NATIONAL ACADEMIES Sciences Engineering Medicine

Transforming Undergraduate STEM Education

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Heads and Chairs

The National Academies (NASEM)

- A non-governmental organization (NGO)
- Founded in 1863
- Bring together committees of experts in all areas of scientific and technological endeavor
- Address critical national issues and give advice to the federal government and the nation

NATIONAL ACADEMY OF SCIENCES

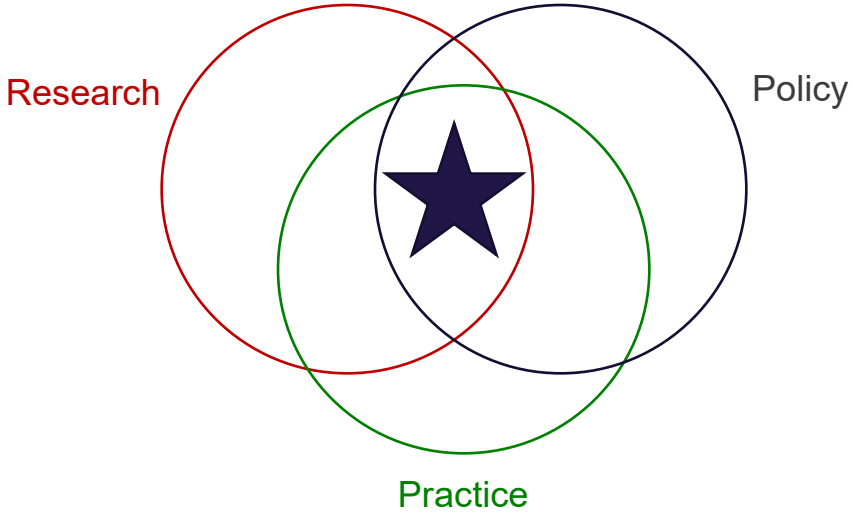
NATIONAL ACADEMY OF ENGINEERING

NATIONAL ACADEMY OF MEDICINE

NATIONAL ACADEMIES Sciences Engineering Medicine

Board on Science Education Mission

- Provide evidence-based guidance for practice and policy
- Identify future directions for research
- Serve as a connection point between research, policy and practice



Consensus Study Acknowledgments

Gates Foundation

We'd also like to thank…

- Commissioned papers authors
- Invited experts participated in public meetings and conference presentations
- Committee on Equitable and Effective Teaching in Undergraduate STEM Education: A Framework for Institutions, Educators and Disciplines
- Staff of the Division of Behavioral and Social Sciences and Education (DBASSE) and in particular the Board on Science Education (BOSE)

Overview of the Charge to the Committee

Develop a framework that articulates approaches to and guidelines for evidence-based, inclusive teaching.

- Base framework on examination of evidence, including successful efforts to improve and support instruction.
- Consider different modes of teaching (e.g., in-person, online, blended and hybrid teaching).
- Consider different educational contexts (e.g., 2-year colleges, hybrid programs, research institutions).
- Consider the roles that technology does, or can in the future, play in supporting equitable and effective teaching.

Identify policies and practices at the departmental, programmatic, and institutional levels that can facilitate implementation of the principles in the framework.

- Examine the institutional infrastructure, policies, and practices needed to encourage and support evidence-based, equitable teaching, such as opportunities for professional development, faculty evaluation policies and practices, and reward and advancement systems.
- Discuss the experiences and training opportunities graduate students and postdoctoral students will need in order to be prepared to employ equitable and effective instruction as future faculty members.

Provide actionable recommendations for institutions, disciplinary societies, funders, and policy makers on steps that could support implementation of the framework.

Call out areas in need of further research.

Scope of the Study

- The committee was inclusive in considering the disciplines of STEM, types of post-secondary institutions, variety of instructors, and all students in their work.

- We include students preparing for careers in fields heavily dependent on STEM knowledge and skills (such as nurses, medical doctors and technicians, biotech workers, scientists, mathematicians, and engineers), as well as those who are taking a course to satisfy a distribution requirement or learn about an interesting topic.

- We include full-time and part-time roles, permanent and contingent employees, adjunct instructors, visiting professors, graduate teaching assistants, and tenured and tenure-track faculty, among others. We make use of the acronym VITAL to denote visiting faculty, instructors, teaching assistants, adjunct faculty, and lecturers.

