Critical Mass

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Critical Mass

Definition??

Critical Mass

- (In Physics) The smallest mass of a fissionable material that will **sustain** a nuclear **chain reaction**.

Critical Mass

- In social dynamics, **critical mass** is a sufficient number of adopters of an innovation in a social system so that the rate of adoption becomes self-sustaining and creates further growth ("**chain reaction**").
- The good news: The mathematical sciences community is finally reaching a **critical mass** with regard to **improving undergraduate mathematics education** on a national scale.

Then….and Now

50 years ago…

Then… Now…

100 years ago…

Now…

100 years ago…

Now…

100 years ago…

Now…

OUTDATED?

- Are our **courses** and **programs** outdated?
- Are our **pedagogies** outdated?
- Is our **use of technology** as part of the curriculum outdated?
- Are our **furnishings** outdated?

OUTDATED!

- Our programs are set up to serve the students we had 20 to 100 years ago.
- We must adapt to the students we have, not the students we used to have or the students we wish we had.

My Job, Your Job

My Job Today

- To get you to **change your mind** about something
- To get you to **try something different** to get students more engaged in your classroom

Your Job Today

- **Try to change your mind** about at least one thing
- Allow me to push you **out of your comfort zone**
- ***Leave here no longer accepting the things you cannot change.***
  Instead, leave here determined to change the things you cannot accept.

National Criticism of Mathematics Education

National Criticism 2012

- Two national reports criticized the collective enterprise of teaching mathematics to undergraduates
  - PCAST "Engage to Excel" (2012)
  - Mathematical Sciences in 2025 (NRC, 2013; Mark Green, UCLA)
- Why all the criticism?

Economic Vitality, Social Mobility, Social Justice

Economic Vitality

- Economist Edward Glaeser, Triumph of the City (2011):
  - He can predict which cities are going to be successful over the next 25 to 30 years and which cities are going to fail. His **economic model is based on educational attainment**.
  - "As the population with college degrees increases by 10%, the GDP increases by 22%."

Social Mobility, Social Justice

- Teaching and learning are forces for **social change**.
- There are societal forces that call upon all mathematics instructors to advocate for increased student access to the discipline of mathematics.
- **Inequity exists in many facets of our society, including within the teaching and learning of mathematics**.

(MAA Instructional Practices Guide, Manifesto)

Social Mobility

- Because access to success in mathematics is not distributed fairly, the **opportunities that accompany success in mathematics are also not distributed fairly**.
- We in the mathematical sciences community **should not affirm this inequitable situation as an acceptable status quo**.

(MAA Instructional Practices Guide, Manifesto)

Social Mobility

- We owe it to our discipline, to ourselves, and to society to disseminate mathematical knowledge in ways that **increase individuals' access to the opportunities that come with mathematical understanding**.

(MAA Instructional Practices Guide, Manifesto)

On a recent visit to Canada…

Entertainment

Kids' TV lacks gender balance and diversity, new study suggests

Racial, gender, economic and physical differences not represented, says study author

Jessica Wong · CBC News ·
Posted: May 04, 2019 4:00 AM ET | Last Updated: 5 hours ago

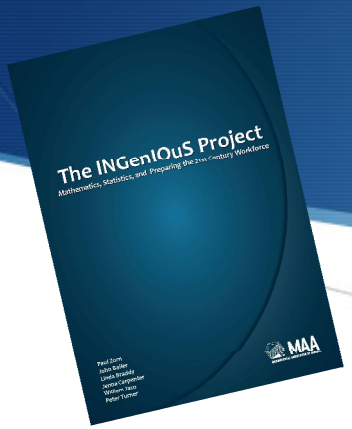
Senait Litchmore watches television with her three daughters in Toronto. (CBC)

Gender Bias & Stereotypes

- Girls solve problems “by magic”
- Boys solve problems using logic, math, problem solving skills
- False racial/ethnic stereotypes are propagated as well

Collective Response of Math Community to the Criticism

Collective Response



- *INGenIOuS* report (MAA-ASA-AMS-SIAM) began in 2012
- *Common Vision* (MAA-AMATYC-AMS-ASA-SIAM) began in 2012

COMMON VISION
for Undergraduate Mathematical Sciences Programs in 2025

- CUPM Curriculum Guide began in 2012

Collective Response

- TPSE Math began in 2014
- *MAA Instructional Practices Guide* began in 2014
- AMATYC *Impact* began in 2015

