# *Improving Undergraduate Outcomes in Mathematics: What Do We Know? What Can We (Reasonably) Do?*

Dr. Wendy M. Smith
University of Nebraska-Lincoln

OnLine Seminar on Undergraduate Mathematics Education (OLSUME)

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# 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**

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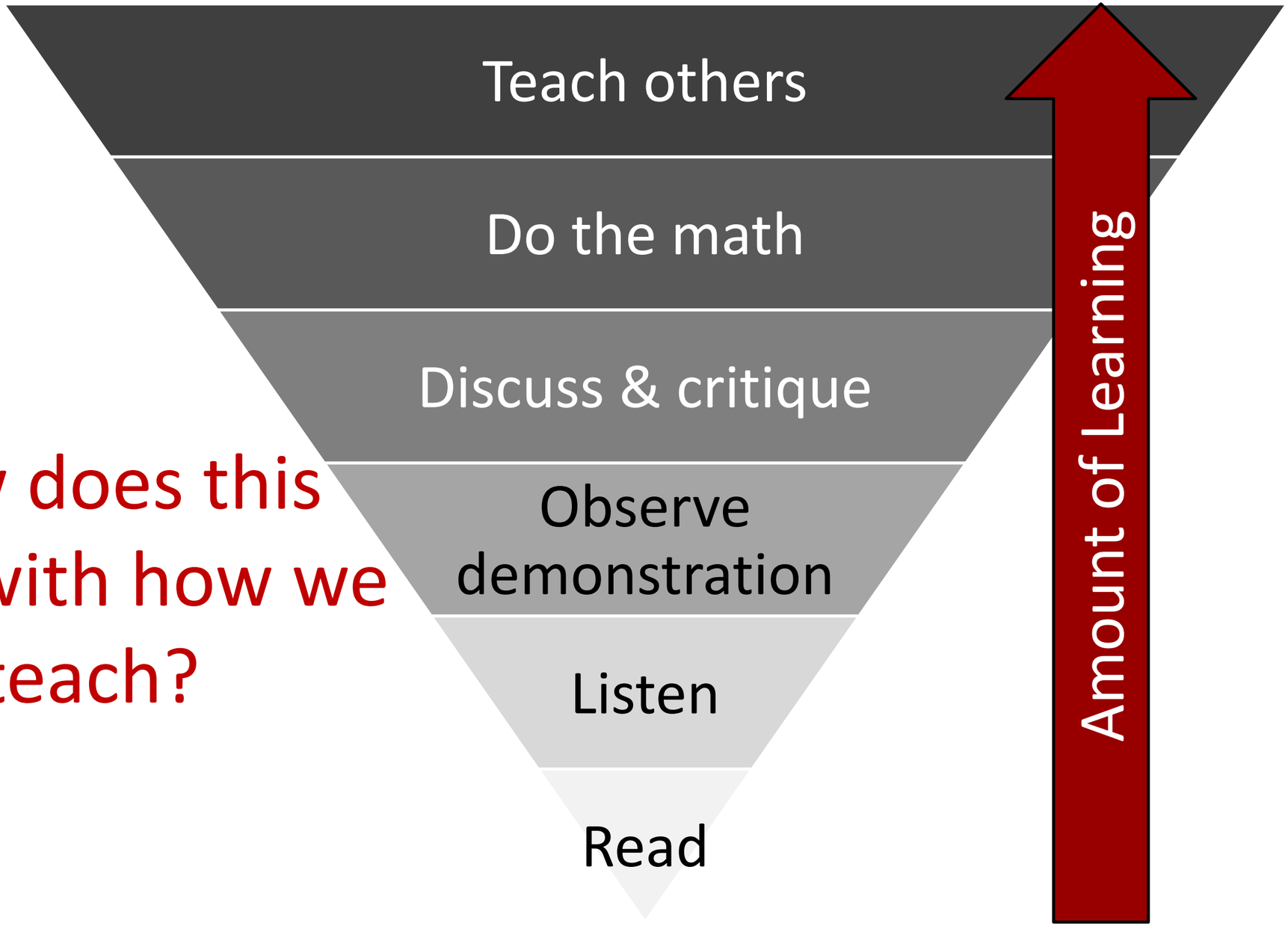
# How Do People Learn?




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

Laursen and Rasmussen (2019)

**Student belonging** is critical to positive academic & social outcomes in higher ed, especially in STEM fields (Strayhorn, 2018)

