Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways

The skills often acquired in the study of science, technology, engineering, and mathematics (STEM) fields are increasingly needed across the economy, and interest in pursuing degrees in these fields has grown among students, including those from underrepresented groups. However, only about 40 percent of students who start degree programs in STEM fields finish them in 6 years or less. What is driving these low completion rates, and how can they be improved?

A committee of the National Academies of Sciences, Engineering, and Medicine examined whether barriers are preventing students from earning the STEM degrees to which they aspire and identified opportunities to promote the completion of these degrees. The committee's findings are presented in its report *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways* (2016).

The report finds that students pursue STEM degrees using a complex array of pathways that institutional, state, and national policies have not been developed to support. The report recommends ways policy makers and institutions can both learn more about students' varied pathways and better support them in reaching their goals and completing their degrees.

MULTIPLE PATHWAYS, NOT A SINGLE PIPELINE

The path toward a STEM degree is often referred to as the STEM pipeline, which implies a linear path. However, this metaphor does not accurately portray the diverse, complex paths that students take to earn STEM degrees. Students often transfer among institutions, enroll at more than one institution simultaneously, and enter, exit, and re-enter STEM pathways at many phases of their studies.

Moreover, the undergraduates who aspire to earn STEM degrees have changed. The percentage of women and students from underrepresented backgrounds who are interested in STEM degrees has grown. The number of students who have previous work experience, who have taken a semester or more away from college, and who have families is also increasing.

The National Academies of
SCIENCES · ENGINEERING · MEDICINE
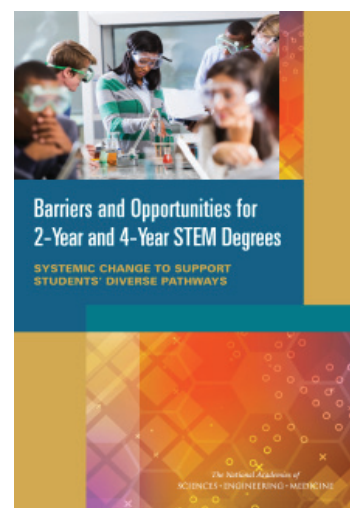
Despite students' growing interest in STEM majors, completion rates for those who aspire to a STEM degree continue to be lower than for students in many other fields. Many barriers can hinder students' successful degree completion, for example:

- Transfer and articulation policies (or lack of these) often slow students' progress to degrees, deter students from transferring, and increase the cost of their undergraduate education.

- Students often pay more for a STEM degree than expected due to tight course sequencing, degree requirements, grading policies, the need for developmental coursework, and the availability of courses.

- The culture of many STEM courses and departments is undergirded by the belief that "natural" ability, gender, or ethnicity is a significant determinant of a student's success in STEM. Related to this view is the tendency for introductory mathematics and science courses to be used as "gatekeeper" or "weeder" courses, which may discourage students from pursuing STEM degrees through highly competitive classrooms and a lack of pedagogy that promotes active participation and emphasizes mastery and improvement.

RECOMMENDATIONS

There is no single approach that will improve the educational outcomes of all who aspire to STEM degreees. Rather, the nature of the challenges of removing the barriers to 2-year and 4-year STEM degree completion can only be addressed by a system of interconnected, evidence-based approaches that create systemic organizational change.

Recommendation 1: Data collection systems should be adjusted to collect information to help departments and institutions better understand the nature of the student populations they serve and the pathways these students take to complete STEM degrees. Currently, many large-scale data systems were built to track students in a pipeline model; they do not account well for the swirling of students among institutions or collect information on students' goals, progress toward a credential, or reasons for leaving or transferring. The limitations of these systems make it difficult for the states and the federal government to understand how the postsecondary education system is serving students.

Recommendation 2: Federal agencies, foundations, and other entities that fund research in undergraduate STEM education should prioritize research to assess whether enrollment mobility in STEM is a response to financial, institutional, individual, or other factors, both individually and collectively, and to improve understanding of how student progress in STEM, in comparison with other disciplines, is affected by enrollment mobility. Many students move across institutions and into and out of STEM programs, and it is often not clear what drives their decisions. Research is needed on how students decide to major (or not) in a STEM field, the factors that attract them to STEM majors, how institutional structures either facilitate or delay their entry into STEM, and to what extent any problems identified may be associated with changing student demographics.