Collective Response

- Conference Board of the Mathematical Sciences (CBMS) – the presidents of 12 mathematics professional associations
  - 2015 Endorsement of ***INGenIOuS, Common Vision***, and **TPSE**
  - 2016 Statement on **Active Learning**

    - https://www.cbmsweb.org/cbms-position-statements/

The White House joins in…(2016)

the WHITE HOUSE
PRESIDENT BARACK OBAMA

BRIEFING ROOM | ISSUES | THE ADMINISTRATION | 1600 PENN

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Active Learning Day in America

OCTOBER 25, 2016 AT 2:29 PM ET BY JO HANDELSMAN AND QUINCY BROWN

Summary: Active Learning Day announcements advance the STEM for All initiative.

"On Active Learning Day, we encourage educators to provide opportunities for each of our Nation's daughters and sons to engage in active science, technology, engineering, and math learning and discover firsthand the power they have to bring their bold ideas to life. By using active learning techniques in our classrooms and out-of-school spaces, we are not only enabling students to take charge of their education, but also equipping them with the tools they need to solve our biggest problems and chart our country's course." **President Barack Obama**

Reforms

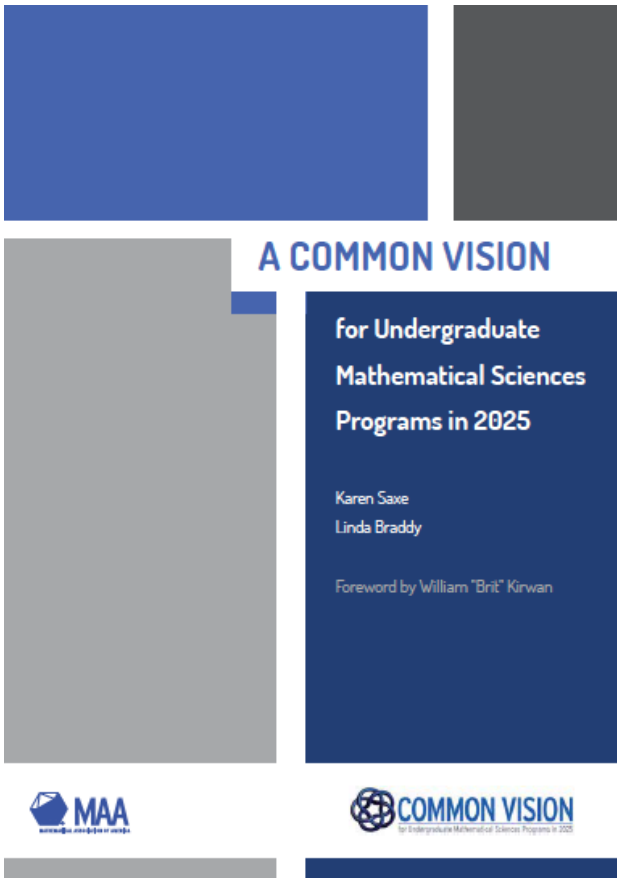
- Carnegie, Dana Center at UT Austin: Mathematics pathways
- Statewide efforts
  - Tennessee, Georgia: Exclusively co-requisite model in mathematics
  - Texas: Scaling up co-requisite model in developmental education
- TPSE Math: Upper division pathways, alternate points of entry

Critical Mass!

Common Vision

Common Vision

- Goal: Develop a shared vision in the math community of the need to **MODERNIZE undergraduate mathematics programs, especially the first two years.**



Common Vision

- Identified common themes found in existing curricular guides published by the five mathematics and statistics professional associations whose mission includes undergraduate education (AMATYC, MAA, AMS, ASA, SIAM).

