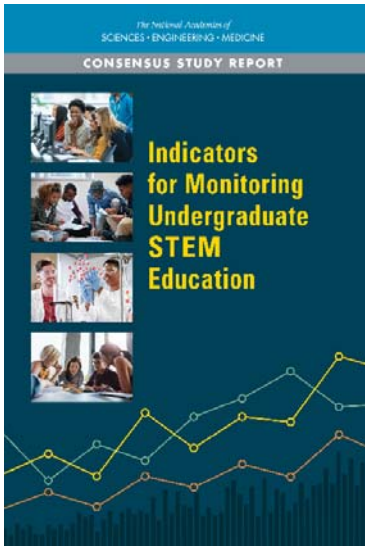
Consensus Study Report

December 2017

HIGHLIGHTS

Indicators for Monitoring Undergraduate STEM Education



Science, technology, engineering and mathematics (STEM) professionals generate a stream of discoveries and innovations that fuel job creation and national economic growth. Undergraduate STEM education prepares these professionals while teaching all students knowledge and skills that are useful across a range of jobs and in civic life.

However, many capable students who intend to major in these fields switch to another field or drop out of higher education altogether—in part because of documented weaknesses in teaching, learning, and supports for students in STEM fields. While various initiatives are now under way to improve the quality of undergraduate STEM education, policy makers and the public do not know whether these initiatives are accomplishing their goals and leading to nationwide progress.

Indicators for Monitoring Undergraduate STEM Education, a report from the National Academies of Sciences, Engineering, and Medicine, identifies a set of national-level indicators to measure the status and quality of undergraduate STEM education over multiple years. The report—which was developed by a study committee of STEM faculty, administrators, education researchers, and economists—also identifies types of data to be collected in order to put the indicators to use, along with possible strategies to gather the data.

GOALS AND OBJECTIVES

As a starting point for its work, the study committee developed a basic model representing undergraduate education as a complex system made up of four interrelated components: inputs, meaning incoming students; processes, which refer to students' educational experiences inside and outside the classroom; outcomes, including mastery of STEM concepts and skills and completion of STEM credentials; and environment, the structural and cultural features of academic departments and institutions.

Using this model as a framework to consider the current status of undergraduate STEM education, the study committee concluded that improving the quality and impact of undergraduate STEM education will require progress toward three overarching goals:

Goal 1: Increase students' mastery of STEM concepts and skills by engaging them in evidence-based STEM educational practices and programs.

Goal 2: Strive for equity, diversity, and inclusion of STEM students and instructors by providing equitable opportunities for access and success.

Goal 3: Ensure adequate numbers of STEM professionals by increasing completion of STEM credentials as needed in different disciplines.

These goals target improvement in various parts of the undergraduate education system and interactions among them in a way that together will enhance students' success in STEM education, whether they are taking general education classes or pursuing a STEM degree. To advance these goals, the committee identified 11 objectives, along with 21 indicators to measure progress toward these objectives. (See table.) The proposed set of 21 indicators is an important first step for monitoring trends over time in the quality of undergraduate STEM education.

DATA FOR THE INDICATOR SYSTEM

The committee reviewed existing data sources and monitoring systems, considering whether they were nationally representative and could provide current data for the proposed indicators. It concluded that—to monitor the status and quality of undergraduate STEM education—federal data systems will need additional data on full-time and part-time students' trajectories across, as well as within, institutions.

Recurring longitudinal surveys of instructors and students are needed as well.

In addition, to monitor progress toward the goal of equity, diversity, and inclusion, national data systems will need to include demographic characteristics beyond gender and race and ethnicity, including at least disability status, first-generation student status, and socioeconomic status.

The committee examined data related to each of the 21 indicators and found that the availability of data for the indicators is limited and new data collection is needed for many of them:

- No data sources are currently available for most of the indicators of engaging students in evidence-based educational practices (Goal 1).
- Various data sources are available for most of the indicators of equity, diversity, and inclusion (Goal 2). However, these sources would need to include more institutions and students to be nationally representative, along with additional data elements on students' fields of study.
- Federal data sources are available for some of the indicators of ensuring adequate numbers of STEM professionals (Goal 3). However, federal surveys would need larger institutional and student samples to allow finer disaggregation of the data by field of study and demographic characteristics.

