Should We Put the "Active" in Learning?

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Overview

- Workforce demand and economic vitality
- National criticism of mathematics education
- Response from the mathematics community
- MAA Common Vision
- What is active learning?
- MAA Instructional Practices Guide

Overview

- Alternate curricular entry points
- Alternate curricular pathways
- National Academies of Sciences workshop summary
- Classroom environments

Then….and Now

50 years ago…

Then… Now…

100 years ago…

Now…


Microsoft
Facebook
Outlook Calendar
Outlook Mail
People
Cortana
Microsoft Edge
Store
Continuum
Camera

100 years ago…

Now…

100 years ago…

Now…

OUTDATED!

- Our courses and programs are outdated
- The entry-level course options we offer students are outdated
- Our pedagogies are outdated
- Our use of technology as part of the curriculum is outdated

OUTDATED!

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

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
- To get you to **implement new** entry-level courses or a new pathways structure.

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.

What should we teach?

How should we teach?

Workforce Demand and Economic Vitality

Workforce Demand

- Keith made my case! THANK YOU!!
- **The skills gap is real**.

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%."

Non-Academic Jobs

- $3 million NSF grant to MAA for PIC Math (2013, renewed, still going)
- Prepares mathematical sciences students for industrial careers by engaging them in **research problems that come directly from industry**.
- Supplies faculty with tools to offer students experiences designed to better prepare them for the demands that accompany non-academic jobs.

https://www.maa.org/programs-and-communities/professional-development/pic-math

Lest we forget…

"The value of thinking about math for math's sake."

- Instructors should intentionally plan curricula to:
  - Enhance students' perceptions of the beauty, vitality, and power of the mathematical sciences.
  - Enhance students' understanding of mathematics as a creative endeavor.

(Common Vision, pg. 12)

National Criticism of Mathematics Education

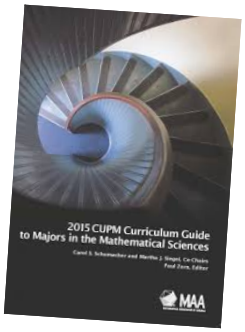
National Criticism 2012-13

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

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
- CUPM Curriculum Guide began in 2012
- TPSE began in 2014
- *MAA Instructional Practices Guide* began in 2014
- AMATYC *Impact* began in 2015
- CBMS Statement on Active Learning in 2015



Collective Response

- Conference Board of the Mathematical Sciences (**CBMS**)
  - 2015 Endorsement of ***INGenIOuS, Common Vision***, and **TPSE**:

    "Collective Effort to Improve the First Two Years of College Math-Statement by Presidents of CBMS Member Professional Societies"