Common Themes

- **The status quo is unacceptable**
- Less traditional lecturing, more **active learning**
- More **statistics, modeling, simulation**, and **computation**
- The increasing role of **two-year colleges**
- **Contingent faculty (part-timers, adjuncts)** need professional development and support

Common Themes

- **Multiple pathways**:
  - Through **developmental** education **and general education** mathematics and statistics requirements
  - Into and through **majors** in the mathematical sciences
- Attention to student **transfer** between institutions (secondary, 2-year, 4-year)
- **Technology** to enhance student learning

Common Themes

- Curricula development efforts with **partner disciplines**
- Emphasis on developing **students' communication skills**
- **Outdated** faculty **reward systems** (e.g., tenure and promotion criteria)
- **Scaling** and **sustainability** of initiatives
- Future teachers
  - The specialized knowledge needed for teaching is distinct from the knowledge needed for other math-intensive professions (**different, not less**)

Common Themes

- **Failure rates**
  - The high rate of failure in post-secondary math classes is an **embarrassment** to our profession
  - Math courses are the most significant barrier to degree completion in **all fields**
- **Developmental courses**: Small % of students make it through the developmental abyss to credit-bearing math courses

Common Themes

- Student **diversity**
  - Our inability to attract and retain a diverse population is a **dreadful shortcoming that must be remedied**
  - 1998: Stiff & Harvey called the math classroom one of the **most segregated** places in the U.S.
  - Today: Upper-level math classes remain **predominantly white**

Common Themes

- Student **diversity**
  - Today: The **equity gap** in math is evident as early as 4th grade
  - It is our **responsibility to remove barriers**, we should not presuppose minorities and women are less capable or less prepared
  - Community colleges have a **"moral obligation"** to support the students we enroll (*The Community College Story,* AACC, 2006)

But what is the ultimate goal?

EQUALITY

EQUITY

BARRIER REMOVED!!

Call to Action

Common Vision built on the work of the *INGenIOuS* report (Zorn, et al, 2014) and reiterated their call to action:

"We acknowledge that **changing established practices can be difficult and painful**. **Changing cultures** of departments, institutions, and organizations **can be even harder**. But there is reason for optimism. **In mathematical sciences research we are always willing, even eager, to replace mediocre or "somewhat successful" strategies with better ones.** In that open-minded spirit we invite the mathematical sciences community to view this call to action as a promising opportunity to live up to our **professional responsibilities** by improving workforce preparation." (p. 25)

Change is hard…

- …but just because it's hard, doesn't mean we ought not to try.
- We must **modernize**!

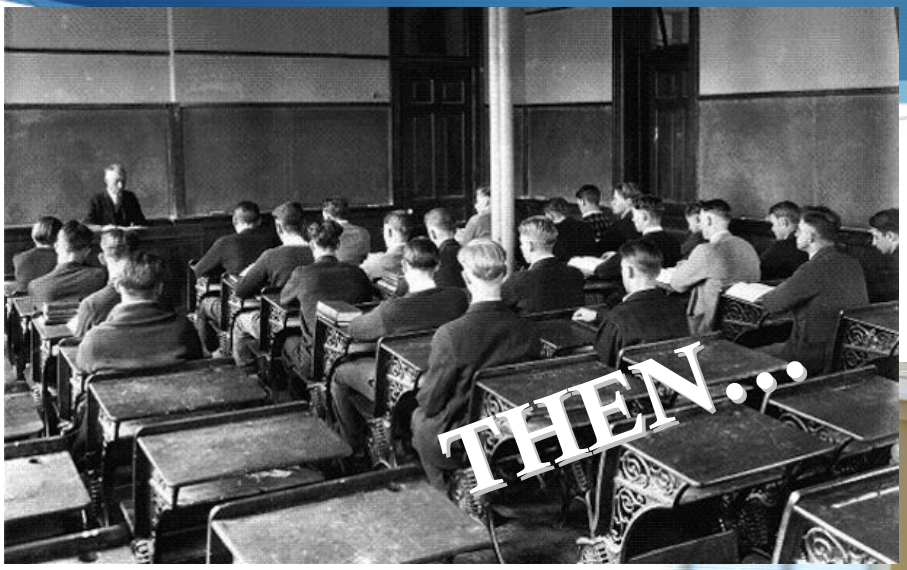

HOW YOU DOIN'?

How YOU doin'??

- Do you **routinely** examine your own data?
  - How many STEM intending students at your college complete that degree? (Nationally, only 40%)
- Do you **disaggregate** your data by gender, race/ethnicity, socio-economic status?
- Do you look at anything **other than final grades** in courses?
- Do you encourage a **culture of wonder** rather than a culture of blame?

Modernize Outdated Pedagogy

Who is doing the thinking?



