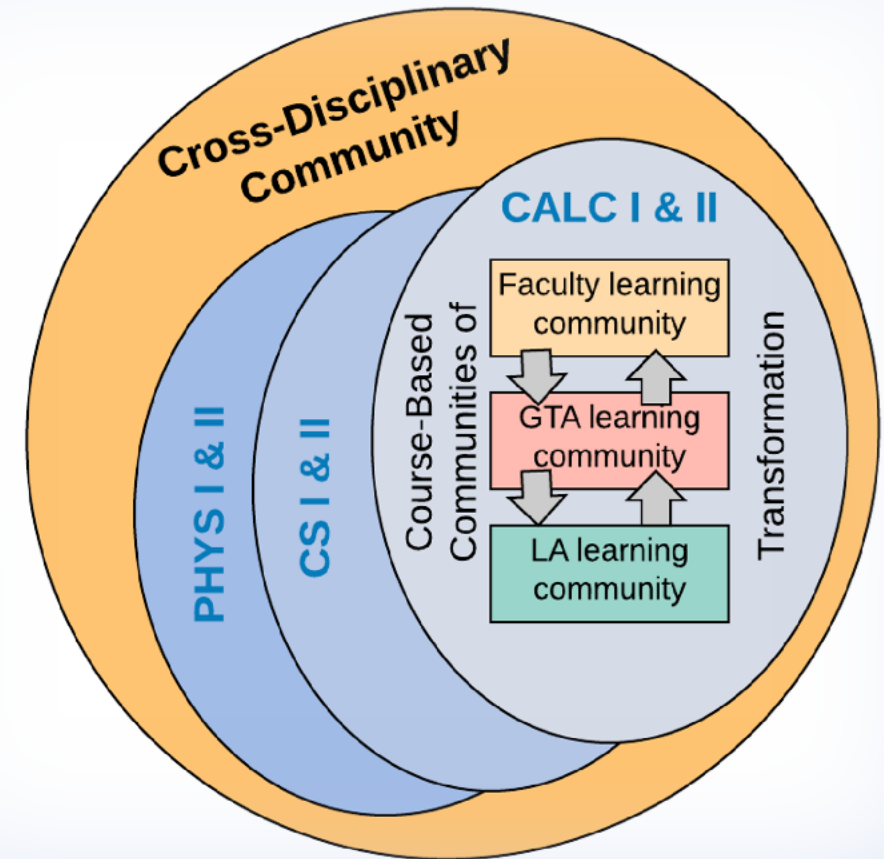
Results of GTA Efforts

- Preparing GTAs to use student-centered practice takes time and/or direct guidance
 - Repeat discussions helps solidify ideas in new instructors
 - Creating and executing student-centered activities can be instructive and fun for more advanced GTAs
- Building community among GTAs provides opportunities for deeper, more challenging discussions.
 - Peer-to-peer discussions builds trust and engages GTAs in examination of their own practice
- GTAs are future faculty - if STEM teaching is to change, we must help them learn new techniques

Use multi-generational teams to spread the culture of active learning within the STEM faculty and facilitate broad adoption

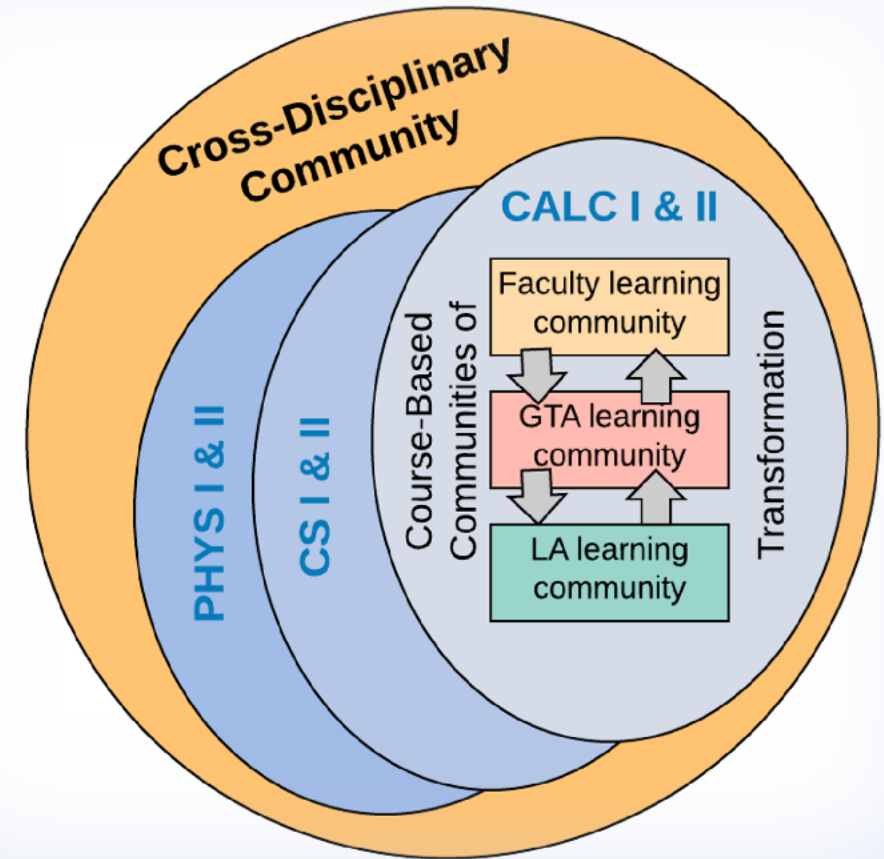
How?

- Create teams of faculty, GTAs, and LAs focused on implementing active learning in targeted gateway courses
- Build course-based communities of transformation (CCTs) within Math, Physics, and CS
- Provide training on active learning and organizational change in higher education



Use multi-generational teams to spread the culture of active learning within the STEM faculty and facilitate broad adoption

- Regular meetings of engaged faculty
 - Math alternates discussion with a seminar on education research
- Engagement across generations depends on course structure
 - Hard in general
 - Very hard during a pandemic