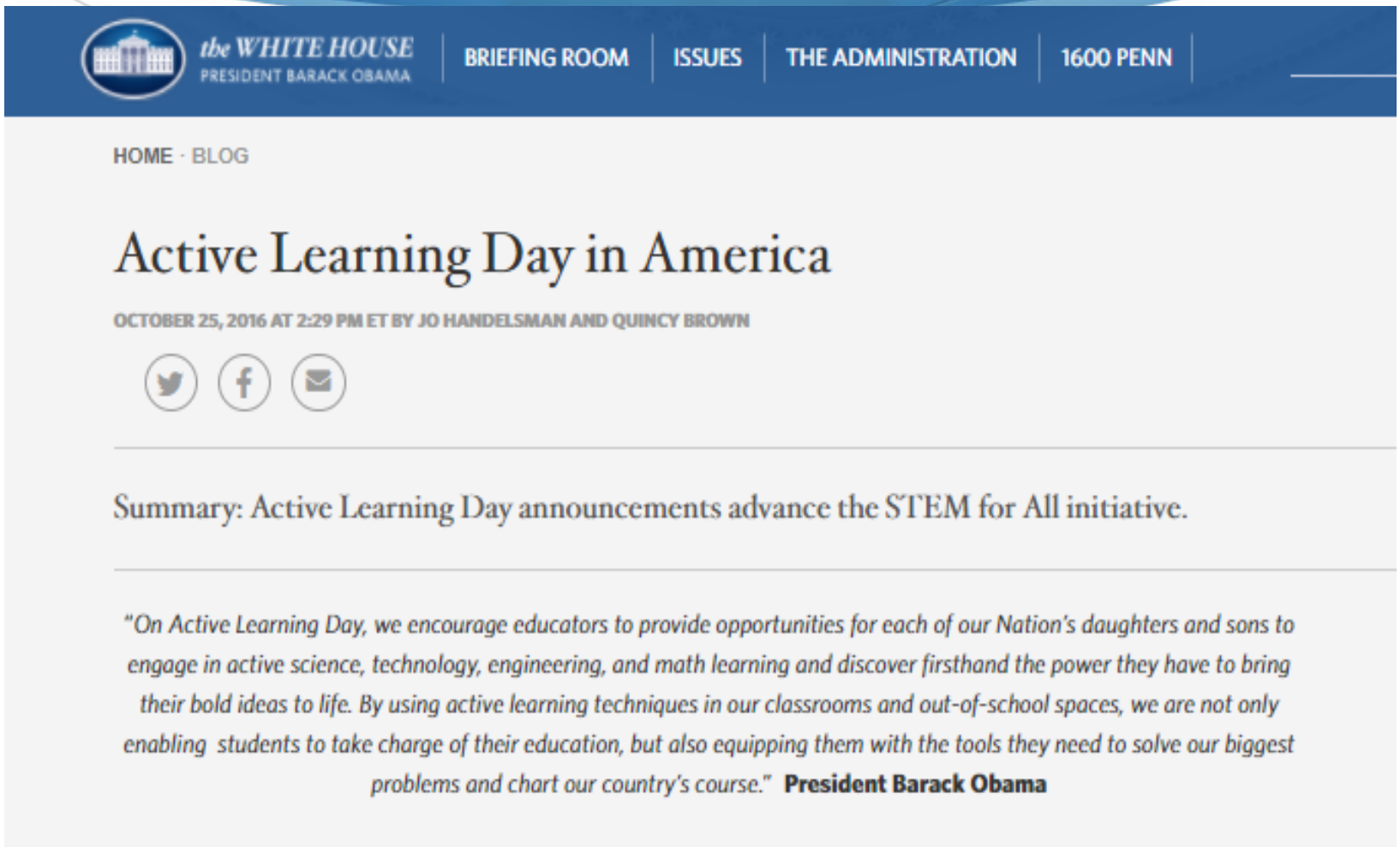
    "We, the undersigned CBMS member society presidents, **express our support for the efforts of these professional societies** and we **encourage the continuation and expansion** of these initiatives in consultation with the teacher educator and K-12 communities."

Collective Response

- Conference Board of the Mathematical Sciences (**CBMS**)
  - 2016 Statement on Active Learning:

    "We call on institutions of higher education, mathematics departments and mathematics faculty, public policy-makers, and funding agencies to invest time and resources to **ensure that effective active learning is incorporated into post-secondary mathematics classrooms**."

The White House joins in…(2016)



the WHITE HOUSE
PRESIDENT BARACK OBAMA

BRIEFING ROOM | ISSUES | THE ADMINISTRATION | 1600 PENN

HOME · BLOG

Active Learning Day in America

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

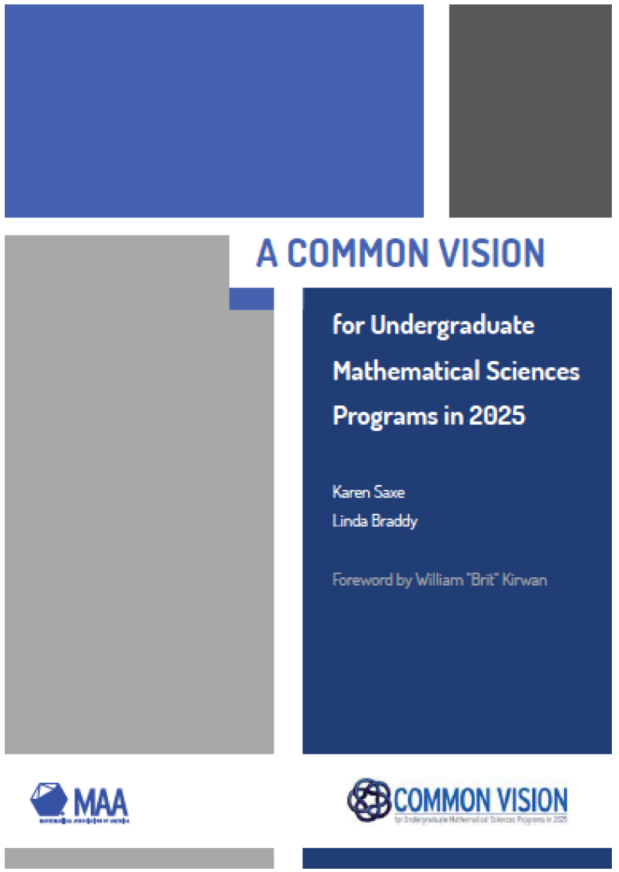
Summary: Active Learning Day announcements advance the STEM for All initiative.