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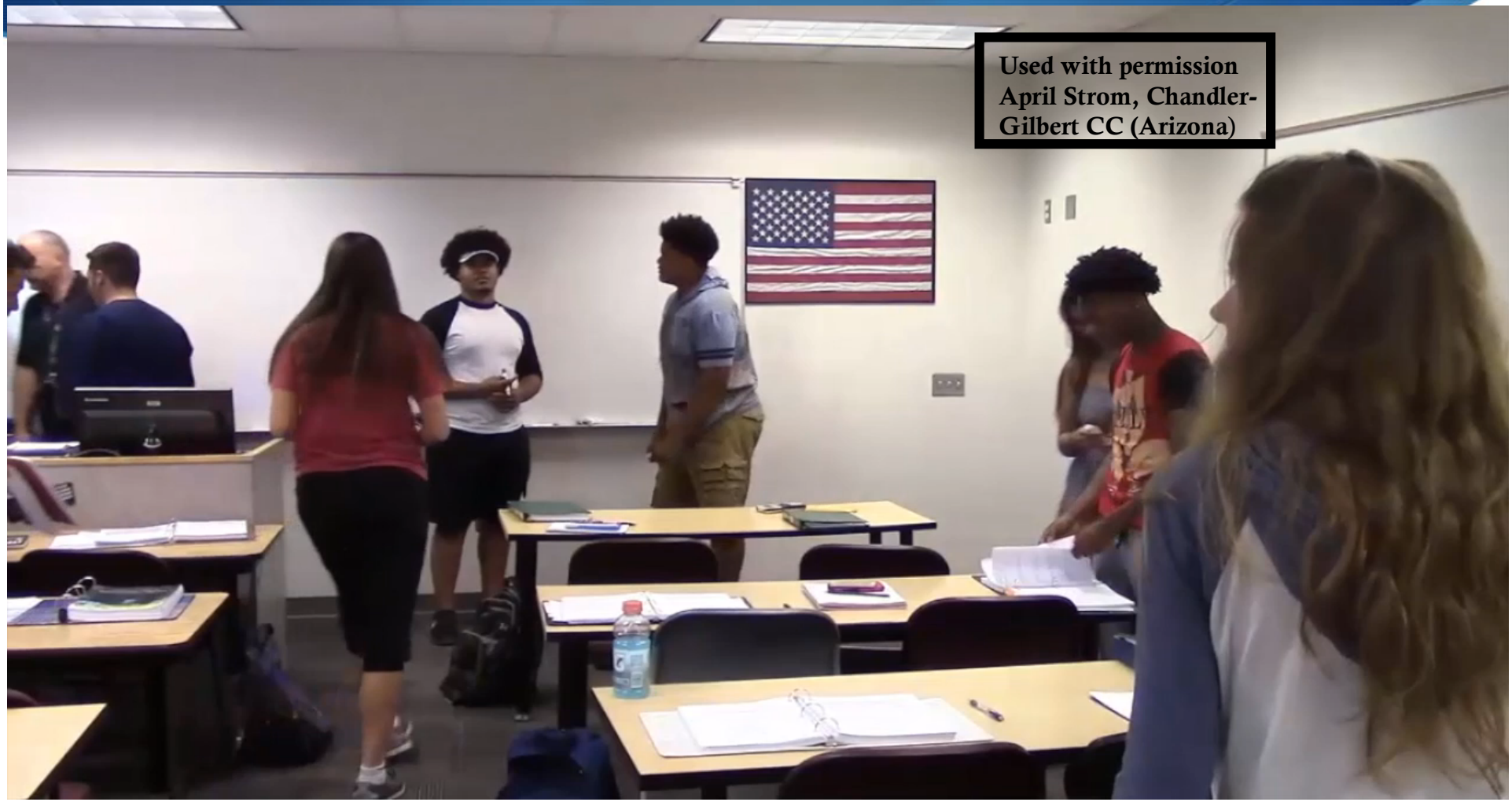


What **is** active learning??

What **is** active learning??

?????

Oh the irony of lecturing about active learning….

Evolving Conceptualizations

Excellence in Teaching Symposium for GTAs
at Montana State University (Elizabeth Arnold)

What is active learning? (before)

GTAs' Pre-Symposium Thoughts
"This is where someone engages in an **activity**."
"I'm not sure."
"Engagement with the material, which leads me to believe that this is a **student choice** rather than something the instructor can mandate."
"Active learning is learning through **guided activities**."