Recommendation 3: Federal agencies, foundations, and other entities that support research in undergraduate STEM education should support studies with multiple methodologies and approaches to better understand the effectiveness of various co-curricular programs. Future research on co-curricular programs—which include internships, summer bridge programs, peer tutoring, and other supports—should reflect the complexity and "messiness" of undergraduate education. Studies should track students over time to assess both the short- and long-term effects of program elements.

Recommendation 4: Institutions, states, and federal policy makers should better align educational policies with the range of education goals of students enrolled in 2-year and 4-year institutions. Policies should account for the fact that many students take more than 6 years to graduate and should reward 2-year and 4-year institutions for their contributions to the educational success of students they serve, which includes not only those who graduate. Undergraduate accountability policies should be revised to take into account the various ways that students are currently using different institutions in pursuit of a degree, certification, or technical skills. At the same time, colleges and universities should shift their institutional policies toward a model in which all students admitted to a degree program are expected to complete that program and are provided the instruction, resources, and support they need to do so, rather than a model in which it

is assumed that a large fraction of students will be unsuccessful and will leave STEM programs.

Recommendation 5: Institutions of higher education, disciplinary societies, foundations, and federal agencies that fund undergraduate education should focus their efforts in a coordinated manner on critical issues to support STEM strategies, programs, and policies that can improve STEM instruction. Colleges and universities should adjust faculty reward systems to better promote high-quality instruction and provide support for faculty to integrate effective teaching strategies into their practice. Disciplinary and professional membership organizations should develop tools to support evidence-based teaching practices and provide professional development in using these practices for new and potential faculty members and instructors.

Recommendation 6: Accrediting agencies, states, and institutions should take steps to support increased alignment of policies that can improve the transfer process for students. Regional accrediting bodies should review student outcomes by participating colleges and require periodic updates of articulation agreements in response to those student outcomes. States should encourage tracking transfer credits and using other metrics to measure the success of students who transfer. Colleges and universities should work with other institutions in their regions to develop articulation agreements and student services that contribute to structured, supportive pathways for students seeking to transfer credits.

Recommendation 7: State and federal agencies and accrediting bodies together should explore the efficacy and tradeoffs of different articulation agreements and transfer policies. There is a need to better understand the efficacy of existing and new models of articulation agreements. Currently it is not clear which types of agreements work for different types of students (including students from underrepresented groups and veterans) and for different types of transfers (vertical, reverse, and lateral).

Recommendation 8: Institutions should consider how expanded and improved co-curricular supports for STEM students can be informed by and integrated into work on more systemic reforms in undergraduate STEM education to more equitably serve their student populations.

To improve degree attainment rates and the quality of programs and to better serve their diverse student populations, institutions can consider a wide range of policies and programs:

- Initiating or increasing opportunities for undergraduate participation in research and other authentic STEM experiences.

- Connecting students to experiences related to careers in their field of interest.

- Expanding the use of educational technologies that have been effective in addressing the remediation needs of students.

- Building student learning communities.

- Providing access to college and career guidance to help students understand the various and most efficient pathways to the degrees and careers they want.

Recommendation 9: Disciplinary departments, institutions, university associations, disciplinary societies, federal agencies, and accrediting bodies should work together to support systemic and long-lasting changes to undergraduate STEM education. For example:

- STEM departments and entire academic units should support learning communities and networks that can help change faculty belief systems and practices and develop sustainable changes. Colleges and universities should offer instructor training and mentoring to graduate students and postdoctoral scholars.

- University associations and organizations should continue to facilitate undergraduate STEM educational reforms in their member institutions, particularly by examining reward structures and barriers to change and by providing resources for data collection and for interventions.

- Federal agencies that support undergraduate STEM education should consider giving greater priority to supporting large-scale transformation strategies that include and extend beyond instructional reform.

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

The nation turns to the National Academies of Sciences, Engineering, and Medicine for independent, objective advice on issues that affect people's lives worldwide.
www.national-academies.org