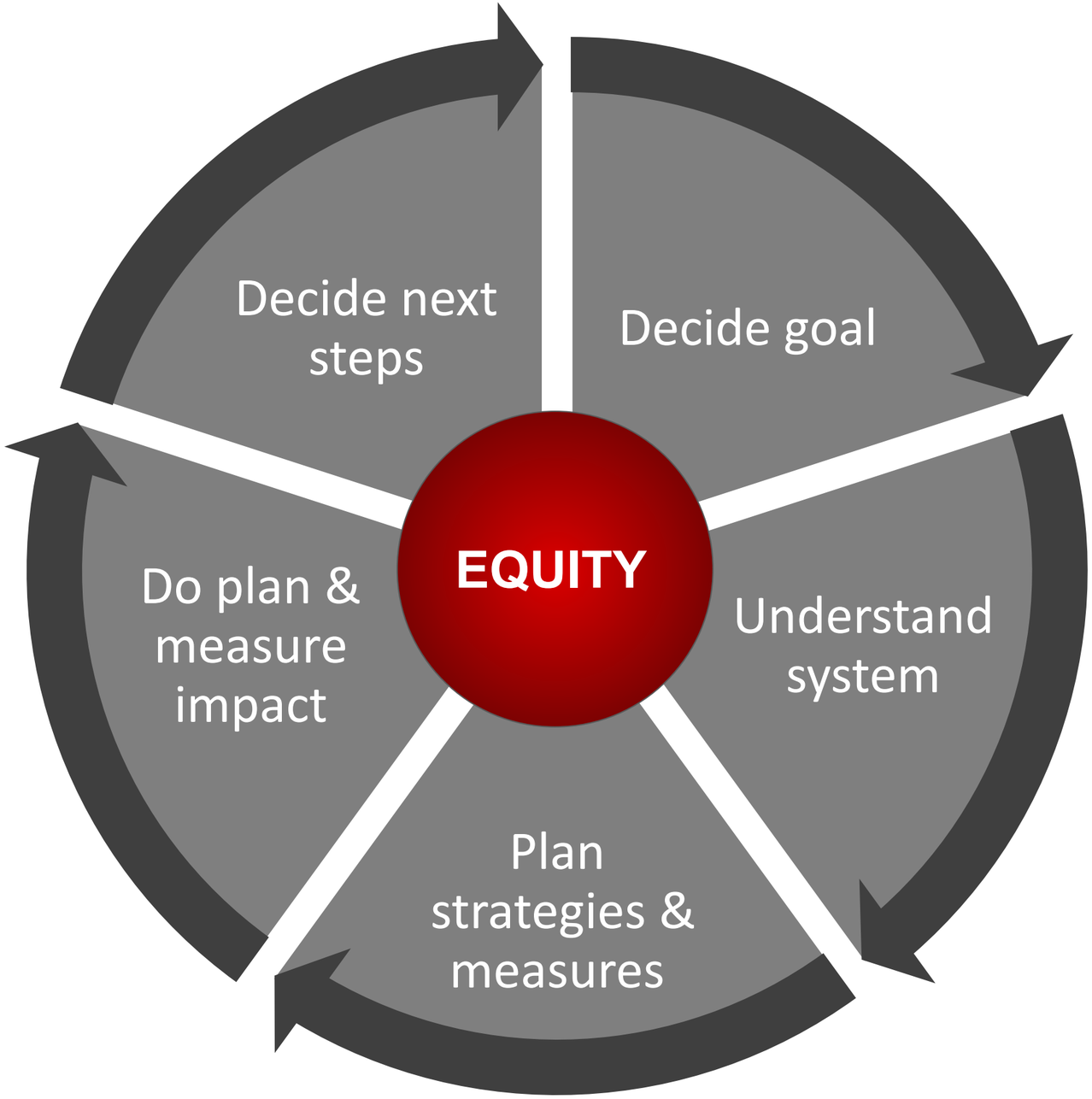
Myriad factors can increase or decrease students' feelings of belonging (personal, academic, social, relational, environmental, etc) (Salami et al., 2021)

Experiencing **microaggressions** leads to lower feelings of belonging (Franklin, 2016)

***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 personnel are involved
3. Change is complex
4. Need "change agents"
5. Mathematical rigor is important

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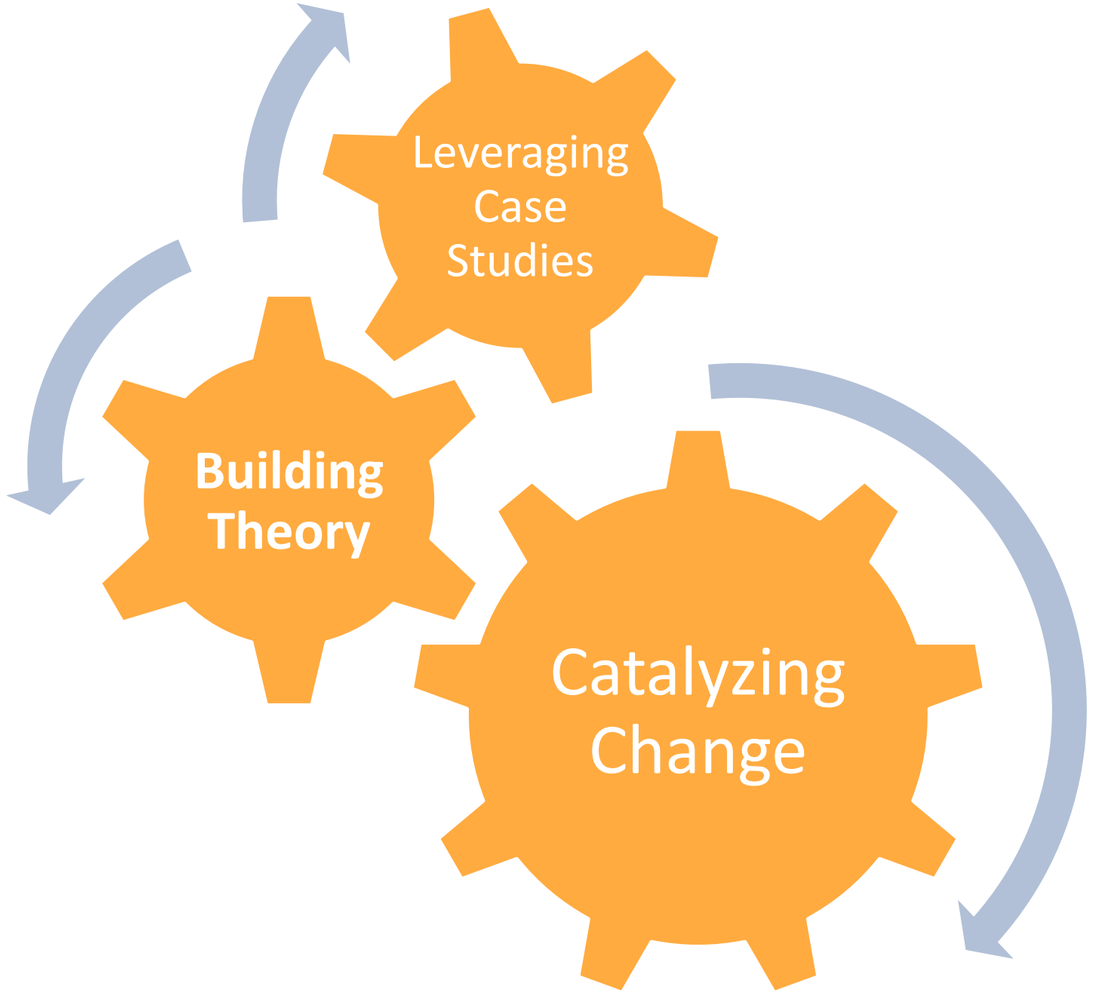
***Goal*: better understand how to enact and support institutional change aimed at implementing active learning in undergraduate mathematics learning environments**