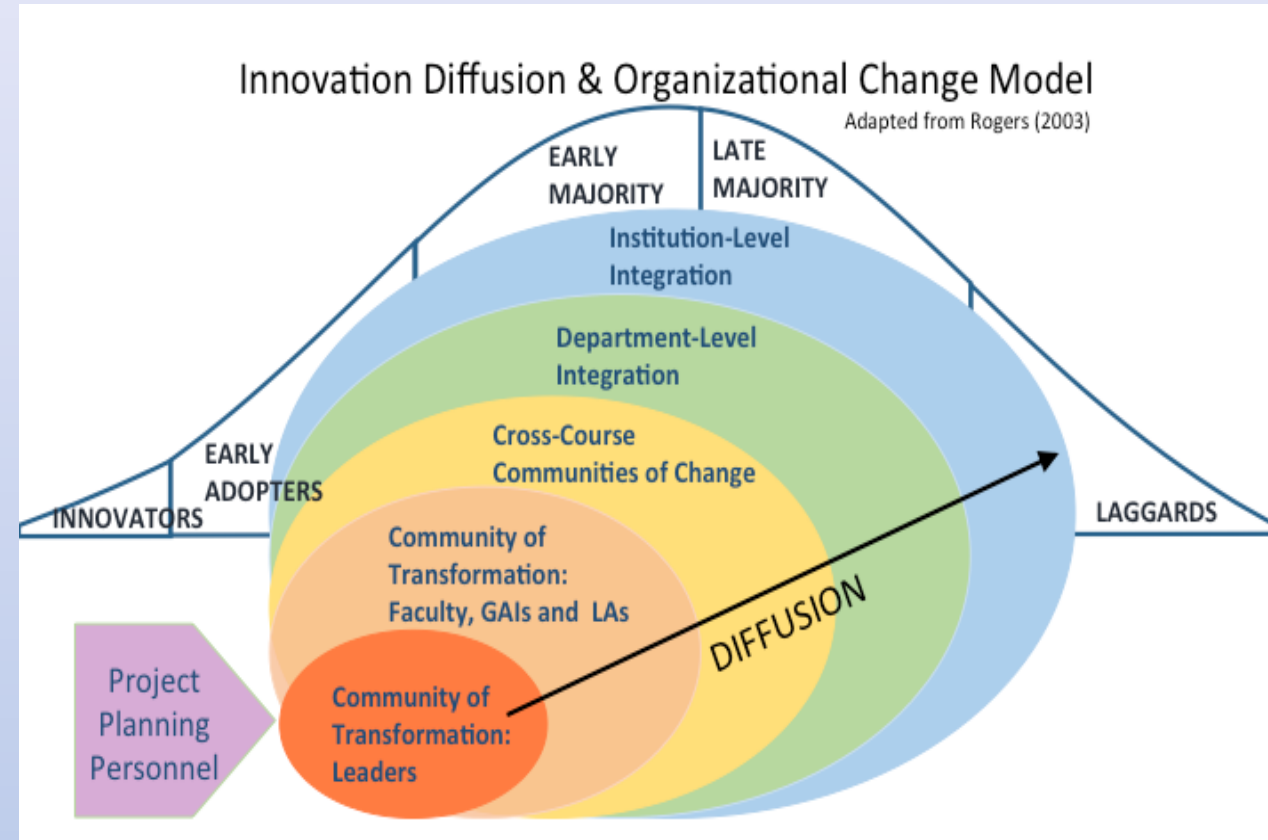
Develop an understanding of how a faculty-driven grassroots approach, combined with institutional support, can build a culture of active learning

Mason is supporting increased active learning: The current strategic plan aims for 30% of all classrooms being Active Learning Classrooms. The accelerator works to support College of Science faculty teaching in these spaces through learning assistants and faculty development.



Collaboration and Diffusion are important

- Active Learning Brown Bags
- Collaboration between CCT leads
- Discussion with campus leaders
- Connection to institutional goals



Final Thoughts

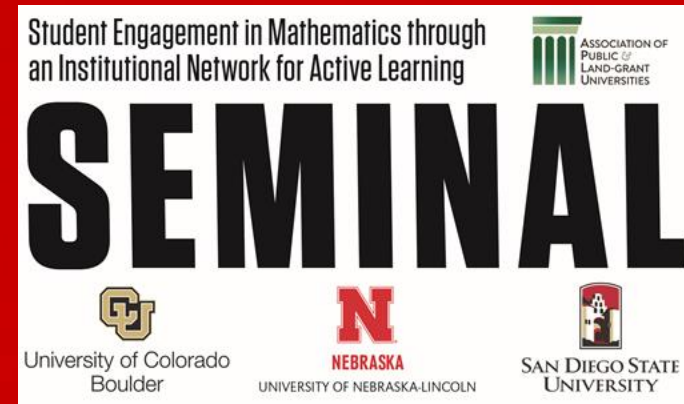
- Institutional and disciplinary norms shape path
 - Even access to collaborative learning spaces has gotten more difficult with rising research status
- Helping graduate students learn new techniques is an easy gateway to improvement
- Developing resources for active learning can help support efforts
- Doing this work highlights areas where coordination is needed and highlights the need for coordination work
- Pandemic and remote teaching makes all of this harder but also has allowed new leaders to emerge

Questions to consider

- What do you see as the levers for changing the culture of teaching particularly with respect to large introductory course? What are the challenges or barriers?
- How do we make these efforts and changes sustainable?

Departmental Transformation to Improve Student Success in First-Year Mathematics Courses

Dr. Wendy M. Smith
University of Nebraska-Lincoln
AAAS Webinar, 26 October 2021



SEMINAL is supported by a grant from the National Science Foundation (DUE-1624643, 1624610, 1624628, and 1624639). All findings and opinions are those of the authors and not necessarily of the NSF.