"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**

Common Vision

Common Vision

- Funded by National Science Foundation (NSF) in 2014
- 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.

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 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)

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 are YOU doing??

- Canada has the highest attainment rate in post-secondary education among OECD* countries:
  - 61% of 25-34 year olds in Canada have post-secondary credentials vs. 43% in the same age group for the OECD average in 2016.
- **Where does your university stand**?

*OECD = Organization for Economic Cooperation and Development

(http://ncee.org/what-we-do/center-on-international-education-benchmarking/top-performing-countries/canada-overview/canada-instructional-systems/)

How are YOU doing??

- Do you **routinely** examine your own data?
  - How many STEM intending students at your university complete that degree? (In the U.S., 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?

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

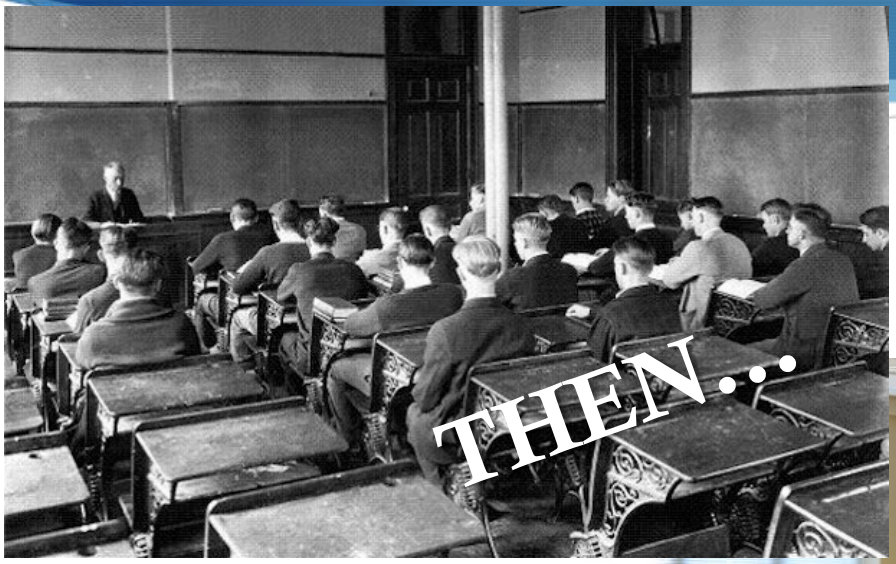
Senait Litchmore watches television with her three daughters in Toronto. (CBC)

Gender Bias & Stereotypes

- Girls solve problems “by magic”
- Boys solve problems using logic, math, problem solving skills

Modernize Outdated Pedagogy

Who is doing the thinking?



Who is doing the thinking?

Used with permission
April Strom, Chandler-Gilbert CC (Arizona)

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

- Active engagement
  Freeman, et al (2014): Meta-analysis, 225 studies on active learning in STEM
  - Likened to a medical study
  - **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 when STEM faculty are embarrassed to lecture for an hour.**
  - **"10 minute talk test"**

Story of German professor…

- In the right environment, anyone can learn.

Are you student-ready?

- We need to stop focusing on the need for **students** to be **college-ready**.
- We need to 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**")
- **Intentionally provocative**

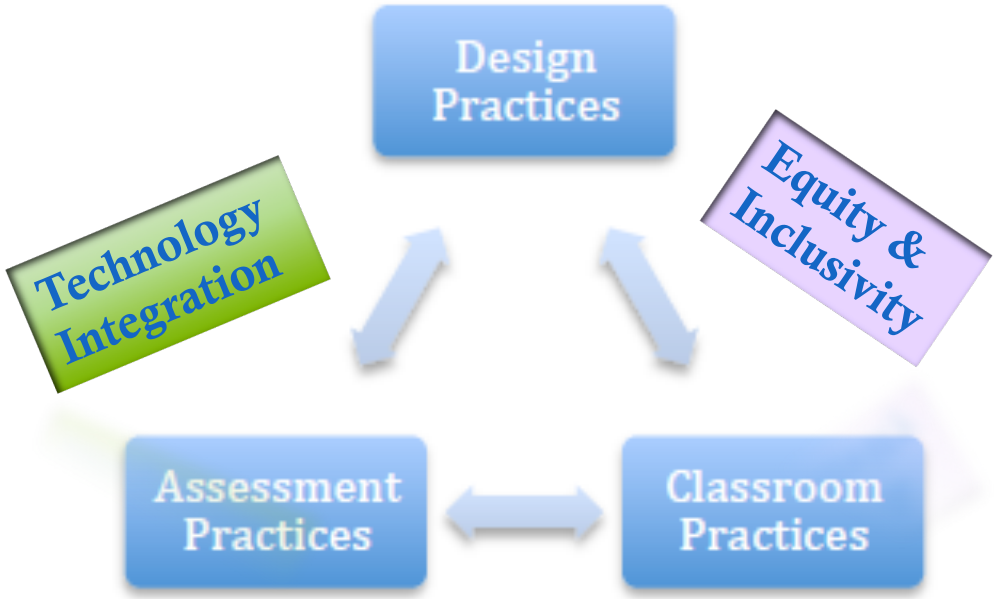
What is its purpose?