Evolving Conceptualizations

What is active learning? (after)

GTAs' Current Thoughts
"I assumed it had to do with physically engaging students in a lecture but I have learnt that it involves the process of **actively engaging the mind.**"
"It encompasses **a lot more than I thought**; e.g. **I thought it implied working with other students**, by definition."
"It does **not** have to be doing activities."
"To me, it's **student engagement**."

Examples of Active Learning

- Activities such as reading, writing, discussion, or problem solving that promote analysis, synthesis, and evaluation of class content
- Cooperative learning, group problem solving
- Problem-based learning, project-based learning
- Inquiry-based learning
- The use of case studies and simulations

Research on Active Learning

- Inquiry-based learning (IBL) helps close gender gaps
  - Laursen, et al (2014)
- Interaction helps close gender gaps (physics education)
  - Lorenzo, M., Crouch, C.H., Mazur, E. (2006)
  - "(T)eaching with certain interactive strategies not only yields significantly increased understanding for both males and females, but also reduces the gender gap. **In the most interactively taught courses, the pre-instruction gender gap was gone by the end of the semester."**

Research on Active Learning

- Freeman, et al (2014): Meta-analysis, 225 studies on active learning in STEM
  - Medical study analogy
  - **100% passive lecturing = Educational malpractice**
  - Jim Lewis, University of Nebraska, former director of NSF DUE: **That theorem has been proven!**
- Linda Slakey, former former director of NSF DUE: **Success will be when STEM faculty are embarrassed to lecture for an hour.**
- Dave Kung: **10 minute talk test**

Story of German professor…

- "Anyone can learn anything under the right conditions."

Are you student-ready?

- We must stop focusing on the need for **students** to be **college-ready**.
- We must focus on ensuring **we** are **student-ready**.

MAA Instructional Practices Guide

aka "IP Guide"

What is it?

- The MAA has published a CUPM Curriculum Guide about once every 10 years since the 1950's.
- The IP Guide is a companion (the "**how**") to the Curriculum Guide (the "**what**")

What is its purpose?

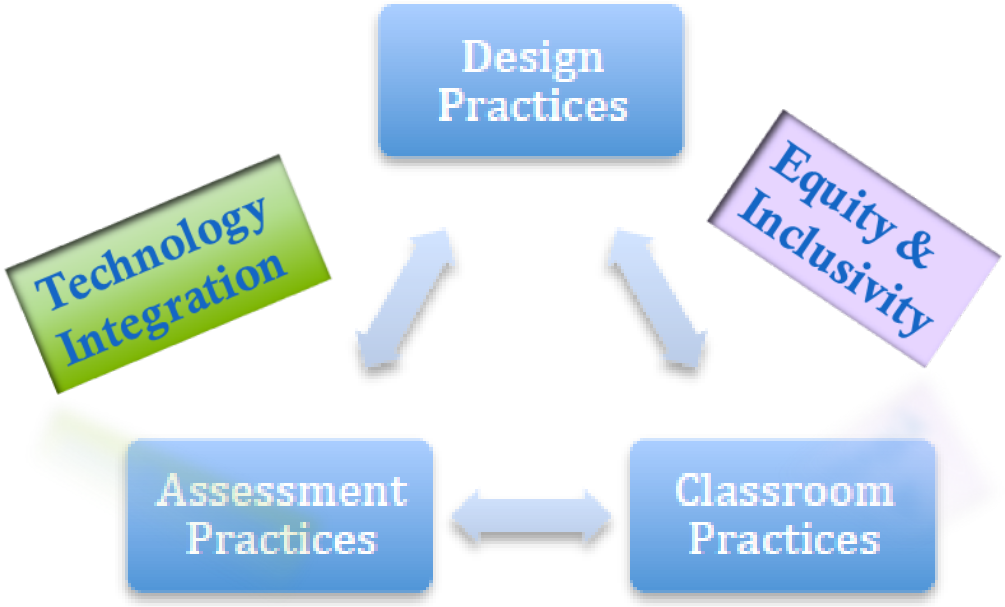
- To serve as a "**how to**" guide
- To promote and support the use of **evidence-based practices** that **actively engage students** in their learning
- To serve as a call to the math community to **scale up** the use of evidence-based instructional strategies and **hold ourselves accountable** as professional educators for **improving learning for all** students

Why evidence-based?