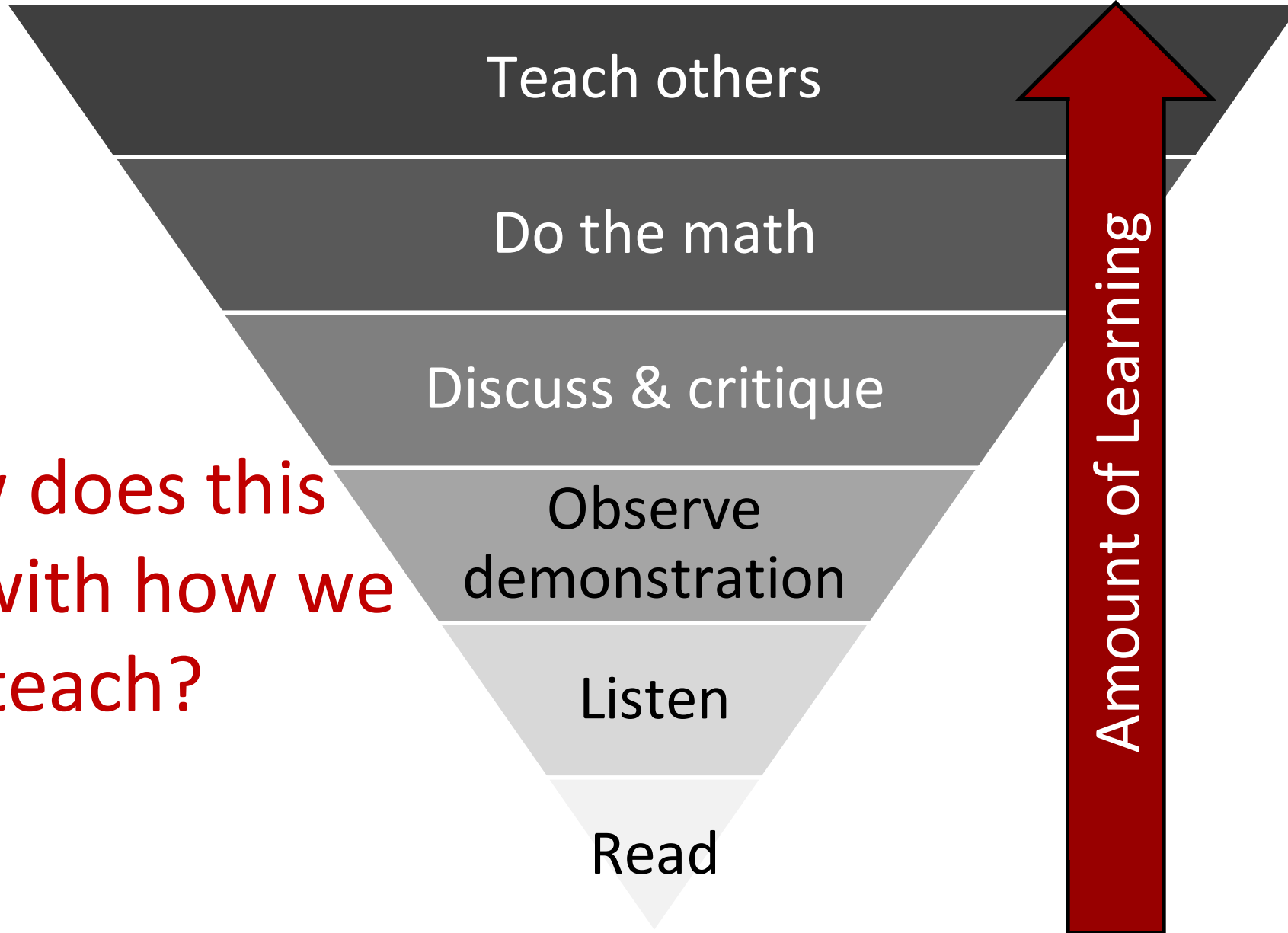
- 1. Learn about change levers from SEMINAL**
- 2. Consider the role of policies in change efforts**
- 3. Consider a systems-thinking approach to policies & change**
- 4. Discuss how to apply findings**

What is the Problem?

- **95% of students in college math are taking courses at/below Calc 2 (3.2M)**
- **Average of 25% DFW at R1 institutions in Calculus (often closer to 50%)**
- **Failing math correlates highly with freshman dropouts**
- **After freshman year, students switch away from STEM majors (9-25%)**
- **Beliefs about & attitudes toward mathematics K-20 follow a decreasing trajectory**



How Do People Learn?



How does this align with how we teach?

Teaching methods and classroom norms that promote:

- 1. Students’ deep engagement in mathematical reasoning**
- 2. Peer-to-peer interaction**
- 3. Instructor interest in and use of student thinking**
- 4. Instructors’ attention to equitable and inclusive practices**



Undergrads in active learning environments can learn more effectively, resulting in increased achievement and improved dispositions (Freeman et al., 2014; Laursen et al., 2014; Rasmussen & Kwon, 2007), particularly for underrepresented groups (Laursen et al., 2011; Theobald et al., 2020).

An n -dimensional problem ($n > 2$) cannot be solved with a 1- or 2-dimensional solution

- Systemic approach needed to address the system that created/perpetuates current problems
- Cultural change is needed for a dept to shift away from lecture as the norm
- Cultural change encompasses **people, power, structures, & beliefs**

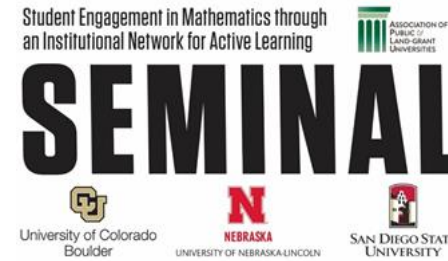
Effective Change Process



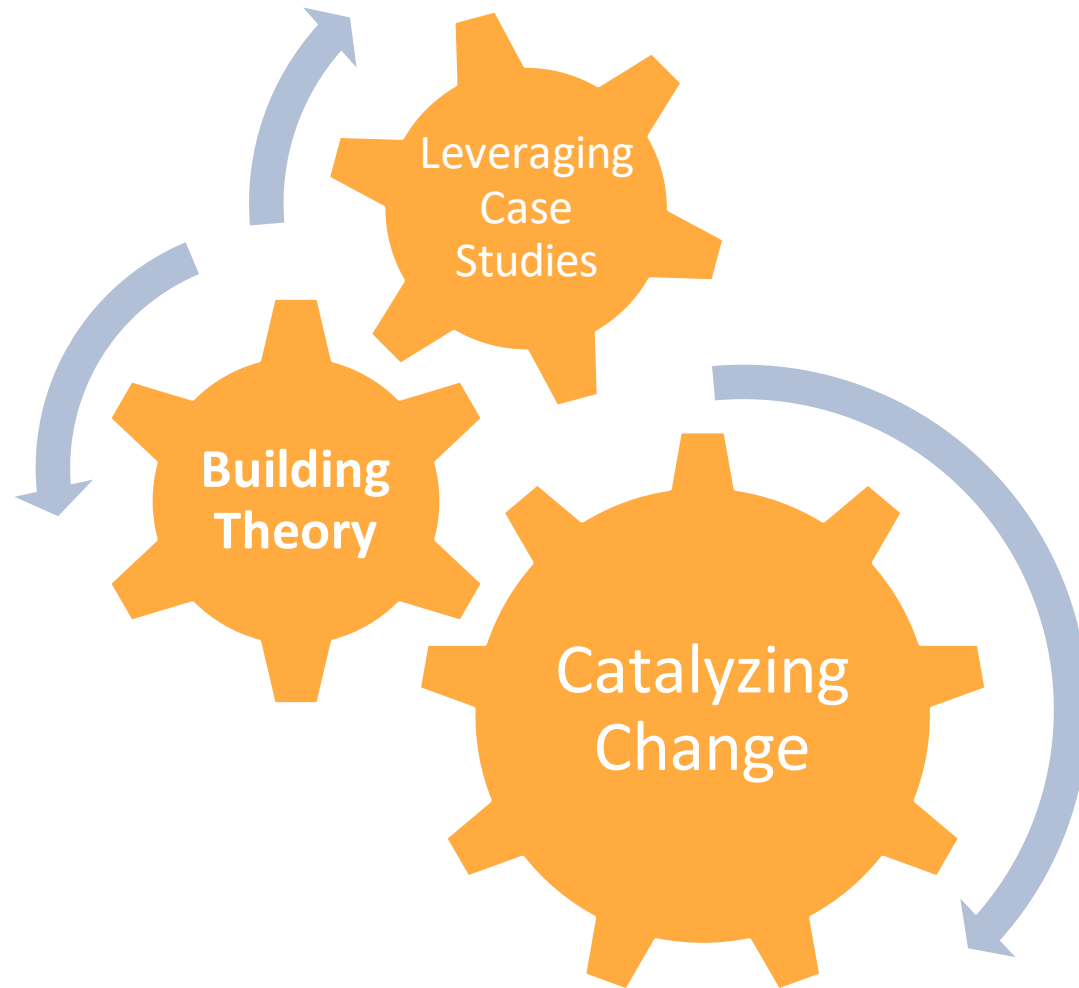
Assumptions

- 1. Start by developing a common vision of “success”**
- 2. All relevant stakeholders are involved**
- 3. Change is complex**
- 4. Need “change agents”**
- 5. Mathematical rigor is important**