The indicator system's potential to guide improvement in undergraduate STEM education at the national level can be realized only with new data collection by federal agencies or other organizations. Three options would provide the data needed for the proposed national indicator system:

Option 1: Create a national student-unit record data system, supplemented with expanded surveys of students and instructors. For this option, there are bills pending in Congress to create a national student-unit record data system. In addition, supporting the complete set of indicators also would require regular surveys of students and instructors.

Option 2: Expand current federal surveys of students and instructors. This option would build on the well-developed system of institutional surveys currently used to obtain IPEDS (Integrated Postsecondary Education Data System) data annually from most institutions with new measures of student progress. The expanded IPEDS would be supplemented by data from regular surveys of students and instructors.

Option 3: Develop a nationally representative sample of student-unit record data, supplemented with student and instructor data from proprietary survey organizations. This option, which might be carried out by a federal agency or another entity (for example, a higher education association), would take advantage of the rapid growth of data collection and analysis by institutions, state higher-education systems and education reform consortia across the country.

Goals, Objectives, and Indicators to Monitor Progress in Undergraduate STEM Education

Conceptual Framework	Objective	Indicator
Goal 1: Increase Students' Mastery of STEM Concepts and Skills by Engaging Them in Evidence-Based STEM Educational Practices and Programs		
Process	1.1 Use of evidence-based STEM educational practices both in and outside of classrooms	1.1.1 Use of evidence-based STEM educational practices in course development and delivery 1.1.2 Use of evidence-based STEM educational practices outside the classroom
Environment	1.2 Existence and use of supports that help STEM instructors use evidence-based educational practices	1.2.1 Extent of instructors' involvement in professional development 1.2.2 Availability of support or incentives for evidence-based course development or course redesign
Environment	1.3 An institutional culture that values undergraduate STEM instruction	1.3.1 Use of valid measures of teaching effectiveness 1.3.2 Consideration of evidence-based teaching in personnel decisions by departments and institutions
Process	1.4 Continuous improvement in STEM teaching and learning	No indicators: see "Challenges of Measuring Continuous Improvement" in Chapter 2
Goal 2: Strive for Equity, Diversity, and Inclusion of STEM Students and Instructors by Providing Equitable Opportunities for Access and Success		
Input	2.1 Equity of access to high-quality undergraduate STEM educational programs and experiences	2.1.1 Institutional structures, policies, and practices that strengthen STEM readiness for entering and enrolled college students 2.1.2 Entrance to and persistence in STEM academic programs 2.1.3 Equitable student participation in evidence-based STEM educational practices
Outcome	2.2 Representational diversity among STEM credential earners	2.2.1 Diversity of STEM degree and certificate earners in comparison with diversity of degree and certificate earners in all fields 2.2.2 Diversity of students who transfer from 2- to 4-year STEM programs in comparison with diversity of students in 2-year STEM programs 2.2.3 Time to degree for students in STEM academic programs
Environment	2.3 Representational diversity among STEM instructors	2.3.1 Diversity of STEM instructors in comparison with diversity of STEM graduate degree holders 2.3.2 Diversity of STEM graduate student instructors in comparison with diversity of STEM graduate students
Environment	2.4 Inclusive environments in institutions and STEM departments	2.4.1 Students pursuing STEM credentials feel included and supported in their academic programs and departments 2.4.2 Instructors teaching courses in STEM disciplines feel supported and included in their departments 2.4.3 Institutional practices are culturally responsive, inclusive, and consistent across the institution
Goal 3: Ensure Adequate Numbers of STEM Professionals		
Process	3.1 Foundational preparation for STEM for all students	3.1.1 Completion of foundational courses, including developmental education courses, to ensure STEM program readiness
Process	3.2 Successful navigation into and through STEM programs of study	3.2.1 Retention in STEM programs, course to course and year to year 3.2.2 Transfers from 2- to 4-year STEM programs in comparison with transfers to all 4-year programs
Outcome	3.3 STEM credential attainment	3.3.1 Number of students who attain STEM credentials over time, disaggregated by institution type, transfer status, and demographic characteristics

COMMITTEE ON DEVELOPING INDICATORS FOR UNDERGRADUATE STEM EDUCATION

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For More Information . . . This Consensus Study Report Highlights was prepared by the Board on Science Education based on the Consensus Study Report *Indicators for Monitoring Undergraduate STEM Education* (2018). The study was sponsored by the National Science Foundation. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu/24943.

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