Important Tenets

- *Transforming the* undergraduate STEM education system requires two things:

  - Providing **all** students with the support they need to succeed, as measured by achievement of clearly communicated learning objectives.
  - Supporting and rewarding **all** instructors by providing them with the resources they need to successfully educate all of their students.

- *When these two things exist, we can expect transformation. In particular:*
  - **All** students will learn and understand STEM concepts and be able to use them in practical ways.
  - **Most, if not all**, students will have the opportunities and the resources to demonstrate their learning by meeting the desired learning objectives.
  - Excellence cannot be achieved if demographic factors are predictive of academic achievement.

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Chapter 2: Institutional Context of Post-Secondary STEM Education

- Who are (STEM) students?
- What institutions do they attend?
- Who is the instructional workforce?
- How are institutions funded?
- History and systemic inequities

- Many longstanding policies and practices in undergraduate STEM education have produced, perpetuated, and exacerbated differences in opportunities, experiences and outcomes.
- Changing demographics, college costs, and STEM workforce demands underscore the need to improve the learning experiences of undergraduate students in STEM courses.

Chapter 3: Understanding Teaching, Learning, and Equity

- Learning is Complex and Well-Studied
  - Active Learning
  - Mastery and Mindset
- Considerations in the STEM Disciplines
  - Foundational Courses
  - Toxic Course Combinations
  - Mathematics course sequences
  - Teaching and learning in the field
- Evidence of Inequities: Grade Penalties, Differences in Persistence to Degree, Differences in Belonging, Power and Privilege
- Existing efforts that promote equity

- Learning in STEM involves complex processes that are shaped by identities, experiences, and backgrounds, social interactions, and cultural context.
- Widespread use of teaching strategies that are not supported by research have contributed to disparities in opportunity and outcomes for undergraduate STEM students.
- Instructional practices that take students' interests and experiences into account and empower them with authentic opportunities to engage with disciplinary content, practices, and analysis are more effective.
- Students' experiences in foundational courses are important for their persistence in STEM.

Waterfall question

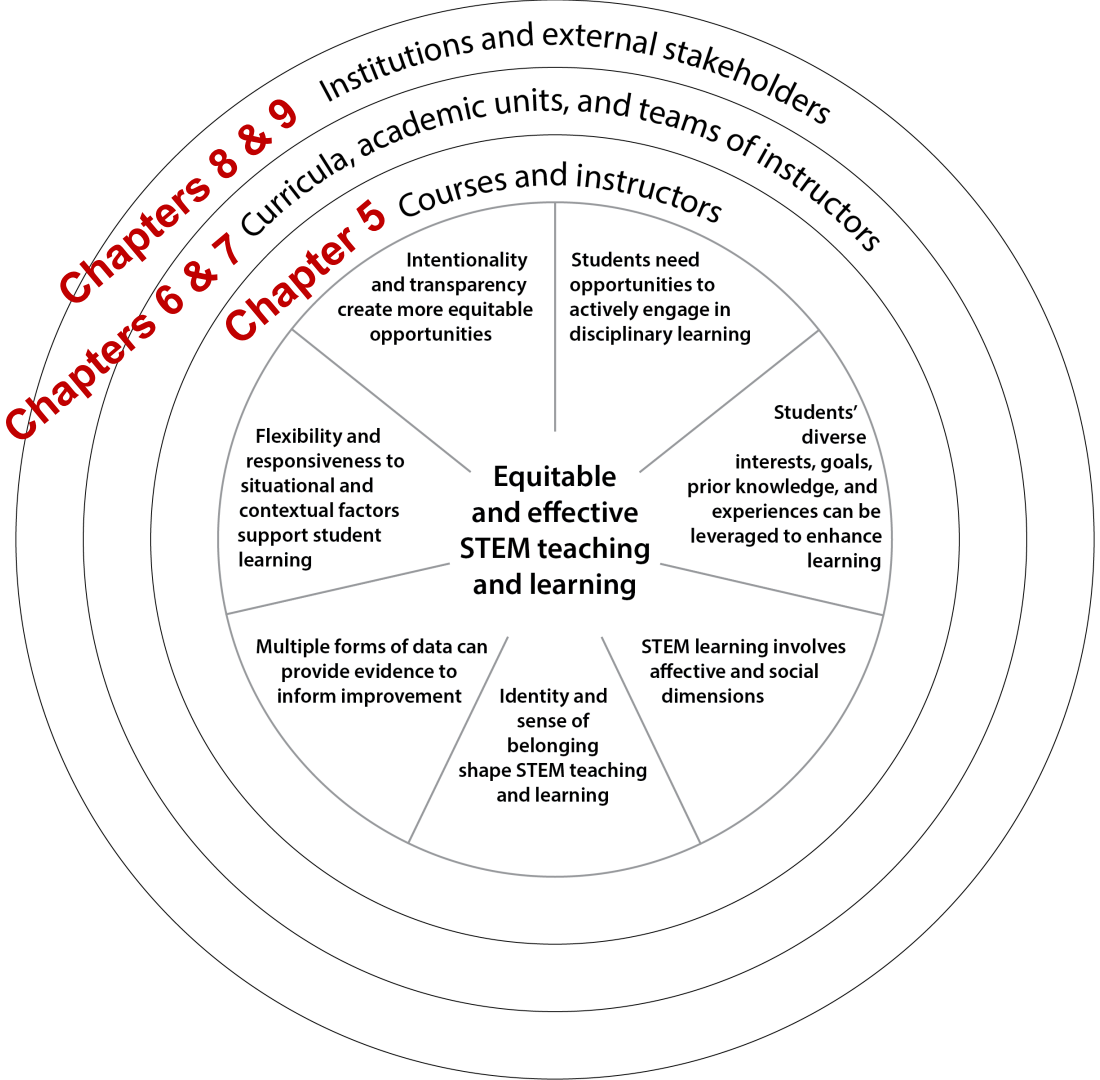
Directions:

1. We will put a question up on the slides.
2. We'll give you a minute or two to type your answer in the chat, but DON'T HIT RETURN.
3. Once enough time has passed, we'll tell you to hit return, and we will all read through and summarize the responses.

What disparities in opportunities or outcomes have you seen in your geoscience undergraduate students?

Chapter 4: Principles for Equitable and Effective Teaching of Undergraduate STEM Education

1. Students need opportunities to actively engage in disciplinary learning
2. Students' diverse interests, goals, knowledge, and experiences can be leveraged to enhance learning
3. STEM learning involves affective and social dimensions
4. Identity and sense of belonging shape STEM teaching and learning
5. Multiple forms of data can provide evidence to inform improvement
6. Flexibility and responsiveness to situational and contextual factors support student learning
7. Intentionality and transparency create more equitable opportunities


Chapters 8 & 9
Institutions and external stakeholders
Chapters 6 & 7
Curricula, academic units, and teams of instructors
Chapter 5
Courses and instructors
Intentionality and transparency create more equitable opportunities
Students need opportunities to actively engage in disciplinary learning
Flexibility and responsiveness to situational and contextual factors support student learning
Equitable and effective STEM teaching and learning
Students' diverse interests, goals, prior knowledge, and experiences can be leveraged to enhance learning
Multiple forms of data can provide evidence to inform improvement
Identity and sense of belonging shape STEM teaching and learning
STEM learning involves affective and social dimensions

Chapter 5: Using the Principles to Improve Learning Experiences

More of…	Less of…
Clear articulation of learning goals and how the work done in the course will help students achieve learning goals	A focus on getting through a set amount of content
Course structures that engage students as active learners	Course structures that maintain students as passive receivers of information
Activities that regularly engage students in using the skills and knowledge of the discipline	Separate laboratory sections focused on skills without clear connections to course content
Being transparent about opportunities and expectations for learning and engagement	Assuming that all students are aware of what they “should” be doing
Grading practices that allow for formative feedback and focus on mastery	Grading practices that focus on a theoretical distribution (a curve) and promote competition in a few high-stakes assessments

Table 5.1

Chapter 6: Role of Academic Units in Achieving Equitable and Effective Teaching

- Overseeing teaching
- The intended-enacted-experienced (and hidden) curriculum
- Academic and disciplinary culture
- Program learning outcomes
- Foundational courses and coordinating across departments
- Valuing and evaluating teaching

- Students are often expected to take multiple courses, but the connections between the courses are often not well coordinated, and the overall goals for what students will learn *across* the courses are not always well articulated.
- Academic units hold collective responsibility for all learning experiences they oversee and can improve the coherence of learning goals across course sequences, programs, and majors.
- Academic units play a major role in decisions and policies about teaching, including how teaching is valued, recognized, evaluated, and rewarded.