Goal: better understand how to enact and support institutional change aimed at implementing active learning in undergraduate mathematics learning environments

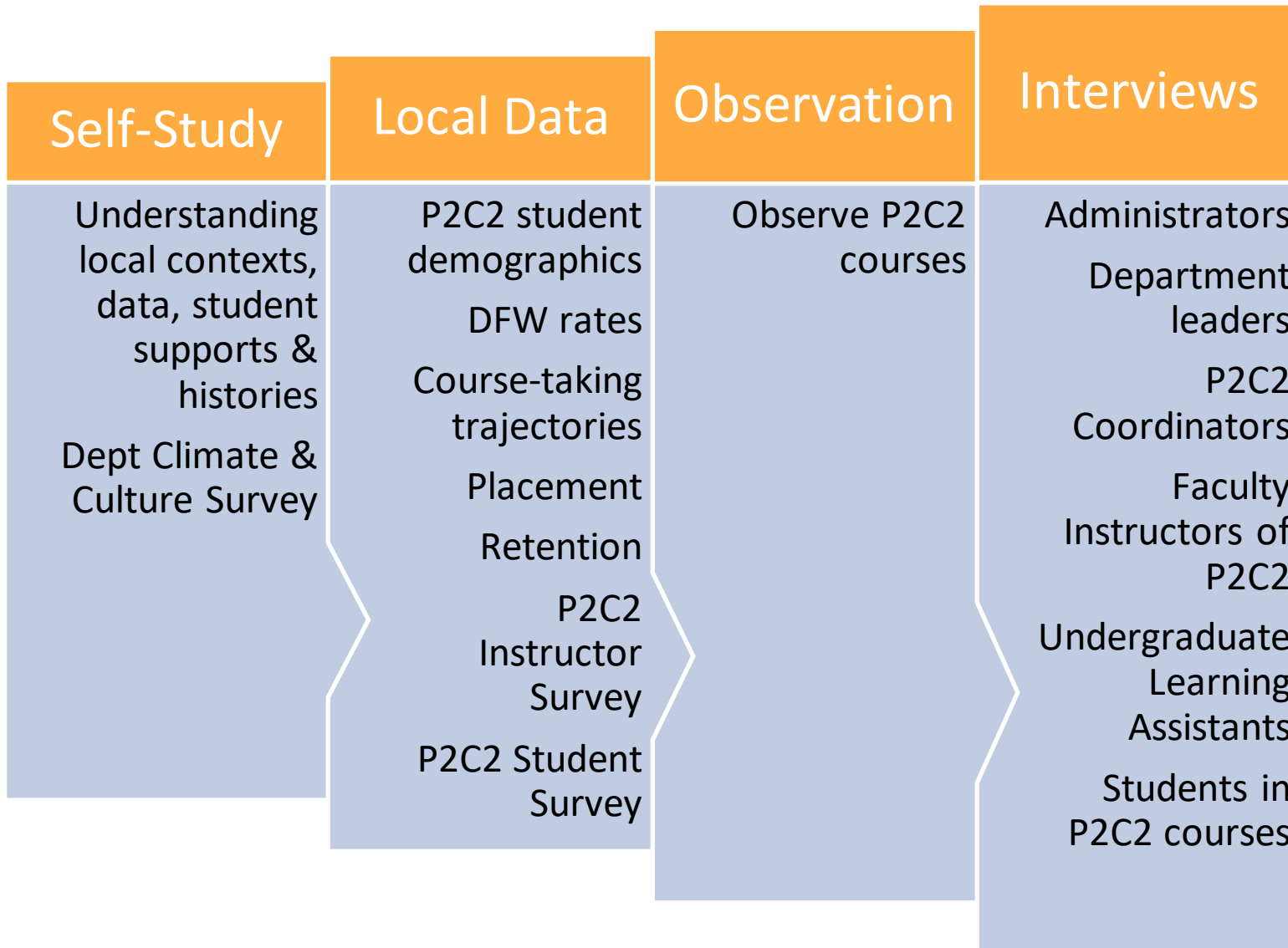


Collaborative Research: NSF I-USE Grant



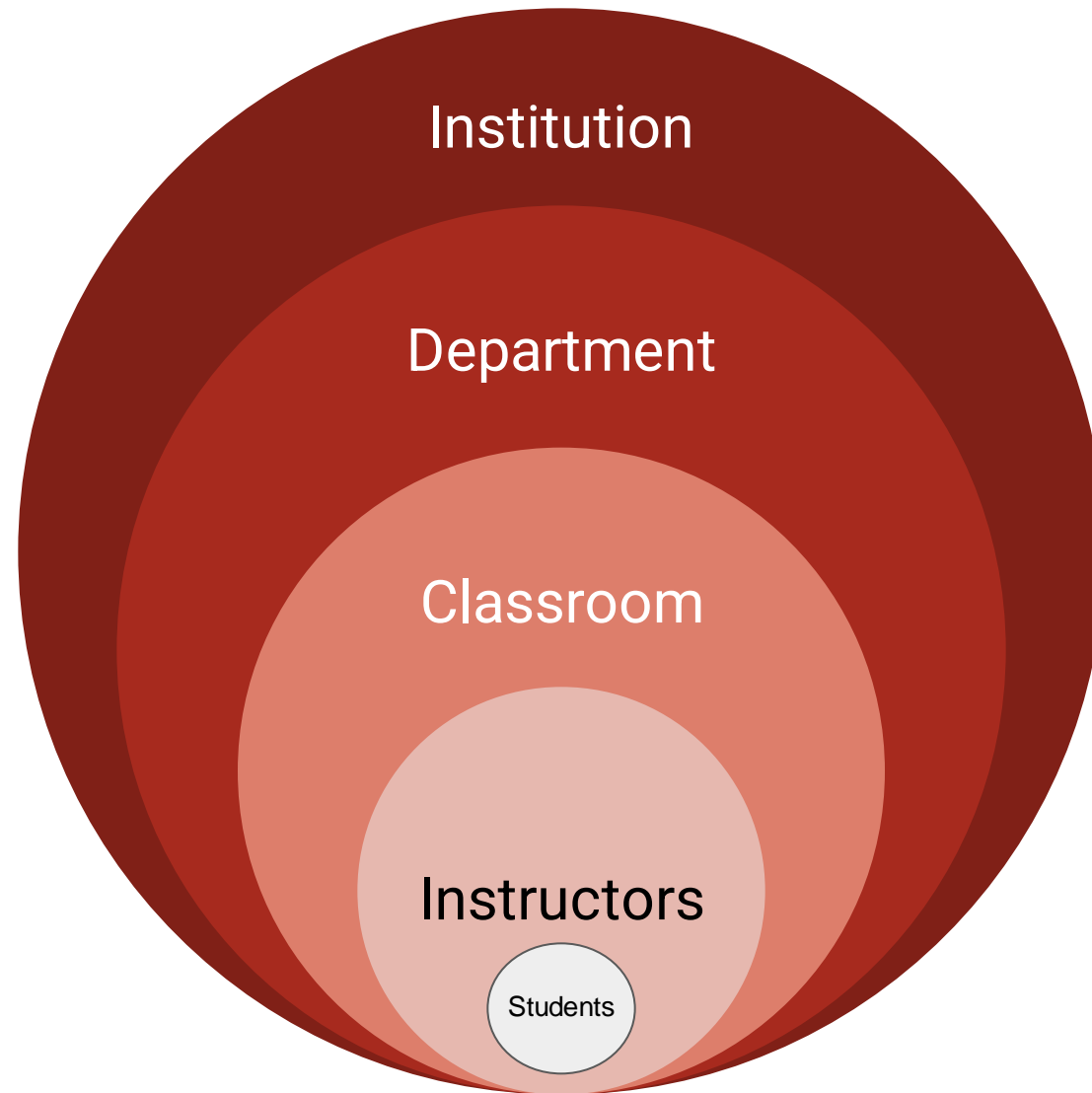
- \$3.6 million, 2016-2022
 - APLU
 - University of Colorado Boulder
