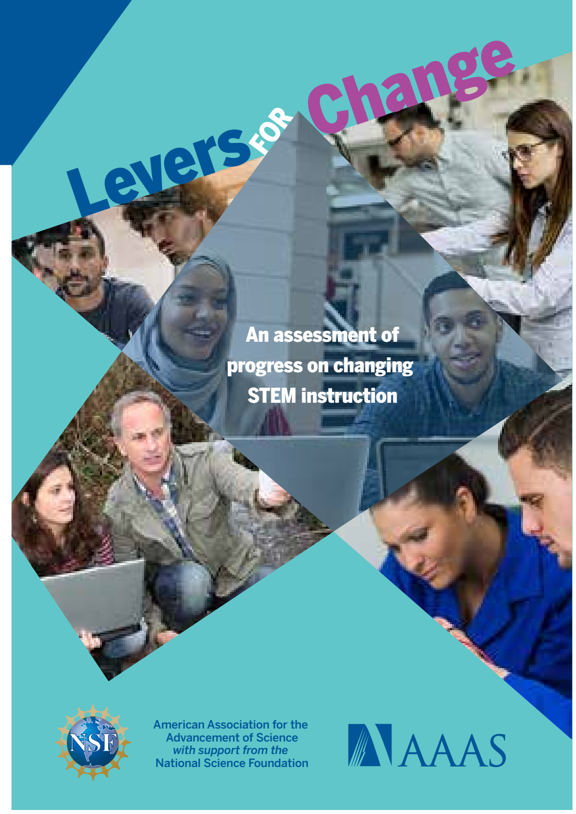
# Levers for Change

## An assessment of progress on changing STEM instruction




A report from AAAS, with support from NSF and HHMI

*Prepared by* Sandra Laursen (University of Colorado Boulder)
*Disciplinary reviews by* Tessa Andrews, Marilyne Stains, Cindy J. Finelli & Maura Borrego, David McConnell, Estrella Johnson, and Kathleen Foote

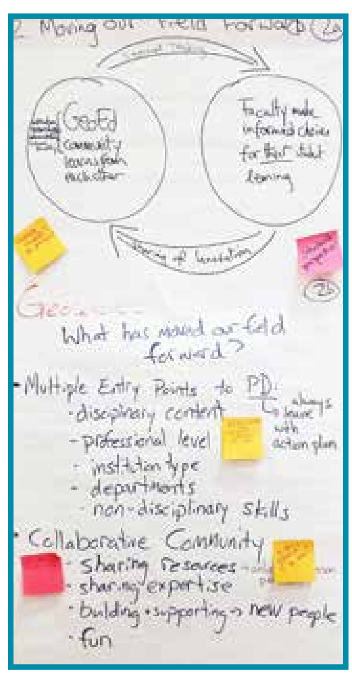
## EXECUTIVE SUMMARY

Education research demonstrates that pedagogical approaches that foster active and collaborative learning can enhance student learning, attitudes, and persistence in science, technology, engineering, and mathematics (STEM) educational paths. Yet most students do not experience these engaging pedagogies, with students from underrepresented groups (e.g., nonwhite racial and ethnic groups and low-income students) least likely to experience these approaches despite being more likely to benefit from them. It is crucial that we learn how to actively lower barriers to and promote instructor adoption of effective evidence-based teaching practices.

We consider this problem in terms of a metaphor — "levers for change." Why levers? In mechanics, a lever is a simple machine used to move an object at one location by applying a force somewhere else. When we try something and see that it is working, we have gained *leverage* on the problem. Here, we consider how systems, structures, and cultures can work as levers to accomplish change in STEM instruction, recognizing the complex and multilevel nature of the environment in which such levers operate.