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## 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

| Self-Study | Local Data | Observation | Interviews |
|---|---|---|---|
| Understanding local contexts, data, student supports & histories | P2C2 student demographics | Observe P2C2 courses | Administrators |
| Dept Climate & Culture Survey | DFW rates | | Department leaders |
| | Course-taking trajectories | | P2C2 Coordinators |
| | Placement | | Faculty Instructors of P2C2 |
| | Retention | | Undergraduate Learning Assistants |
| | P2C2 Instructor Survey | | Students in P2C2 courses |
| | P2C2 Student Survey | | |

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

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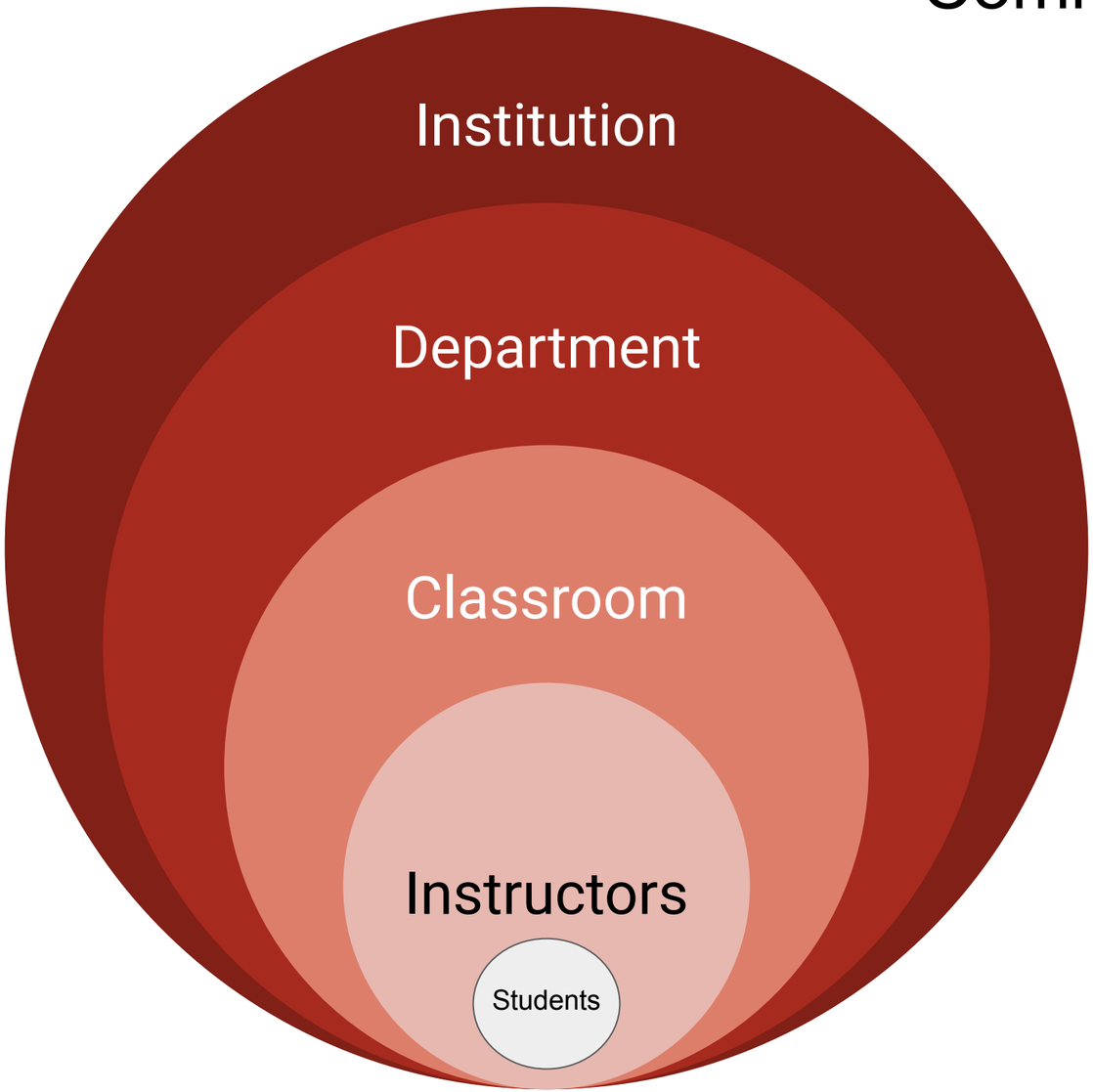
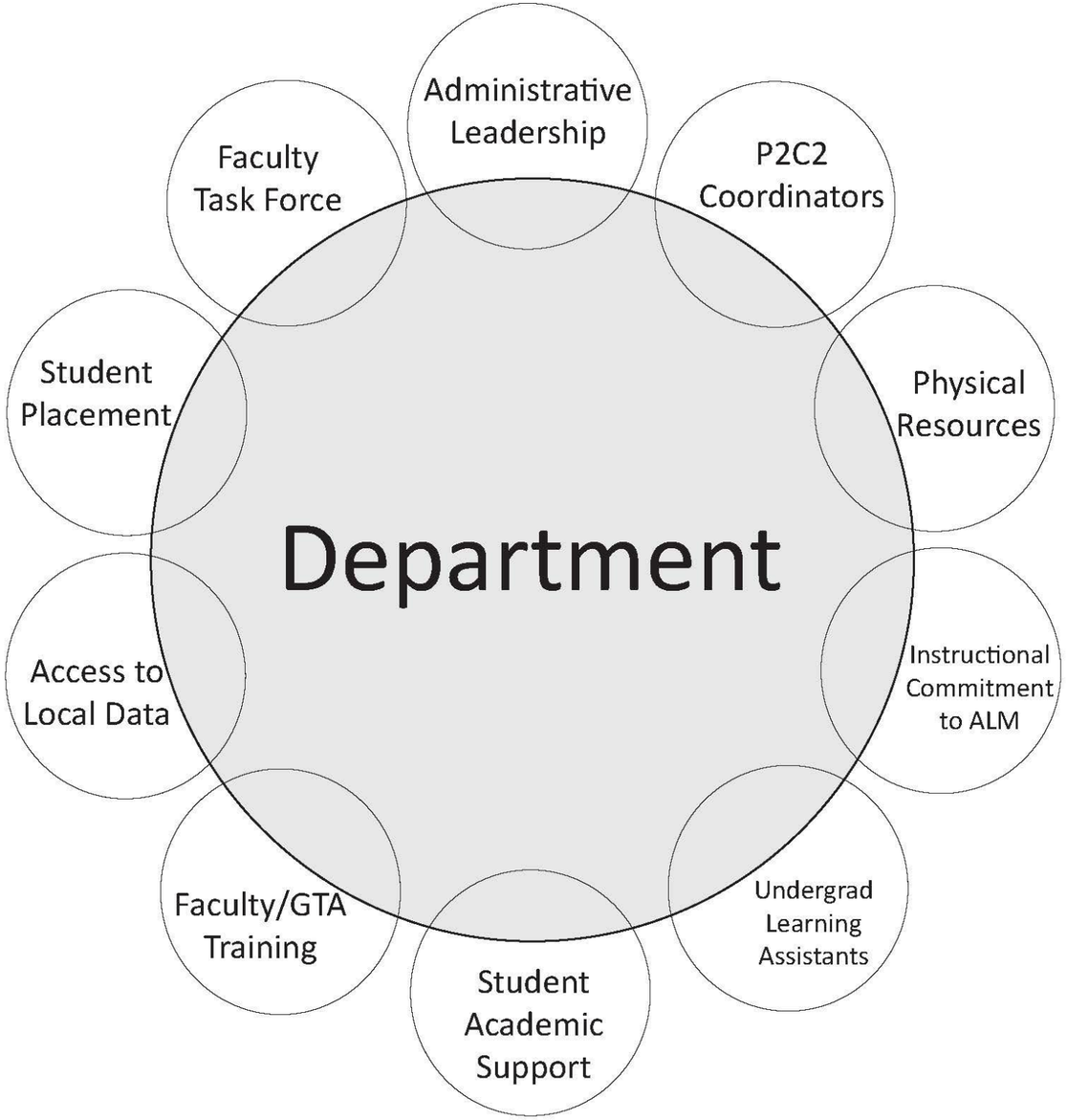
# Seeing the System

