



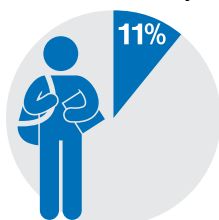
PROGRESS TOWARD ACHIEVING SYSTEMIC CHANGE:

A Five-Year Status Report on the AAU Undergraduate STEM Education Initiative



Association
of American
Universities
Inquiry · Innovation · Impact

A Message from the President



11% of undergraduates
at 4-year institutions

AAU universities educate

1.2 million

Undergraduates

AAU institutions are distinguished for their world-class research and the quality of their graduate education programs. Less recognized and valued is the role AAU universities play in undergraduate education. Yet AAU institutions educate close to 1.2 million undergraduate students every academic year. In educating these undergraduate students, AAU universities have a responsibility to promote the use of evidence-based teaching practices proven by research to be most effective at advancing student success. Additionally, they must provide their faculty members with the encouragement, training, and support to effectively employ these instructional approaches in the classroom. The AAU Undergraduate STEM Education Initiative is a significant test of the degree to which a group of prominent research universities can work collectively with their national organization to improve the quality of teaching in undergraduate STEM courses, especially large introductory and gateway courses, thereby enhancing the learning experiences of many thousands of their undergraduate students.

The results of the Initiative thus far indicate a resoundingly affirmative answer to this test. At the same time, the Initiative has helped AAU understand how it, as a major association of research universities, can help to support meaningful change at various institutional levels to improve undergraduate STEM education. While there is much work to be done to realize a 'new normal' – one characterized by personal and institutional expectations that all faculty members will both use and be rewarded for using evidence-based approaches to instruction – our Initiative suggests that progress is being made.

AAU continues its commitment to achieving widespread systemic change in this area and to promoting excellence in undergraduate education at major research universities. We are now reaching a major tipping point. We cannot condone poor teaching of introductory STEM courses because we are trying to weed out the weaker students in the class or simply because a professor, department and/or institution fails to recognize and accept that there are, in fact, more effective ways to teach. Failing to implement evidence-based teaching practices in the classroom must be viewed as irresponsible, an abrogation of fulfilling our collective mission to ensure that all students who are interested in learning and enrolled in a STEM course – not just those who will choose to major in or pursue an advanced degree in that discipline – are provided with the maximum opportunity to succeed. This change is what is needed to ensure that we have the STEM-literate workforce and general population required to propel the nation forward into the 21st century and beyond.

A handwritten signature in black ink that reads 'Mary Sue Coleman'. The signature is fluid and cursive, with a large, stylized 'M' and 'C'.

Mary Sue Coleman

President

Association of American Universities

Executive Summary

In September 2011, the Association of American Universities launched a major initiative to improve undergraduate STEM education. The overall objective was to influence the culture of STEM departments at AAU institutions so that faculty members are encouraged and supported to use teaching practices proven by research to be effective in engaging students in STEM education and in helping students learn.

The Undergraduate STEM Education Initiative's intent was to help research universities better assess and improve the quality of teaching in STEM fields by: promoting the use of teaching techniques in STEM classes demonstrated by scholarship to be the most effective at engaging and helping students learn; encouraging universities and STEM departments to better evaluate, recognize and reward faculty members for the quality and effectiveness of their teaching; and facilitate the creation of an effective network for disseminating and sharing best practices in undergraduate STEM education reform and classroom based educational improvements.

AAU's Initiative was not launched with the intention of producing yet another report. Instead, its aim was to encourage and support research universities to act upon and implement recommendations already made in national reports.^{1, 2} The initiative was, in some sense, an experiment to see if as a leading association of research universities, AAU could facilitate meaningful and long-lasting systemic change in undergraduate STEM education by providing its members with a framework accompanied by additional tools, support, and encouragement.

To help with this effort, AAU established a project team and convened an advisory committee composed of experts in undergraduate STEM teaching and learning. It also established five overarching goals for the initiative:

1. **Develop an effective analytical framework for assessing and improving the quality of STEM teaching and learning, particularly in the first two years of college.**

1 President's Council of Advisors on Science and Technology (PCAST), [Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics](#) (Washington, DC: PCAST, 2012).