 - University of Nebraska-Lincoln
 - San Diego State University
- Phase 1: 6 cases of retrospective change
- Phase 2: 9 cases of incentivized change
- Phase 3: 12 cases of networked change
- AMS/MAA/CBMS handbook (May 2021)

Retrospective, Longitudinal & Ongoing Case Studies

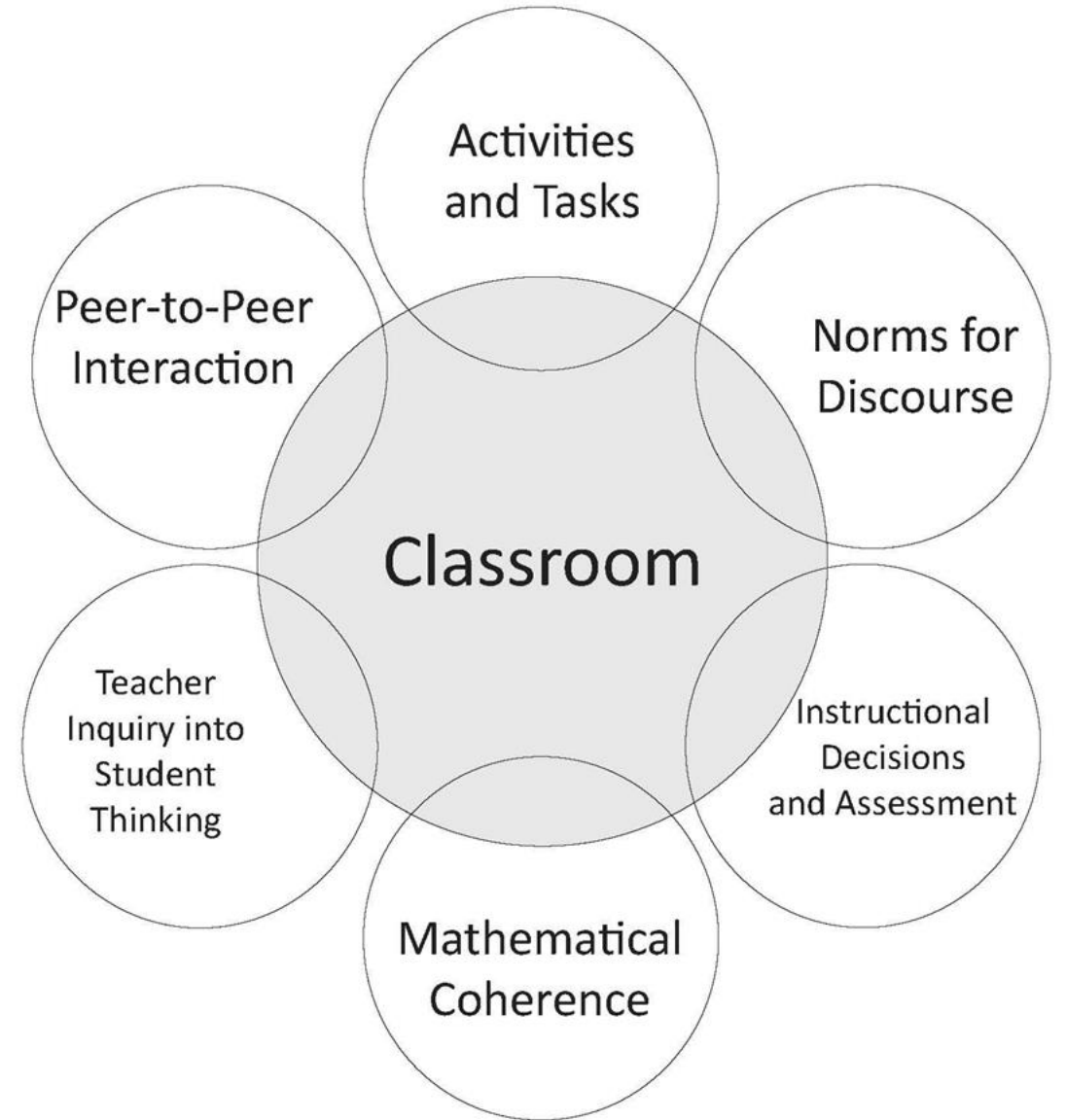
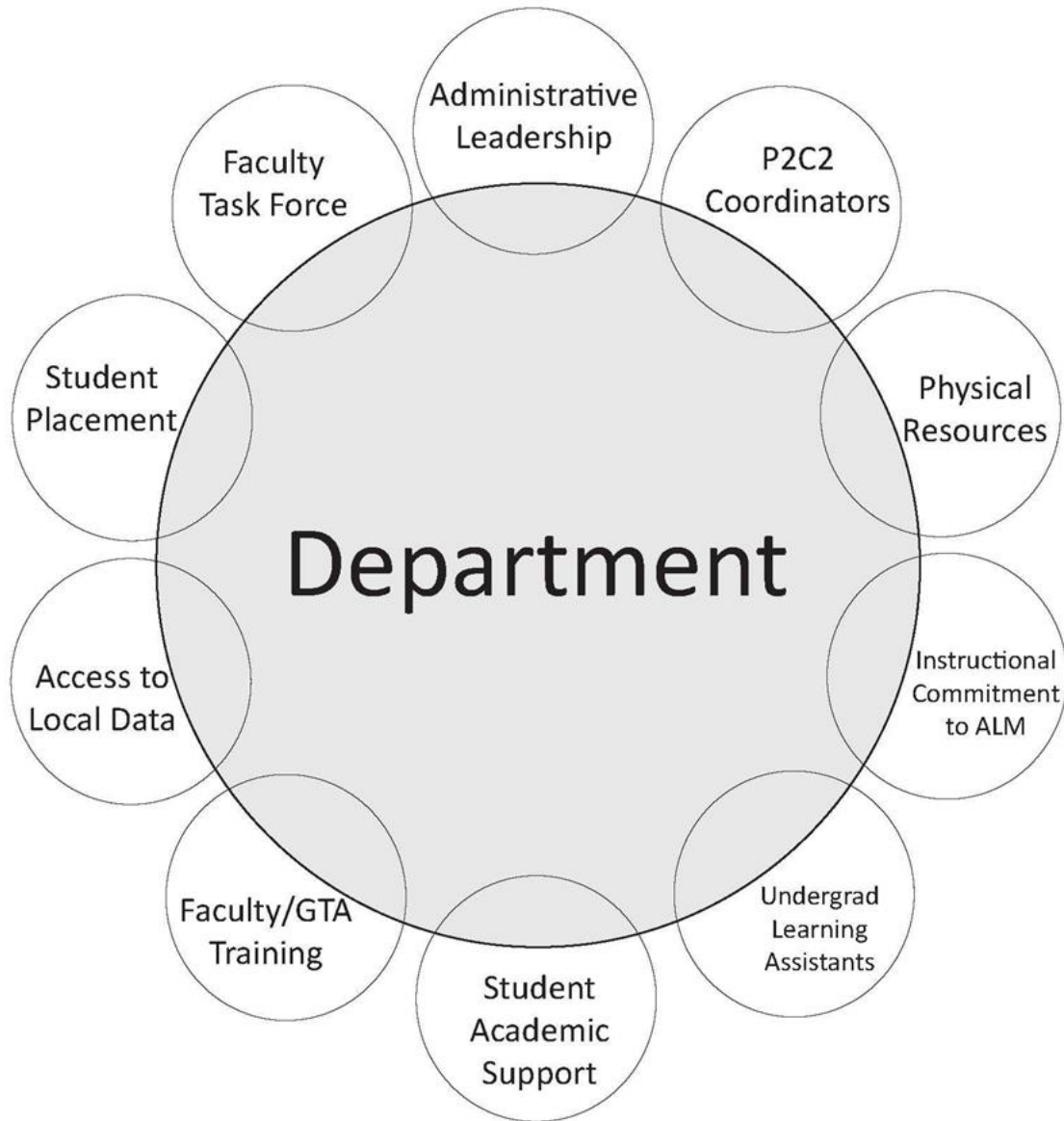