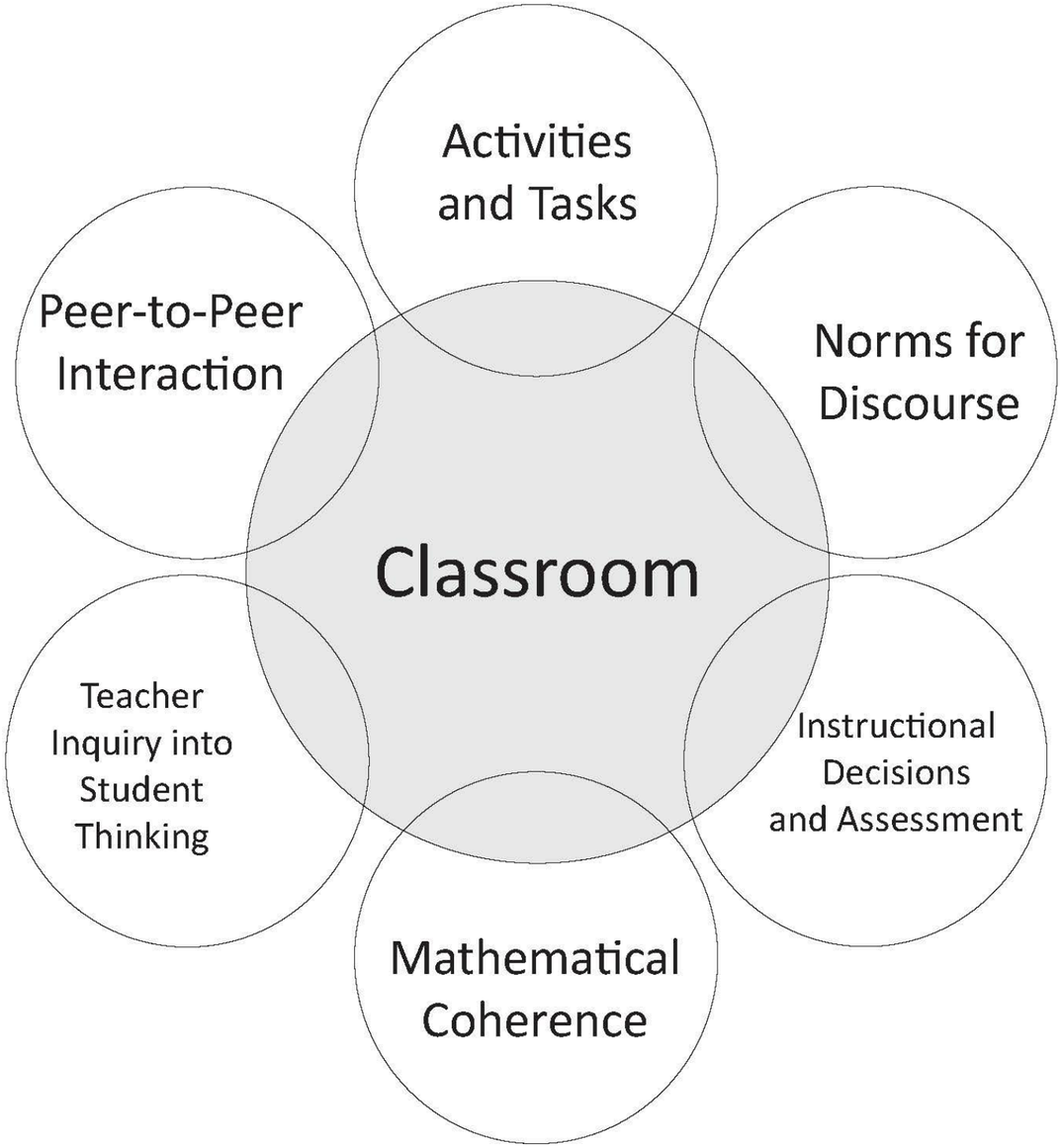
Community




Connections to other departments

# 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 Phases 2 & 3 - 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**
- **Recruiting strategic members (positions of power)**
- **Connecting with a network**

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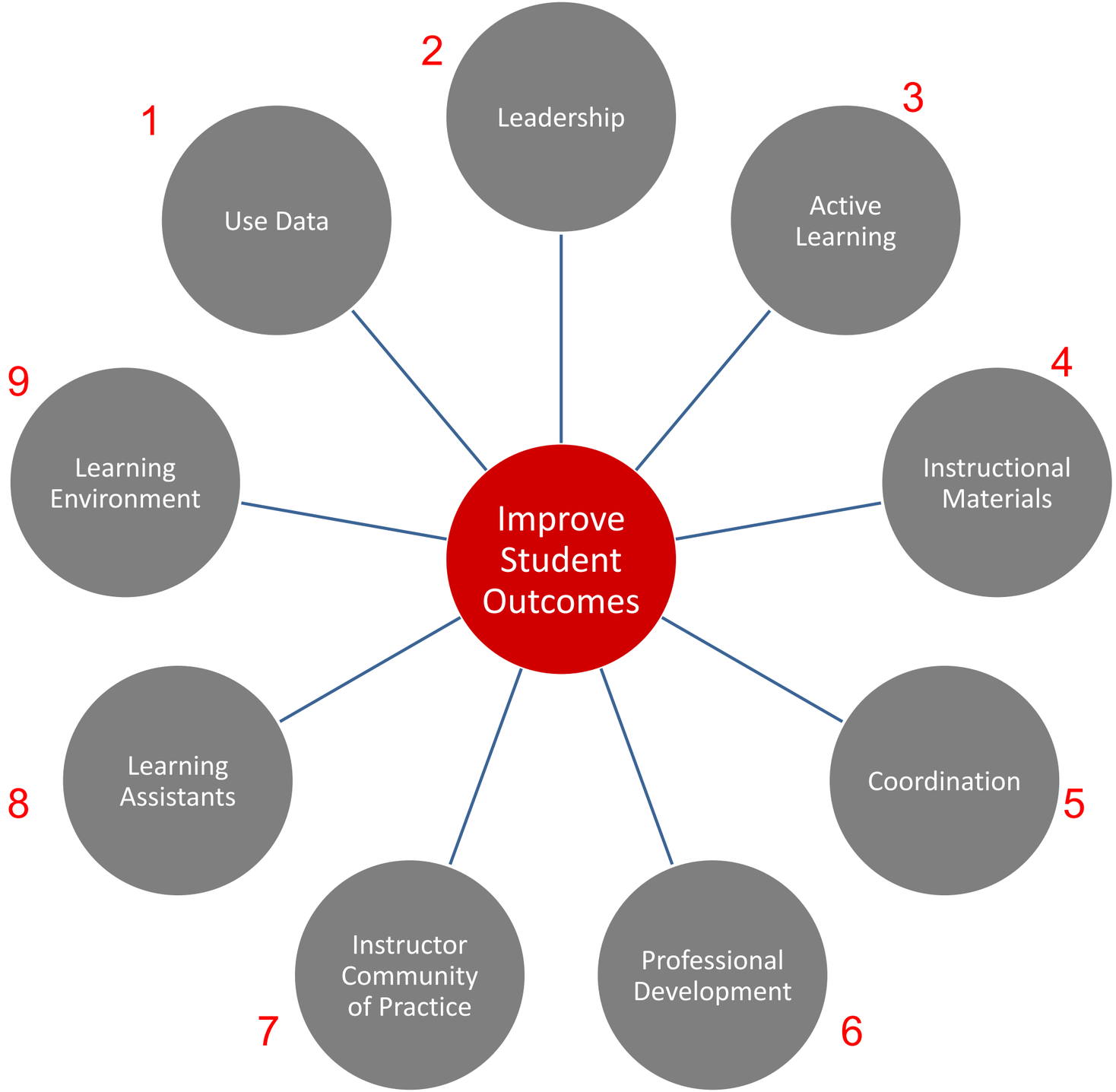