- To serve as a "**how to**" guide
- To promote and support the use of **evidence-based practices** that contribute to effective teaching through **active learning** and **student engagement**
- 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

IP Guide Manifesto

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.

Why is the research important?

- We have to stop reinventing the wheel.
- We especially have to **stop reinventing the flat tire**!!

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

Excellent resource for IBL

Academy of Inquiry-Based Learning

Video series on IBL
http://www.inquirybasedlearning.org/ibl-video

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 making use of the think-pair-share strategy discussed in this chapter.

Modernize Outdated Courses & Programs

Alternate Curricular Entry Points & Pathways

Entry Points & Pathways

- Curricula in the mathematical sciences traditionally aim toward **upper-level majors' courses** focused on theory. Shorter shrift is usually given to applications that reflect **the complexity of problems** typically faced in BIG environments, and to appropriate uses of standard BIG **technology tools**. The computation that mathematics and statistics majors typically see introduces them to important scientific computing constructs, but it should also help prepare students for big data applications through **mathematical and statistical modeling, data analysis, visualization, and high performance computing**. Mathematical sciences departments should **modernize programs** and incorporate **alternative curricular entry points** to better capitalize on the interplay of mathematics and statistics with a broad spectrum of career options.

  (Ingenious report, pg. 2-3)

Entry Points & Pathways

- **Alternative curricular entry points** (e.g., courses **other than freshman-level algebra or beginning calculus**) and **pathways** to undergraduate and graduate degrees should be developed. They could at once broaden students' awareness of career options and build the mathematical competencies, computational facility, and career success skills such as written and **oral communication and teamwork** required for rapid transition into the workforce.

(Ingenious report, pg. 20)

Entry Points & Pathways

- Acknowledging that points of entry and degree paths have changed, Howard Hughes Medical Institute (HHMI) President Robert Tijan said:

  > "These days, a large number of students are arriving at college through remarkably diverse pathways. The scientific leader of tomorrow may be in a community college today or she may be a first-generation college student. **Higher education should** acknowledge these differences among students and **create programs that offer diverse entry points and pathways to STEM degrees**" (HHMI, 2015).

Alternate Curricular Entry Points

Alternate Entry Points

- SIAM's 2014 report of its second Modeling Across the Curriculum workshop questioned whether there are points of entry into the mathematical sciences besides the traditional calculus track:
  - Might a **freshman mathematics modeling class** interest students in applied mathematics who might not otherwise choose mathematics as a major?
  - Within **the calculus track**, is there a new approach that would improve student outcomes?

Modeling and Computation

- Modeling and computation can be used to introduce the scientific method and experimentation into mathematics courses, and both should also be seen as a means for **enhancing conceptual understanding**.
- We use the term "**modeling**" as an umbrella term referring to the **creative process** that can be **mathematical, statistical, computational, data-based, or science-based**.

(Common Vision, pg. 15-16)

Modeling and Computation

- SIAM (2012) recommended departments offer modeling experiences at the entry level by developing "**a first year modeling/applied mathematics course that precedes and motivates the study of calculus and other fundamental mathematics for STEM majors**" (p. 4).
- A central reason for introducing students to modeling is to engage and retain students in STEM disciplines.

(Common Vision, pg. 15-16)

Alternate Curricular Pathways

Alternate Pathways

- National efforts should be made to develop materials for challenging and interesting courses that include bridges and **alternate pathways to the major**.

(2015 CUPM Guide, pg. 2)

Modeling and Computation

- We should develop **stronger computational skills** in mathematics and other STEM majors. Examples:
  - First year students learning simple tasks like **managing electronic files** and handling different types of **file formats**
  - Math majors taking an **introductory programming course**.
  - Requiring students in mathematics courses to use **software packages** (e.g., MATLAB) that are **standard in engineering practice**.

(Common Vision, pg. 16)

Modernize Curricula

a.k.a.,

"What Keith Said"

What Keith said…

- CUPM Guide (2015) recommended students in the mathematical sciences work with **professional-level technology tools** (e.g., **statistical packages**) and acquire **modest programming skills** to help them tackle ill-posed, real-world problems (p. 11).
- Keith never took a statistics class, had to learn about **uncertainty, statistics, and error analysis** elsewhere.