Geoscience departments and programs as academic units

- Overseeing teaching
- The intended-enacted-experienced (and hidden) curriculum
- **Academic and disciplinary culture**
- **Program learning outcomes**
- **Foundational courses and coordinating across departments**
- Valuing and evaluating teaching

Issues to consider:

- Geoscience has a unique disciplinary culture—how does this impact students?
- Foundational courses serve multiple purposes and are a key opportunity to engage students in disciplinary work
- Geoscience students often face challenges in allied science and math requirements in other departments
- Program learning outcomes may not be as relevant as they could be

Waterfall question

Remember the directions?

Two options for questions this time, you can choose one.

What data do you have access to for your department/program that could inform improvements?

How have you *already* used data to inform changes in your curriculum, teaching evaluations, persistence to degree, etc.?

Categories of Recommendations

- **Toward Equitable and Effective Learning Environments**
  - Recommendations 1-3
- **Valuing and Supporting Instructors**
  - Recommendations 4-10
- **Measuring and Advancing System Change**
  - Recommendations 11-15

Recommendation 2

- Members of **academic units** collectively should take responsibility for reviewing the portfolio of courses offered and the sequencing of courses using the Principles for Equitable and Effective Teaching.

- They should work collectively to **define clear course and program learning outcomes and use them to refine and revise the content and pedagogy of course sequences and individual courses.**

- As part of the review, academic units should use both aggregated and disaggregated data of multiple forms to identify courses or course sequences that appear to be producing systematic, inequitable outcomes and undertake revisions to address them. learning data.

Recommendation 6

- **Graduate and postdoctoral program leaders** should revise programs and expectations to make preparation for teaching an integral learning goal of programs.

- They should work to **change cultures so that all participants are encouraged and supported in meaningful professional learning and development** activities focused on teaching, learning, course design, and creating an equitable learning environment that embraces and promotes equitable and effective teaching.

- When teaching, graduate students and postdoctoral scholars should be supported by a mentor who has expertise in the use of the Principles to support equitable and effective teaching.

Recommendation 7

Academic unit leaders should develop policies and practices that value, recognize and reward equitable and effective teaching. Steps they can take include:

- **Providing time in unit meetings to discuss teaching-related topics** such as reviewing students' outcomes in courses, discussing the unit's strategy for continuous improvement of teaching, and sharing information about successes and challenges in teaching.
- Supporting individual and groups of instructors as they improve and revise their courses including providing dedicated time to work on course revision or additional financial compensation.
- Encouraging and providing time and resources for collaboration among instructors to work on course and curriculum revision and redesign.
- **Designing policies and practices for making teaching assignments that value the teaching of all courses and the contributions of all instructors regardless of their appointment type**.
- Identifying and supporting cohorts of instructors who are dedicated to and interested in implementing equitable and effective teaching and providing them with leadership opportunities.
- **Facilitating the access and use of relevant data that can help instructors identify and monitor differences and changes in student outcomes.**

Recommendation 9

- **Academic unit leaders** should use the Principles for Equitable and Effective Teaching as **professional standards** that form the basis of teaching evaluation processes.

- To achieve this goal, they should use evidence-based approaches to evaluate the entire portfolio of teaching related activities.

- This **holistic evaluation should go beyond student surveys** to include other forms of evidence such as structured teaching observations, analysis of teaching artifacts, course design, and instructor reflections.

Recommendation 12

- Members of **academic units** should take into account the complexity of the undergraduate population and their varied goals and pathways to ensure that all students can equitably and effectively experience and benefit from the unit's courses, programs, and credentials.

- They should examine data for obstacles and barriers to undergraduate STEM learning and apply the Principles for Equitable and Effective Teaching to smooth the educational journeys of their students.

- **Academic units should analyze transition points, course offerings, student experiences, and student outcomes and use the information to remediate obstacles that limit student learning or student progress towards a credential, especially obstacles that disproportionately impact students who are members of underserved groups.**

Support for acting on the recommendations

- You don't have to do this alone.
- NAGT's Traveling Workshops Program has customizable modules focused on:
  - Developing/strengthening program learning outcomes and ensuring their integration throughout the curriculum
  - Supporting all students and attending to department culture
  - Transforming introductory courses
  - …and more!
- Annual workshops on mentoring and course design to support individual faculty
- This group!

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- Workshop local host, BYU

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Comments, questions, concerns?

Feel free to unmute yourself or type in the chat.

Thoughts about these recommendations?

Supports this group can provide?

Other questions?

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Thank you!

The report can be read and downloaded for free from NASEM.

Use the URL or QR code to access the project page, which also has a highlights document and a link to an online interactive website.

https://nationalacademies.org/UG-STEM-Teaching