2 National Research Council (NRC), [Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering](#) (Washington, DC: National Academies Press, 2012).

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2. Support AAU STEM project sites at a subset of AAU universities to implement the Framework, and develop a broader network of AAU universities committed to implementing STEM teaching and learning reforms.
 3. Explore means that institutions and departments can use to train, recognize, and reward faculty members who want to improve the quality and effectiveness of their STEM teaching.
 4. Work with federal research agencies to develop means of recognizing, rewarding and promoting efforts to improve undergraduate learning.
 5. Develop effective means for sharing information about promising and effective undergraduate STEM education programs, approaches, methods, and pedagogies.

Since the Initiative was launched, AAU has received 11 grants (\$7.9M) from private and corporate foundations and the federal government to advance the Initiative. *Progress Toward Achieving Systemic Change* provides a five-year status report on the AAU Undergraduate STEM Education Initiative.



Engagement by AAU Universities

AAU universities have demonstrated widespread enthusiasm and interest in the Initiative.

Participation in the Initiative by AAU member institutions has been high. This is demonstrated by the fact that all 62 AAU institutions have designated a STEM Campus Point of Contact to serve as a liaison between AAU and his or her campus for the Initiative.

- To date, 55 AAU member universities have participated in the Initiative, including more than 450 unique faculty members and institutional leaders.
- 42 institutions convened campus stakeholders (e.g., faculty members and administrators) to respond to our request for comments on the initial Framework draft.
- Over half of AAU's membership is active in the AAU STEM Network and more than 275 unique faculty members and institutional leaders have participated in network events.
- 31 institutions submitted proposals to be considered as a STEM Project Site and to receive STEM Network Mini-grants.

AAU universities are engaged in multiple innovative efforts to improve undergraduate education and to help all students succeed. For example,

- department-wide innovations to undergraduate STEM courses are becoming institutional priorities;
- teaching and learning centers are being redesigned to better support department educational reform efforts;

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- data infrastructures and analytics are being capitalized on to improve student learning;
 - campuses are exploring new hiring practices to advance improvements in STEM education;
 - learning spaces are being developed and re-engineered; and
 - campuses are addressing the critical challenge of improving the evaluation of faculty teaching.



AAU STEM Project Sites

Central to the project site reforms was the role of the academic department and its faculty members.

Seed-funding was awarded to eight AAU member project sites (Brown University; Michigan State University; The University of Arizona; University of California, Davis; University of Colorado Boulder; University of North Carolina at Chapel Hill; University of Pennsylvania; and Washington University in St. Louis) to implement reforms that address the core elements of the Framework and specific challenges facing their campus in undergraduate STEM education.

- Over three academic years the eight STEM Project Sites have engaged 39 departments, reformed 162 courses, involved 230 faculty members and 1,676 learning assistants (graduate and undergraduate), and transformed STEM courses for 138,531 student-seats.
- Project sites reported trends toward improved learning gains, decreased failure rates, improved persistence from introductory to later courses, and narrowing achievement gaps especially for women, under-represented minorities, and first-generation college students.
- All project sites increased the number of courses targeted for reform based on evidence-based pedagogy, and increased the number of faculty members (tenure-track and non-tenure track) participating. One-half of project sites expanded their reach to additional departments which were not originally included in their proposals. One-half of project sites developed and disseminated common tools used to assess teaching and instruction. Additionally, several project sites linked co-curricular activities with reformed courses to increase retention in STEM majors.
- Across the eight project sites, use of graduate and undergraduate assistants in active learning classes more than doubled, from 740 to 1,676, during the three years of the AAU project. Inclusion of undergraduate and graduate students in instructional roles has benefits for institutions at the level of the course or section. With more trained individuals in the room, the capacity to facilitate and evaluate evidence-based pedagogy increases. The experience also benefits the students themselves by reinforcing core concepts and helping them to learn effective teaching practices.



Examining the Impact

Evaluation is a key component of the Initiative.