We set out to assess the state of reform in STEM undergraduate instruction and to identify effective levers for change on STEM undergraduate teaching and learning, both within and across six STEM disciplinary clusters: I **life sciences**; **chemistry and biochemistry**; **engineering and computer science**; **geosciences**; **mathematical sciences, including statistics**; and **physics and astronomy.** We use the term "uptake" to reference the overall degree of instructors' adoption and use of research-based instructional strategies (RBIS) — in other words, the net state of reform toward the sustained use of RBIS rather than the process or situation of any single instructor. We sought scholarship- and community-based answers to the following questions:

- What is the current state of research-based reform in undergraduate instruction within these six clusters of STEM disciplines?
- How did each arrive there? What levers for change — activities, events, influences, movements, groups, documents, contexts — have been important in reaching this state? And how are these levers similar or different for each discipline?
- What provides evidence for these trajectories of change, and why?
- What can be learned from this evidence about how to expand and deepen the impact of these changes in the next decade?




We commissioned scholarly essays by researchers who study instruction and change in each of the six disciplinary clusters. Then, to gather and assess knowledge from practitioners, we convened a working meeting of about 60 people involved in a wide swath of instructional change activities across a diverse array of higher education institutions and professional organizations. We then considered what this current state of STEM instruction suggests about the opportunities for the next decade or two, using what has been learned so far to suggest strategies for the future. By highlighting these

opportunities, we hope the report will be useful for stakeholders in STEM higher education, including researchers, practitioners, and change agents working in institutional, disciplinary, and cross-institutional arenas.

Recognizing STEM field differences, the report generally indicates that:

- Faculty awareness of and use of RBIS in STEM has increased, but uptake of these strategies, including attention to teaching a diverse student population, is not yet widespread.
- Reform in STEM undergraduate assessment lags behind change in other teaching practices. The body of education research that could support planning for undergraduate lab reforms is also less developed, as are the research tools and methods needed to study laboratory learning and experiences.
- Agents of change, local and national faculty professional development, and communities of practice are of high importance in influencing use of RBIS. Important work includes developing and empowering change agents within departments and across the institution and embedding science education faculty who can be informed advocates in STEM schools and departments. In addition, more attention should be given to preparing graduate students and postdoctoral fellows to use RBIS in their current and future teaching.
- Faculty development activities at colleges and universities often address topics about teaching a diverse undergraduate student population, but less attention is paid to infusing practices to support STEM diversity, equity, and inclusion in the everyday operations of departments and the institution.
- To increase the uptake and use of RBIS and attention in these practices to equity and inclusion, cultural changes — including institutional support, departmental changes, rewards, and internal and external policies — are needed.
- Factors that influence use and uptake of STEM RBIS are complex and not fully understood; these include students' reactions to use of these strategies and the time and support that faculty need to effectively implement and become skilled in using RBIS.
- Better approaches are needed to measure the impact of change in undergraduate STEM instruction on students and faculty at all types of institutions.
- STEM professional associations can be key players in promoting the use of RBIS, developing instructional materials, convening experts to synthesize knowledge and findings, providing guiding documents and professional development, and disseminating education research and best practices on teaching via journals and annual meetings.
- Government funding initiatives, guidelines and support have been instrumental in driving the use of RBIS in undergraduate STEM instruction.
- Disciplinary differences in the levers for change reflect variations in cultural norms, educational practices and organizational structures of the disciplines. Such contexts should be considered when assessing whether strategies and approaches from one discipline are useful as levers for change in others.

Each of the levers discussed may be part of an overall change strategy — and none of them is effective alone. If we recognize STEM higher education as a complex system of interlocking parts and subsystems, it is clear that approaches to the uptake problem must be combined strategically. Challenges and opportunities will manifest differently in different parts of the system, and multiple approaches will be needed to exert leverage throughout the system.

The levers for change should address both individual and environmental levels, and they should include a mix of approaches that encourage the use of well-developed practices and involve people in analyzing data, reflecting on their situation, and making decisions collectively.

Taken together, the findings show a sense of accomplishment in progress made and a sense of optimism that further progress is possible. These are coupled with high awareness that the next steps for STEM instruction involve collaborative, multilevel approaches and moving beyond simple propagation strategies of the past that assume methods can be developed and handed off. They reflect an emerging organizational perspective that acknowledges the need for theories of change that address the systems and structures where STEM instructors work as well as the instructors themselves. This perspective will be essential to drive leaders' learning and foster the new types of collaborations needed to infuse equity concepts and classroom strategies into professional development and campus conversations about STEM instruction.

*Executive Summary prepared by*
Sandra Laursen, Yolanda George, and Beth Ruedi