# Levers for Change

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

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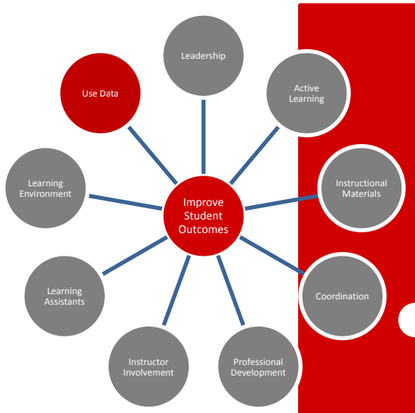


# Use Data

- 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

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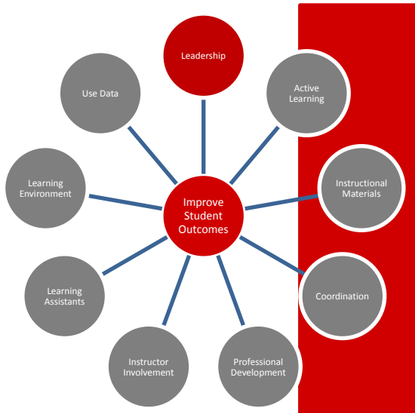


# Leadership

- **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**

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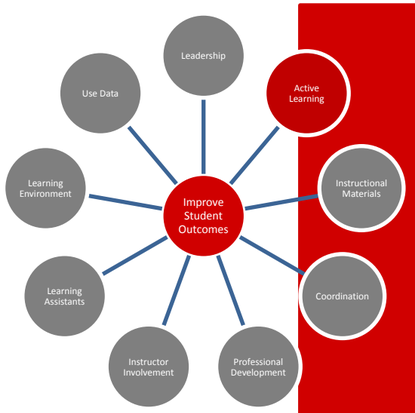


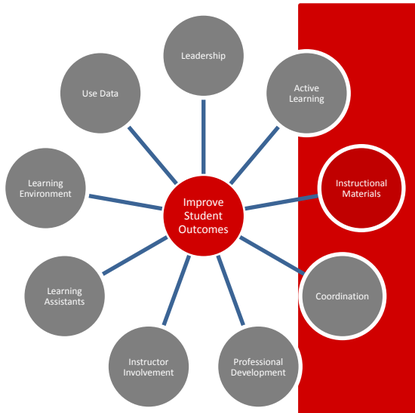

# Active Learning

## 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)

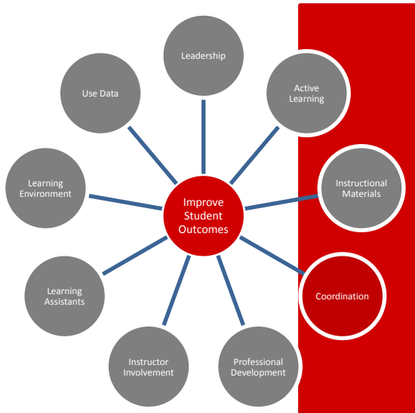
## In large lectures

- Clicker questions to prompt discussions



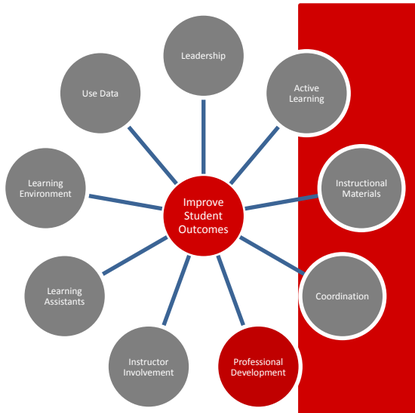

# Instructional Materials

- **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 topics that need more attention

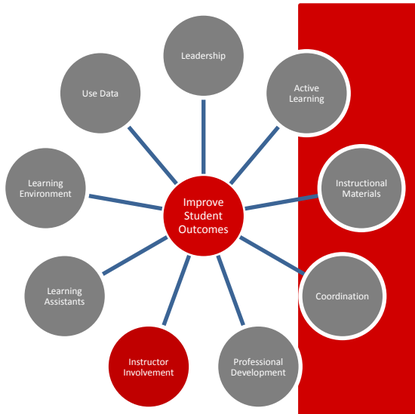



# Professional Development

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

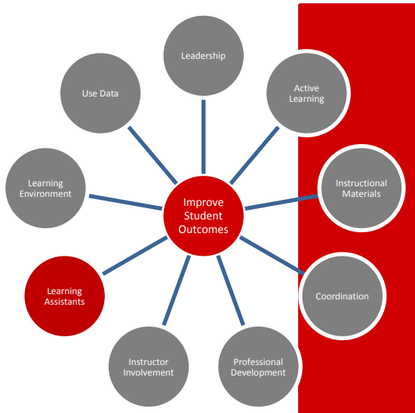
**“While it may be tempting to simply authoritatively state the correct order in which to perform horizontal transformations, doing so effectively removes ownership of knowledge from students, and encourages them to view mathematics as a set of arbitrary rules to be applied blindly. By removing ownership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