- Phase 1 retrospective cases: 6 site visits - Spring 2017
 - Handbook coming April 2021
- Phase 2 longitudinal incentivized cases: 9 sites x 3 site visits 2018-2021
 - PRIMUS special issue online (2020)
- Phase 3 ongoing case studies: 12 sites (virtual visits)

Seeing the System



SEMINAL hypothesis

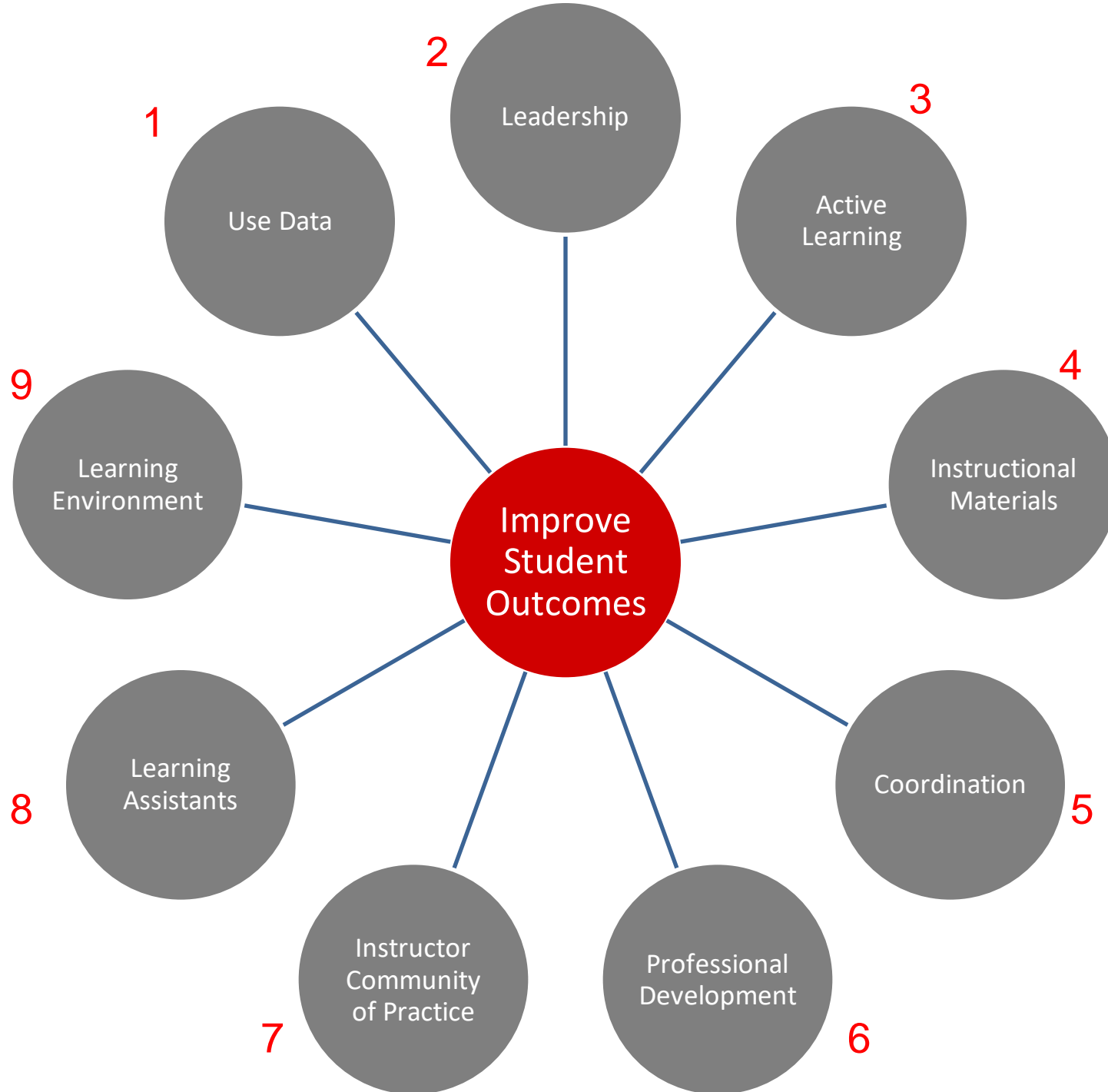


Critical features of transformed institutions:

- ✓ Institutional & community identities
- ✓ Campus culture with respect to teaching
- ✓ Effective leadership (opportunistic)
- ✓ Willingness to pay the costs of improved instruction
- ✓ Coordination of multi-section courses
- ✓ Sufficient support for enacting new pedagogies
- ✓ Flexibility
- ✓ Plan for succession/enculturation of people

SEMINAL Phase 2 - Local Change Strategies

- **Initiate & expand course coordination (including assessments)**
- **Hiring (course coordinators, learning assistants; instructors)**
- **Instructor professional development**
- **Local data & course placement**
- **Active learning tasks & materials**
- **Culturally responsive teaching**
- **Planning for sustainability**



Levers for Change

Involvement of:

- Campus administrators for undergraduate education (provost & dean levels)
- Chair & Vice Chair
- Faculty Task Force
- Course Coordinators
- Math Ed Researchers
- Instructors (faculty, adjunct, grad)
- Learning Assistants
- Students



Use Data

- Access to university data system (student demographics, major, retention, graduation)
- Attendance (class, Learning Center)
- DFW rates & enrollment
- Course-taking trajectories (subsequent grades)
- Student surveys (beliefs, perceptions)
- Focus group interviews (students, instructors)
- Instructor survey, interviews
- Observation (coordinators, peers)
- Assessments (homework, exams, item-level)
- Department culture, instructor networks



- **Dept chair committed to efforts**
- **Faculty committee to drive and sustain reforms**
- **Align to university efforts**
 - Freshman retention; graduation rates
 - Campus administrators' priorities
- **Coordinators**
 - Semi-permanent
- **Plan for sustainability**
- **Plan for turnover & bringing new people on board**



In most classes

- **Group work for majority of time**
- **Class time focuses on application problems**
- **Mini-lectures for 5-10 min as needed**
- **Instructor (+ Learning Assistant)**

In large lectures

- **Clicker questions to prompt discussions**



- **Common course activities**
 - Worksheets
 - Course Packets
- **Assessment**
 - Homework
 - Quizzes
 - Exams/Midterms
- **Textbook/OER**
- **Messaging to students & instructors**



Coordination

- **Syllabus**
- **Textbook (OER)**
- **Lesson Plan Repository**
- **Course Packets/Worksheets**
- **Homework (e.g., WeBWoRK)**
- **Exams (Midterms & Final)**
 - Common Grading (e.g., Grade Scope, Crowdmark)
- **Weekly instructor meetings**
 - Begin prior to semester
 - Anticipating student misconceptions



Professional Development

- **Pre-Semester**
- **Weekly**
 - Instructor meetings
- **Dept Teaching Seminar**
 - Faculty & grad students
- **Travel to workshops (IBL)**
- **Pedagogy Course for GSI/LA**

“While it may be tempting to simply authoritatively state the correct order in which to perform horizontal transformations, doing so effectively removes ownership of knowledge from students, and encourages them to view mathematics as a set of arbitrary rules to be applied blindly. By removing ownership from students, we ultimately discourage students from building their own base of knowledge surrounding the topic.”

--Precalculus Instructor

Instructor Community of Practice



- **Textbook**
- **Lesson Plan Repository**
contribute revisions, worked examples
- **Weekly instructor meetings**
- **Advice networks for teaching and learning**



Learning Assistants

- **Support group work**
- **Training in supporting active learning**
- **Meet with instructors weekly**
 - Reflect after class
- **Recruited from math majors & 'A' students in courses with learning assistants**

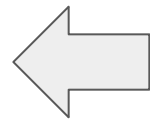


Learning Environment

- **Dedicated, renovated classrooms**
- Tables & chairs
- Whiteboards all around
- **More time (50 - 75 min)**