Interdisciplinary

- There are now, perhaps more than ever, amazing career opportunities for people with training in mathematically-intensive fields. **Rapid advances in technology and in connections between mathematics and other fields** present tremendous opportunities…

(Common Vision, pg. 5)

Interdisciplinary

- The reports *The Mathematical Sciences in* 2025 and *Fueling Innovation and Discovery: The Mathematical Sciences in the 21st Century* explore **new areas of the physical, biological, and geophysical sciences; and of engineering, computing, and social sciences** in which mathematics will play an essential part.

(2015 CUPM Guide, pg. 2)

Interdisciplinary

- From reports at focus groups and from data collected by CBMS surveys, we have found that departments have expanded their scope to more of the mathematical sciences, **incorporating more statistics and probability, computing, discrete methods and operations research.** Indeed, we see that many mathematical sciences programs are becoming more applied and **more interdisciplinary**.

(2015 CUPM Guide, pg. 1)

Interdisciplinary

- Modernize curriculum to integrate **modeling, data science, information science, computational science, statistics and probability, discrete methods and operations research**
- This is hard, and we must **collaborate with our partner disciplines**.

Statistics Majors

- Undergraduate statistics majors should develop skills that enable them to **handle increasingly complex data** and use sophisticated data analysis approaches.
- Graduates should be **facile with professional statistical software** and other tools for **data exploration, cleaning, and validation**.

(Common Vision, pg. 16)

Statistics Majors

- Graduates should possess the ability to **program in a higher level language** (including the ability to write functions and use control flow in a variety of languages and tools such as **Python, R, SAS, or Stata**), to think algorithmically, to use **simulation-based statistical techniques**, and to conduct **simulation studies**.

(Common Vision, pg. 16)

Statistics Majors

- Graduates should also be proficient with managing and manipulating data, including joining data sets from different sources in different formats and restructuring data into a form suitable for analysis. **Acquisition of these skills should begin during their first two years of college**.

(Common Vision, pg. 16)

Entry-Level Statistics

- Alternate entry-level courses
- Entry-level courses should:
  - Reflect the discipline
  - Require students to collect, organize, analyze, interpret, and use data to make informed decisions
  - Focus on data science, data analytics

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?

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 serial)
  - Placement
  - Equity
- Link to video recording http://sites.nationalacademies.org/dbasse/bose/developmental_math/index.htm

NAS Vision (Summary)

- We are ensuring equitable opportunities for ALL students to learn the mathematics they need to navigate the world and achieve their life goals.
- Mathematics is a human experience: students experience the power and beauty of mathematics and experience joy in doing mathematics.
- Mathematics education enables people to use mathematics tools effectively and ethically in integrated ways.

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 that 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.

Classroom Environments

IP Guide Manifesto

- All instructors can facilitate student success in math, and we **cannot underestimate the power of the environment** in our classrooms, departments, and institutions to positively impact student learning.

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

Salient Issues (Barriers)

- Belongingness
- Stereotype threat
- Fixed mindsets
- Fear of failure
- Sage on the Stage
- Hidden rules of college (Becker, Krodel, & Tucker, 2009)

Remedies

- Help students see themselves as mathematicians or statisticians
- Create a learning environment that values effort and engagement as a path to belonging
  - Facilitate peer interactions
  - Make students work public
  - Normalize productive failure and productive struggle

Remedies

- Embrace the growth mindset model – http://www.turnaroundusa.org/7-things-growth-mindset-isnot/
  - Teachers' mindsets are known to significantly affect their pedagogical practices
- Avoid language and cues that promote stereotypes
- Avoid language and cues that activate stereotype threat

Remedies

- Helpful language
  - "You're just not there YET." (utilize the power of "yet.")
  - "After you do this lesson, I'm going to ask each of you to share a mistake you made while doing your work, because mistakes can help us learn." (normalize productive failure)
  - "I'm giving you these comments because I have high standards, and I know that you can meet them." (communicate high expectations)

Call to Action

Call to Action

- I hope you leave here with a sense of urgency regarding:
  - The need to employ instructional practices that promote **active learning** and **student engagement** in the learning process.
  - The need to develop **alternate pathways** into and through mathematics majors.
  - **The need to modernize curricula, programs, and pedagogies.**

Call to Action

- I hope you also leave here with:
  - At least **one new tool** in your teaching toolbox.
  - A determination to **stop reinventing the flat tire**.
  - A determination to **change the things you cannot accept**.

Questions?

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