--Precalculus Instructor



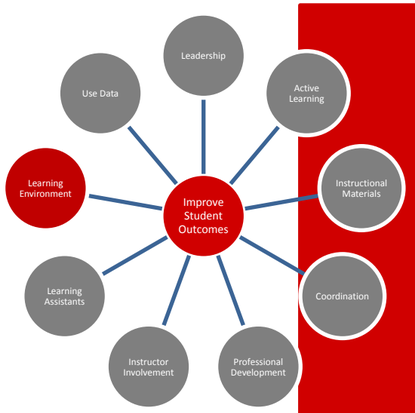

# Instructor Community of Practice

- **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 & students in courses with learning assistants**



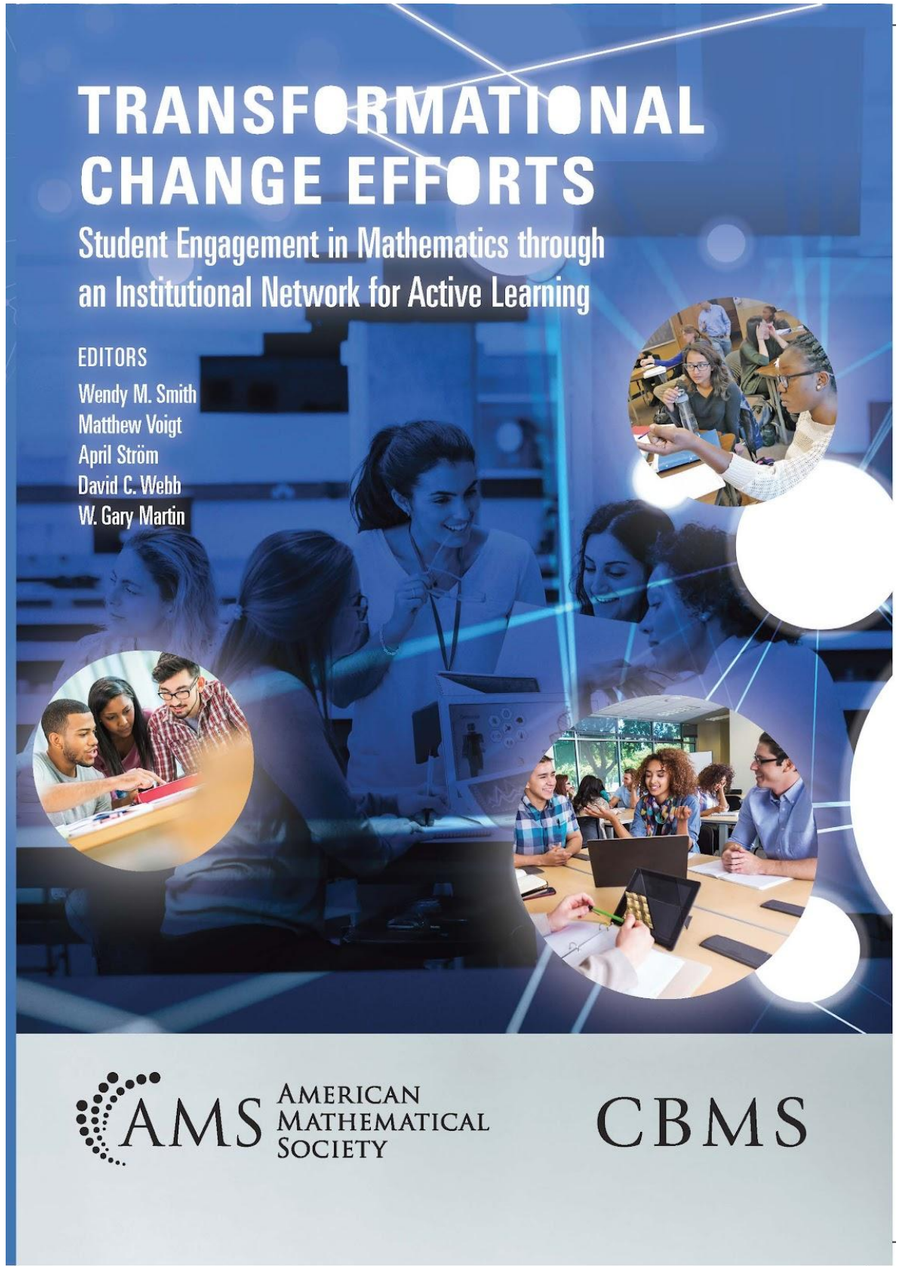

## Learning Environment

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

# Discussion Questions

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

# Useful Resources




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

SEMINAL book

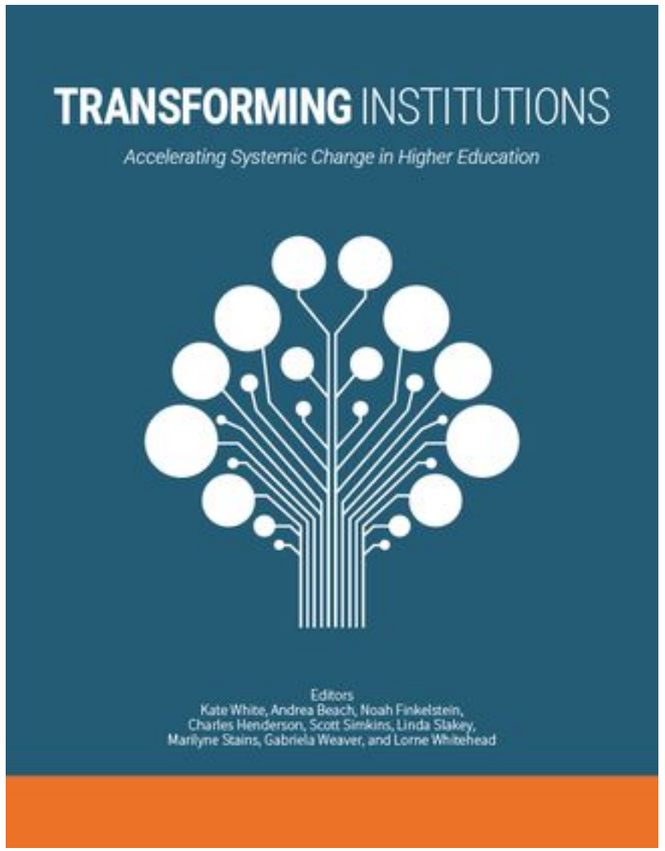
PRIMUS Special Issue

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

