INTRODUCTION AND OVERVIEW
PURPOSE AND GOALS OF THIS MODULE COLLECTION

Conversation Module 1

Presented by Mark Mitsui at the meeting of the
Roundtable on Systemic Change in Undergraduate STEM Education
held at the Keck Center in Washington, DC on October 24, 2024

Higher education institutions prepare a wide array of learners with diverse backgrounds and aspirations to contribute to a dynamic and changing world. Preparing learners to be capable contributors to the workforce, to participate as engaged and knowledgeable citizens, and to live meaningful lives requires more effective and impactful STEM education. To meet this responsibility, universities and colleges need to create environments in which all learners have the opportunity to thrive.

The members of the Roundtable on Systemic Change in Undergraduate STEM Education, an initiative of the National Academies of Sciences, Engineering, and Medicine, have developed this collection of succinct modules to highlight practical and well-tested strategies and resources for institutions taking up the challenge to strengthen undergraduate STEM education. The ideas provided in the modules have emerged from panels, presentations, and discussions held at Roundtable meetings since 2017.

This collection of conversation modules is written for all those who are committed to excellence in higher education and recognize the importance of ensuring that the graduates of our higher education institutions achieve their potential. The ideas in these modules may be useful in your institutional planning, discourse, and actions.

The Collection is…

- A set of modules designed for busy leaders and stakeholders in higher education, who are working to advance excellence in undergraduate STEM education.
- A time-efficient guide to help administrators, faculty, and other higher education stakeholders understand foundational research and the rationale for systemic change to strengthen undergraduate STEM education.
- A summary of key levers for change based on evidence and experience, gathered from resources the Roundtable has reviewed and discussed over a number of years.
- A modular tool with flexible entry points, targeted to those in various leadership roles in higher education, to provide practical guidance for contributing to and facilitating organizational change.

WHAT IS THE ROUNDTABLE ON SYSTEMIC CHANGE IN UNDERGRADUATE STEM EDUCATION?

In 2017, the Board on Science Education (BOSE) at the National Academies of Sciences, Engineering, and Medicine created the Roundtable on Systemic Change in Undergraduate STEM Education (hereafter called the Roundtable) to explore ways to improve undergraduate STEM education that recognize the complexity of today's students, institutions, and society.

The Roundtable convenes individuals and organizations from varied roles in and around academia, including industry, government, and scientific and educational associations and societies. Members and speakers have

included professionals from a representative cross-section of US post-secondary institutions, including faculty, department chairs, deans, provosts, chancellors, and presidents from community colleges, liberal arts colleges, regional universities, minority-serving institutions, and research universities.

With intentional recognition that producing a diverse and well-prepared set of graduates supports the well-being of the country, the Roundtable focuses on postsecondary undergraduate STEM learning experiences and how best to prepare learners for their civic, personal, and professional lives. The Roundtable has explored the changes needed to meet the challenges and opportunities of our dynamic social and economic environment, with attention to the implications of dramatic shifts in student demographics, modes of learning, technology, STEM knowledge, and changes in work and workplaces. Roundtable convenings have focused on exploring pathways to undergraduate STEM degrees, the role of undergraduate research experiences, creating and sustaining student-ready colleges, departmental and institutional leadership, teaching evaluations, and STEM workforce development.

WHY IS SYSTEMIC CHANGE IN UNDERGRADUATE STEM EDUCATION NEEDED?

American higher education has been a critical catalyst for change across many domains throughout our nation's history, and the learning that happens in higher education is central to fostering societal improvements. Using learning to help society is at the heart of the history of the National Academies of Sciences, Engineering and Medicine. Born during a time of great conflict, the then National Academy of Science was formed in 1863 to mobilize the collective knowledge of the scientific community to help meet the nation's needs. Since then, the National Academies and higher education have collectively contributed to the well-being and advancement of our nation in a variety of ways, across many pivotal moments in our nation's history.

Our country's institutions of higher education have played, and continue to play, a key role in preparing students for their careers, for their engagement in our society as informed citizens, and for improving the overall quality of their lives. The positive impacts for individual students have rippled outward to benefit society as well. Effective undergraduate learning ultimately contributes to the strength of the nation's economy, the expansion of knowledge, the quality of the national workforce, the effectiveness of national security, and the well-being and strength of the democracy.