AAU is assisting member universities in tracking the progress of their reform efforts in addition to evaluating the overall impact of the STEM Initiative.

- To document cross-institutional effects, AAU collected data from all project sites over a three-and-a-half-year period. Common data collection included a survey of instructor attitudes and practices in participating departments; department chair narratives on policy and practice to assess teaching in the promotion and tenure process; and campus and department level assessment of learning spaces. Findings are presented on pages 60-61, 82-83, 89.
- AAU collected annual reports and conducted two site visits at each of the eight project sites to allow for a more qualitative evaluation of project implementation and progress. In total, AAU met and talked with 325 individuals across the eight project sites. Information from site visits, common data collection, and project site reports are among the sources used to provide much of the detailed analysis found in Section 2.
- In partnership with Adrianna Kezar, Professor, Rossier School of Education and Co-Director, Pullias Center for Higher Education at the University of Southern California, AAU has examined the role that a national higher education association can play in promoting and scaling systemic institutional reforms in undergraduate teaching and learning. A summary of the project is on pages 124-125.



Progress Toward Institutional Change

AAU universities are successfully implementing strategies to achieve long-lasting improvements in undergraduate STEM teaching and learning.

Based upon a comprehensive review of the undergraduate STEM education reforms occurring at AAU universities, we found the following key elements at various institutional levels to be important factors in improving the quality and effectiveness of undergraduate STEM teaching and learning.

- **Shift from individual to collective responsibility by departments for introductory course curriculum.** AAU has observed that departments most likely to emphasize evidence-based active-learning strategies in foundational courses have thought deeply about the curricula and content of these courses, along with ways to assess student learning. Ultimately, collective responsibility for shared learning objectives by course will necessitate developing a uniform vision of educational improvement among faculty members within and across departments, as well as the development of mechanisms to assess progress in teaching effectiveness for all students.
- **Hire educational experts within departments to bolster reforms.** One strategy to successfully institutionalize reform is to embed instructional expertise within the department to provide educational leadership and to support

all faculty members in the adoption and use of evidence-based pedagogy. Although the types of appointments of individuals with this type of expertise vary widely (e.g., tenure-track, non-tenure track, junior and senior ranks), these individuals all have in common an understanding of the discipline and how students learn best within the discipline. When used most effectively, these individuals are well positioned to provide educational leadership to the department.

- **Harness institution-wide data to support student learning.** Research universities can greatly facilitate STEM education improvement by supporting the development and use of institution-wide data and analytical tools on student instruction and learning outcomes. Keys to successful use of data analytics include: 1) distinguishing between the types of data useful for individual faculty members designing and assessing their courses and the types of data used in departmental decision-making; 2) the ease and efficiency of use are essential to broad acceptance of teaching-related metrics; and 3) data should not be seen as sufficient in their own right but must be used to help make decisions and establish policies aimed at advancing educational improvement.
- **Reorganize administrative support services to better support departmental reform efforts.** Another key to successful institutionalization of undergraduate instructional reforms is to align relevant administrative units, such as Centers for Teaching and Learning, with department-based instructional improvement efforts. Providing college or campus-wide structures to support departmental reform efforts increased the likelihood of institutionalization in AAU project sites.
- **Develop and re-engineer learning spaces.** Creating collaborative learning spaces to support evidence-based pedagogy has been a catalyst for faculty members to reflect on how they teach their courses. Students have also attributed learning gains to classroom environments that foster engagement and interaction.
- **Better manage the simultaneous pursuit of high quality teaching and research.** The development and use of more effective ways to evaluate teaching quality and effectiveness in the faculty reward structures will be required to institutionalize STEM educational reforms.
- **Commit to systemic and long-term STEM reforms.** Institutionalizing reforms of undergraduate STEM education at research universities eventually requires internal institutional investment and alignment of resources; it cannot be achieved solely by a series of isolated externally-funded grants. Public pronouncements of support for these undergraduate reforms by university leaders also contributes to the spread of instructional reforms across departments. Without further institutional commitment, however, such pronouncements fail in achieving meaningful and long lasting reform.