# 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

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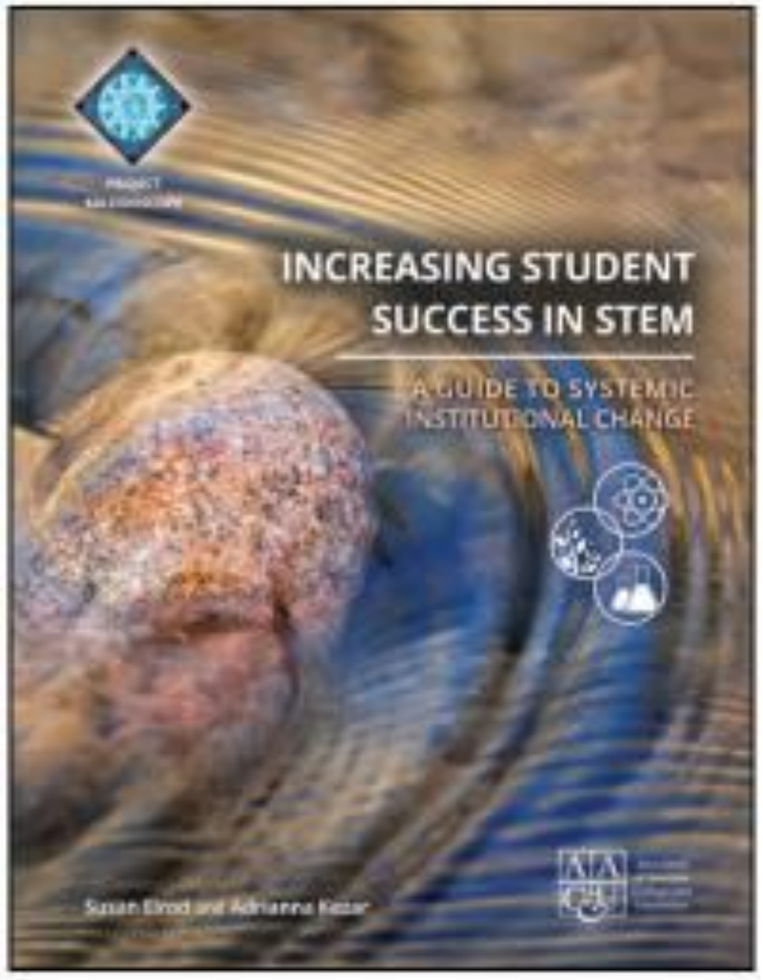


Practical plan for starting changes (checklists, inventories)

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

TEACHING FOR PROWESS

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
- **JMM 2023**
  - Special Session on *Lessons Learned from Successful Departmental Efforts to Transform Precalculus and Calculus* (Jan 6 & 7 afternoons)
  - PEP *Inclusive Active Learning in Undergraduate Mathematics (Jan 5 & 7, 8-10am EST)*

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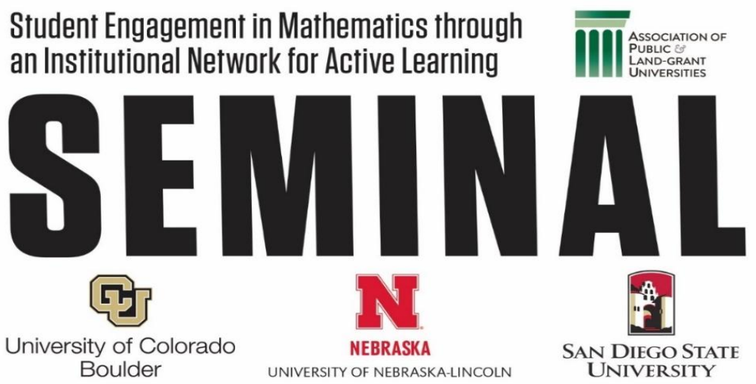
# Questions?




seminal@aplu.org
wsmith5@unl.edu