Our nation is once again navigating new landscapes of challenge and opportunity. Technological innovation is accelerating, and global health and environmental challenges have increased, as well as competition in STEM fields. In addition, the population growth of young people in the US is declining, posing recruitment challenges for higher education, the military, and employers. However, the historic strengths of the US, coupled with the dynamics of the current context, present a significant opportunity. The complex, multifaceted challenges facing our nation are best met with innovative solutions. Many of these solutions are most likely to emerge as STEM professionals work together and employ an array of approaches informed by a diversity of perspectives and backgrounds. Given this context, the rich and diverse heritage of the US is an important national strength. Therefore, it is critical that opportunities for students to access and thrive in an excellent undergraduate STEM education be made available to all students, regardless of background or zip code. Doing so will provide significant benefits to the students, their families, their communities, STEM employers, and our nation as a whole. Increasing access to and success in high-quality undergraduate STEM education can: increase economic mobility; decrease STEM skills gaps; support economic growth and global competitiveness; enhance national security; and contribute to an individual's sense of meaning, well-being, and overall growth.

WHAT IS MEANT BY THE TERM "SYSTEMIC CHANGE"?

Given the complex nature of higher education institutions, advancing opportunity for all students in undergraduate STEM education on a large scale and over a long period of time will require efforts that do much more than address a single program or department, policy, or process. It will require systems thinking and systemic change. A systemic change approach goes beyond conceptualizing institutions as isolated or "siloed" programs or departments and, instead, frames the institution's individual units as interconnected ecosystems where participants in these ecosystems are aligned in working toward shared goals. Individual elements of these ecosystems pursue their unique roles in ways that are synergistic with other system elements. Alignment and synergy are key factors in an effective systems change approach to institutional transformation, as is an evolution from being reactive and tactical to being more proactive and strategic. Systems change approaches can help institutions move from enacting repeated temporary "fixes" to pursuing more sustained, strategic changes.

What Key Ideas are Useful to Understand?

The concepts below, which highlight the broad ecosystem that influences student learning, are useful in understanding and discussing how to improve undergraduate STEM education. These concepts appear throughout the modules offered in this collection:

Student-Centered Institutions: An institutional approach that emphasizes what educators and leaders can do to create stronger institutional environments that build on students' strengths and address their needs, in contrast to focusing on what students lack when they arrive. Such institutions understand who their students are, including their characteristics and assets as learners and their experiences within the institutional context, and identify what students need from the institutions to enable them to succeed.

Student-Ready: This term refers to institutional approaches that " shift, from focusing more on what students lack to focusing on what we can do, as educators, to create stronger, higher-quality educational environments" (McNair, et al., 2022, p xiv) that are ready to support the success of the learners who enroll.

STEM Culture: Culture is composed of implicit values and assumptions shared and experienced among those in an organization that manifest in observable ways (Schein, 2010). Academic culture may be observed through an institution's hiring policies, instructional and grading practices, curriculum, non-academic support, recruiting and admission processes, and many other processes and practices that evidence the institution's norms and values. While STEM fields share some common cultural elements, each discipline has its own unique culture that shapes student experience.

STEM Higher Education Ecosystem: The many units within a university or college and the many entities across the nation that interact with and impact higher education (e.g., employers, families, government agencies, and funders) constitute the overall higher education ecosystem.

Systemic Change: A systemic change approach involves recognizing that the university or college is a dynamic organization embedded in a broad ecosystem. This ecosystem involves both the complex internal organization (e.g., students, faculty, staff, and multiple units) and the external environment (e.g., other institutions, employers, funders, government agencies, and accrediting bodies). A systemic change approach requires more than one lever or strategy, employed across the units and organizational levels of the institution, to encourage transformational change.

WHAT CONSTITUTES THE CONTENT OF THE CONVERSATION COLLECTION?

Roundtable members reviewed ideas and resources that emerged from numerous presentations and discussions with experts held from 2017-2024. The conversation modules in this collection highlight key ideas and resources that have emerged as central to the work of improving undergraduate STEM education. They are presented in a format designed to facilitate discussion and use by stakeholders across the higher education community, including administrative leaders and faculty, working to strengthen undergraduate STEM education.