- We must **stop reinventing** the wheel.
- And we must especially stop reinventing **the flat tire**!!

IP Guide Content

Effective Teaching



The IP Guide highlights research on effective

- **Classroom practices**
- **Assessment**
- **Course design**
- **Technology integration**
- **Equity and inclusive strategies**

What does the research say?

Effective teaching and deep learning require student engagement with content both inside and outside the classroom.

How is the *Guide* being used?

- By **individual faculty** for personal use
- As a text for a **faculty reading group**
- As a **resource for professional development** with TA's and faculty
- By **administrators** who want to initiate systemic change in their math departments and across their institutions

Features throughout the *Guide*

- Easy-to-follow vignettes to illustrate instructional practices
- Practical tips
- Advice on avoiding pitfalls

How should the *Guide* be read?

- It need **not** be read front to back
- Classroom Practices are addressed first as a way to engage the reader who is just beginning to transform their teaching; as they gain more experience with the student-centered practices, they can move back and forth among the chapters as needed.

Classroom Practices Chapter

- Provides **examples** of teaching practices that **foster student engagement**
- Describes how to select appropriate mathematical tasks that contribute to **building a sense of community** within the classroom

Assessment Practices Chapter

- Centers on the interplay between **formative** and **summative** assessment with a **strong focus on learning outcomes**

Design Practices Chapter

- Provides a **brief introduction** to **instructional design theories and practices** to help achieve desired learning outcomes

Classroom Practices Topics

- Building a classroom community
- Wait time
- Responding to student contributions in the classroom
- One-minute paper or exit ticket
- Collaborative learning strategies (think-pair-share, paired board work, small group work)

Classroom Practices Topics

- Just-in-time teaching
- Developing persistence in problem solving
- Inquiry-based teaching and learning strategies
- Peer instruction and technology

Classroom Practices: Practical Tips

- When requiring more interaction in the classroom, **establish behavioral norms and guidelines** for productive exchanges by having a conversation about the expected behaviors (a.k.a. "rules of engagement"):
  - Late arrivals to class impact all group members
  - Unnecessary cell phone use unfairly distracts from group interactions and attentiveness in class
  - Willingness to listen intently and communicate ideas promotes learning and engagement

Practical Tips: Wait Time

- After asking a question, actually keep track of how many seconds you wait. Some instructors count to seven on their fingers behind their back.
- If you reach 10 or more seconds with no response, consider using the think-pair-share strategy discussed in this chapter.

The 20 Year Question

20 years from now?

- What do we want students to take from our classes that they will still have with them in 20 years?
  - **Effective thinking skills, mathematical thinking, critical thinking, analytical thinking**
  - Burger, E. B., & Starbird, M. (2012). *The 5 elements of effective thinking*. New Jersey: Princeton University Press.
  - **Ask yourself that question every day before you walk into your classroom.**

National Academies of Sciences (NAS)

Workshop on Developmental Mathematics Education

NAS Workshop

- Workshop on developmental mathematics education
  - Multiple pathways
  - Co-requisite model of remediation (parallel, just-in-time; not sequential)
  - Placement
  - Equity
- Link to video recording http://sites.nationalacademies.org/dbasse/bose/developmental_math/index.htm

NAS Vision (Summary)

- "Developmental education" will no longer exist. Instead, it's "College mathematics for ALL" and "Mathematics literacy for ALL."
- Demographics are no longer barriers.
- National free college model.
- More students in high demand fields reflect the population.

NAS Vision (Summary)

- Barriers among K-12, 2-year, and 4-year institutions are eliminated; pathways are aligned and span the entire spectrum of education (no more repetition, no more blame game, no more unproductive competition).
- Normative practice includes:
  - New student success measures.
  - Supporting and serving students effectively.
  - Placement is no longer necessary. Rather, guidance into appropriate pathway and appropriate academic support for individual learners.

NAS Vision (Summary)

- All pathways are rigorous; College Algebra and Calculus are no longer synonymous with rigor.

Call to Action

Call to Action

- I hope you also leave here with a determination to:
  - **Try something new** to engage students.
  - **Stop reinventing the flat tire**.
  - **Change the things you cannot accept**.

Questions?

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