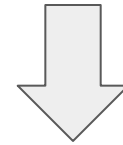


Useful Resources



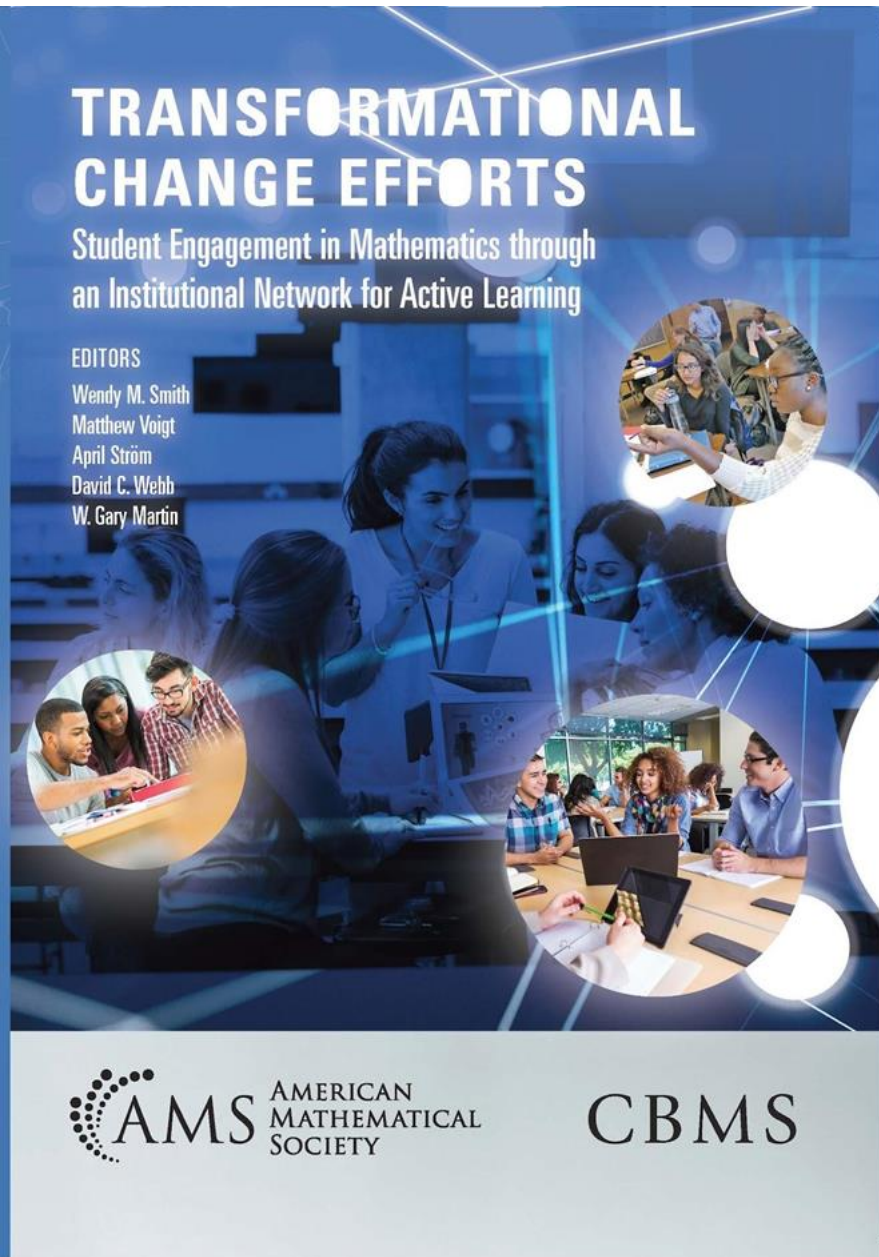
SEMINAL book

PRIMUS Special Issue



Rasmussen, C., Smith, W. M., & Tubbs, R. (2021). Infusing active learning into precalculus and calculus courses: Insights and lessons learned from mathematics departments in the process of change. [Special issue]. *PRIMUS*, 31(3-5).

<https://www.tandfonline.com/toc/upri20/31/3-5?nav=tocList>



TRANSFORMATIONAL CHANGE EFFORTS

Student Engagement in Mathematics through
an Institutional Network for Active Learning

EDITORS

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 AMERICAN
MATHEMATICAL
SOCIETY

CBMS

https://bookstore.ams.org/mbk-138/?_zs=L5oRC1&_zl=rSpG6

Useful Resources

Accelerating Systemic Change Networks (ASCN) information on transforming institutions

ASCN Change Dashboard

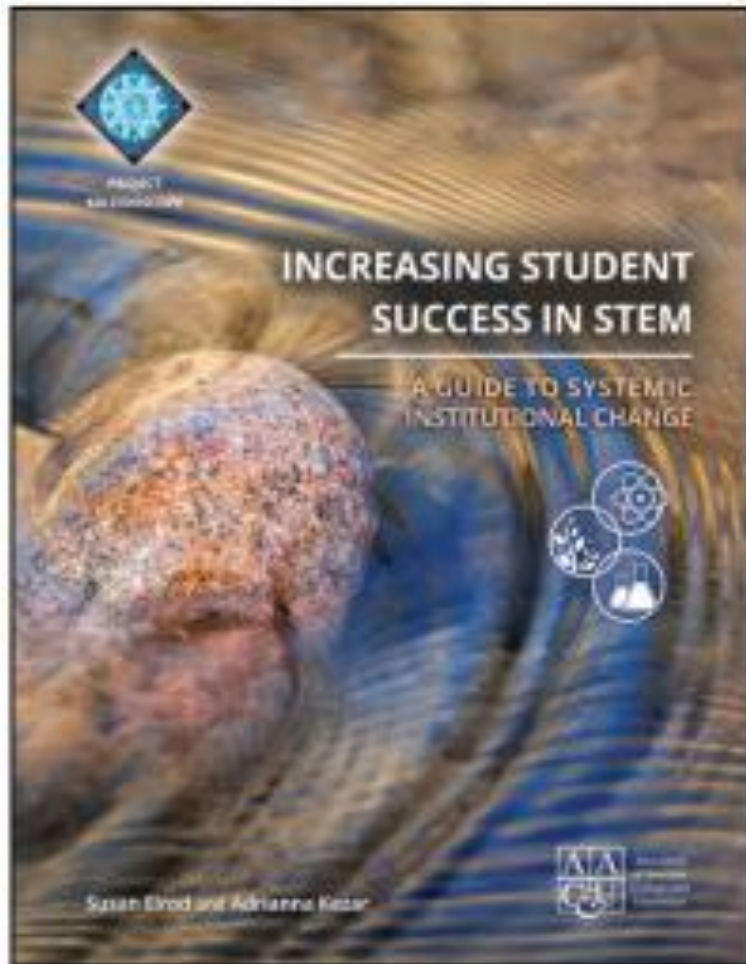
https://ascnhighered.org/ASCN/change_dashboard/index.html



<https://ascnhighered.org/ASCN/publications.html>

Useful Resources

Practical plan for starting changes (checklists, inventories)



<https://www.aacu.org/publications-research/publications/increasing-student-success-stem-guide-systemic-institutional>



Teaching for Prowess
--Project focused on 2-year colleges and active learning

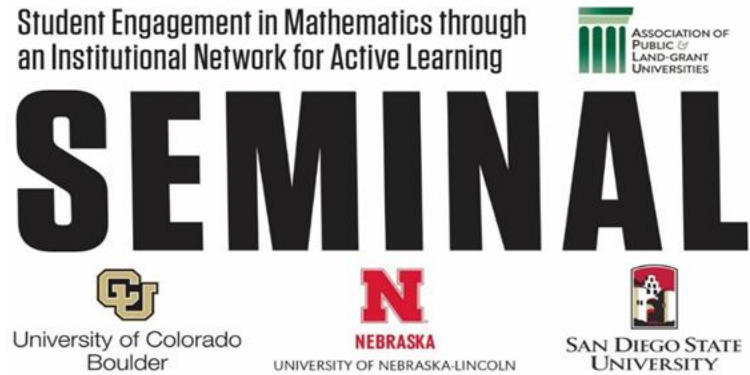
<https://teachingforprowess.wordpress.com/>

Opportunities for Continued Engagement

- **Accelerating Systemic Change Network**
 - <https://ascnhighered.org/index.html>
- **Online communities**
 - **COMMIT Network** <https://www.comathinquiry.org/>
 - **MAA CONNECT** <https://connect.maa.org/home>
 - **AMATYC Communities**
<https://my.amatyc.org/communities/allcommunities>
- **MSRI CIME 2021 (2022)**
 - full in-person CIME March 16-18, 2022
<https://www.msri.org/workshops/1001>

- **What are the most dominant aspects of your system context related to student outcomes in STEM courses?**
- **What are your campus policies and cultural norms around educational innovation?**
- **How might you use change levers to make progress toward improvement goals?**

Questions?



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Facilitated Breakout Rooms:

1. Navigate to the bottom of your screen and click “Breakout Rooms” button
2. Self-select into your breakout group based on your topic interest and last name

Note: If you do not see the Breakout Rooms button, please post in the chat to ask to be placed in a breakout room.



Discussion Breakout Room Recap

Jessica Rosenberg
Phoebe McClincy
Julie Shank
Wendy Smith
Rachel Funk
Antonio Martinez



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Thank you for attending!

Slides and recording will be available later this week.

We value your feedback, please take a few minutes to complete the survey.



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