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- **Leverage AAU to advance educational reforms and institutional change.** AAU involvement has symbolic implications that can help campuses achieve cultural and institutional change by providing legitimacy to STEM education reform efforts.



Resources for Universities

AAU has developed resources to help research universities take a systems perspective to improving undergraduate STEM education.

To help facilitate institutional change, key resources and tools have been developed. These include:

- The *Framework for Systemic Change in Undergraduate STEM Teaching and Learning* provides a change model for improving the quality and effectiveness of STEM teaching and learning at research universities.³ The Framework recognizes the wider setting in which educational innovations take place — the department, the college, the university and the external environment — and addresses key institutional elements necessary for sustained improvement to undergraduate STEM education.
- *Essential Questions and Data Sources for Continuous Improvement of Undergraduate STEM Teaching and Learning* helps member campuses track the progress of their reform efforts.⁴ This resource complements the Framework and provides a set of key questions designed to engage institutional leaders and faculty members in discussions about teaching and learning. The report also provides data sources and analytical tools available to answer these questions and inform decision-making, as well as provides guidance to address common challenges in evaluating the quality and effectiveness of undergraduate education.
- *Aligning Practice to Policies* provides specific guidance to departments and institutions on how to implement new methods for evaluating, recognizing, and rewarding teaching at research universities, particularly relating to how teaching is judged for purposes of promotion, tenure, and annual reviews.⁵ This resource was developed in collaboration with the Cottrell Scholars funded by Research Corporation for Science Advancement.

³ Association of American Universities (AAU), [Framework for Systemic Change in Undergraduate STEM Teaching and Learning](#) (Washington, DC: AAU, 2013).

⁴ Association of American Universities (AAU), [Essential Questions and Data Sources for Continuous Improvement of Undergraduate STEM Teaching and Learning](#) (Washington, DC: AAU, 2017).

⁵ Association of American Universities (AAU), [Aligning Practice to Policies: Changing the Culture to Recognize and Reward Teaching at Research Universities](#) (Washington, DC: AAU, 2017).



Sustaining the Momentum

AAU is committed to improving STEM education at research universities.

AAU leadership has committed to extend the initial five-year undergraduate STEM effort indefinitely by integrating continued support for undergraduate STEM education reform and improvement into its ongoing staffing structure and portfolio of work. AAU will also look to broaden its efforts to improve undergraduate instruction beyond STEM fields in the future.

- A major award provided an additional 24 AAU universities with institutional mini-grants to further advance and coordinate existing efforts aimed at improving undergraduate STEM teaching and learning.
- AAU actively engages a broader network of faculty members and administrators at AAU universities committed to improving undergraduate STEM teaching and learning. The AAU Undergraduate STEM Education Network has convened conferences annually to discuss innovative practices to improve STEM education and hosted a variety of targeted workshops to address critical issues. A workshop, convened by AAU, brought together STEM department chairs from AAU universities to share information about and discuss improving STEM teaching within their departments and recognizing and rewarding faculty members for the quality and effectiveness of their teaching. Moving forward AAU will convene the AAU Undergraduate STEM Education Network and STEM Department Chairs on alternating years.
- AAU will continue to collaborate with other national associations, organizations, funders, and industry partners to coordinate activities relating to undergraduate STEM reform and to develop effective means to disseminate promising and effective programs, approaches, methods, and strategies. The Initiative is engaging multiple stakeholders to promote long-lasting reform to undergraduate STEM education and working to address the cultural and policy barriers within research universities that hamper educational improvement and innovation.
- In partnership with federal agencies, AAU is finding new ways to engage faculty members to broaden the impact of their research by becoming more innovative in the classroom, teaching more effectively, and providing for authentic research experiences to undergraduate students.
- An ongoing examination of how universities can successfully coordinate multiple undergraduate STEM education reforms to achieve sustainable change is underway. This project is designed in recognition of the reality that many AAU universities are advancing multiple department-level as well as institution-wide efforts to improve undergraduate STEM teaching and learning. ■