The compilation contains this introductory module (Module 1) and two sets of modules. Together the collection provides conversation modules designed to advance the motivating goal of the Roundtable to connect, inform, and improve undergraduate STEM education across the full spectrum of institutional types.

Introductory Module (Module 1): Using a systems view to improve undergraduate STEM education. This module outlines the goals and purpose of the entire collection, focusing on how a systems view can be applied to improve undergraduate STEM education, and emphasizing the importance of the various elements within the educational ecosystem and their interconnectedness in efforts to drive meaningful change. It also provides information to users about navigating the modules.

Part I: A set of modules that provide an overview of a systems approach to advancing effective and excellent undergraduate STEM education. These modules provide a foundation for understanding core ideas related to strengthening undergraduate STEM education by explaining what key concepts mean and how they can help universities and colleges to meet societal and education needs.

- **Module 2: The ecosystem of undergraduate STEM education and system change.** This module discusses how and why to consider the ecosystem of undergraduate STEM education, recognizing both that higher education institutions are complex and dynamic organizations and that creating systemic change requires understanding and mapping the full ecosystem and finding strategic partners within and external to one's institution.

- **Module 3: Understanding STEM culture.** This module addresses expectations for who is seen as a future scientist/engineer/mathematician, how these learners can be prepared and taught most effectively, and the challenges that can develop as students navigate through the cultures and complex course sequences and prerequisites of the various STEM fields.

- **Module 4: Student-ready institutions.** This module provides an overview of what "student-ready institutions" are (McNair, et al., 2022. It discusses institutional strategies that help educators to know

their students and monitor how they are doing, recognize what students need in order to succeed, and foster policies and practices that provide fertile ground for student success.

Part II: A set of modules that present practical strategies for using the core ideas explained in Part I to strengthen undergraduate STEM education. Each module is tailored to a specific audience in higher education, with practical ideas for leaders and stakeholder groups to use in their efforts to advance systemic change in undergraduate STEM education.

- **Module 5: How institutional leaders can foster systemic change to improve undergraduate STEM education.** This module addresses higher education leaders, with emphasis on presidents, provosts, deans, and center directors, providing strategies they can use to help their institutions take a systemic approach to promote and support change throughout the institution in support of creating more student-ready environments.

- **Module 6: How academic unit leaders can foster systemic change to improve undergraduate STEM education.** This module translates the features of student-ready STEM education to the department level and helps move department administrative and faculty leaders into action through improved understanding of student needs, commitment to building on the assets and strengths students bring to their education, and improvement at the unit level to ensure student-readiness.

GUIDE TO USING THE COLLECTION

This collection is designed to support champions of academic change–that is, the many educators and institutional leaders who care about and support student learning. These champions of academic change include course and laboratory instructions, deans and department chairs, directors of teaching and learning centers, curriculum committee chairs, teaching assistant coordinators, and many others. The modules encourage campus-based, practical discussions among these various groups who are dedicated to supporting today's learners. While each individual module offers useful ideas, the modules can be used as a collection in various ways. Starting with Module 1 will be helpful to all users by providing an orientation to these materials. Some users will want to move in a linear way throughout the set, from start to finish. However, the modules are written and organized to enable users to start with the modules most relevant to their needs. Note also that, while the Roundtable has focused specifically on improving undergraduate STEM education, the modules offer ideas that may be useful in a wide range of disciplines.

If you want to understand more about the nature of the ecosystem in which efforts to strengthen undergraduate STEM education are situated, you will find Module 2 is a good place to start. For more information on STEM culture and how it relates to the student learning experience, see Module 3. Those wanting to consider the concept of "student-ready institution" will find Module 4 to be useful.

If you hold a positional role as an institutional leader, you may want to start with Module 5, which provides information on practical approaches that can be used right away to foster on-campus conversations about making the institution's learning environment more robust, effective, supportive, and sustainable for all students. If you are a department chair, you will find that Module 6 is written specifically to address your needs and questions. It provides guidance for organizing department-level discussions and projects to create more student-ready environments to support students' daily learning experiences.

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REFERENCES CITED IN THIS MODULE

Brown McNair, T., et al. (2022). Becoming a student-ready college: A new culture of leadership for student success. 2nd. Ed. Jossey-Bass.

Schein, E. H. (2010). *Organizational culture and leadership*. John Wiley & Sons.