ESSENTIAL QUESTIONS & DATA SOURCES

FOR CONTINUOUS IMPROVEMENT OF UNDERGRADUATE STEM TEACHING AND LEARNING

Association of American Universities

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Essential Questions & Data Sources for Continuous Improvement of Undergraduate STEM Teaching and Learning is intended to be a useful resource for the individuals and institutions who work together to help foster continuous improvement of undergraduate STEM education. Informed by the broad literature on post-secondary STEM education, this resource draws primarily from the Association of American Universities' experience in implementing the AAU Undergraduate STEM Education Initiative with our member campuses. It provides a set of questions that can be used at multiple levels within the university to assess progress along the set of key institutional elements identified in AAU's ***Framework for Systemic Change in Undergraduate STEM Teaching and Learning***. Questions are presented to examine the pedagogical, scaffolding, and cultural elements of the framework at each organizational level in the institution. Data sources and analytical tools available to answer these questions are profiled in a subsequent section. A final section provides guidance to address cross-cutting challenges to assessing improvement of undergraduate STEM teaching and learning.

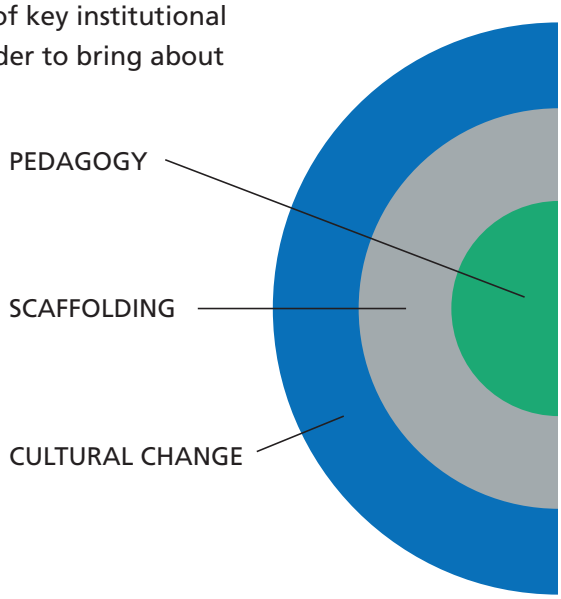
Through reflecting on these key questions, institutions can engage in deep discussions about undergraduate education; aggregate individual and program-level data to obtain an institutional portrait; and identify cross-cutting teaching and learning issues. Strong measures and indicators provide a foundation to advance larger cross-department, -college, -institution and potentially multi-institutional conversations among faculty members and institutional leaders, and to inform decision-making about reforms in undergraduate STEM education.

Essential Questions identifies key questions institutions can use to:

- engage institutional leaders and faculty members in discussions about teaching and learning;
- establish strong measures of teaching effectiveness both to describe program performance and to incorporate in meaningful ways into faculty reward structures;
- ensure quality and inclusive educational experiences for all students across all programs;
- support the development or redesign of learning spaces; and
- demonstrate the institution's commitment to the importance of evidence-based, student centered teaching to faculty members, students, and other relevant internal and external audiences.

FRAMEWORK ELEMENTS

The Framework for Systemic Change in Undergraduate STEM Teaching and Learning, developed as part of AAU's Undergraduate STEM Education Initiative, provides a set of key institutional elements that need to be addressed in order to bring about sustainable change.



Pedagogy	Scaffolding	Cultural Change
Articulated Learning Goals	Provide Faculty Professional Development	Leadership Commitment
Educational Practices	Provide Faculty with Easily Accessible Resources	Establish Strong Measures of Teaching Excellence
Assessment	Collect and Share Data on Program Performance	
Access	Facilities and Learning Spaces	Align Incentives with Expectation of Teaching Excellence

PEDAGOGY

SCAFFOLDING

CULTURAL CHANGE

ESSENTIAL QUESTIONS

INSTITUTIONS

- **Which schools/colleges and departments at the institution make the most use of evidence-based pedagogical educational practices? How are they being rewarded? How are other departments encouraged to follow their lead?**
- **What is being done across schools and departments to ensure that all students are succeeding? Are measures of student success disaggregated demographically? How are improvements reflected in data over time?**
- **What measures does the institution use to assess student progression/retention/completion and other relevant factors? How often do top institutional leaders look at these data and discuss them with deans, department chairs, students, and others?**
- **How are needs to support the use of evidence-based pedagogy, as well as projected future enrollments and demographics, factored into facilities planning (e.g., learning spaces) at the institutional level?**
- **What expectations have top institutional leaders articulated for each school/college and department to develop measures of evidence-based teaching beyond student evaluations?**
- **How are measures of teaching excellence included in a meaningful way in annual/merit review, promotion, and tenure processes for all instructors at the institution?**

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CULTURAL CHANGE

SCHOOLS/COLLEGES

- How has the school/college assured that all departments have made dedicated efforts to define core competencies and skills and to connect these outcomes to learning goals?
- How much do departments within the school/college vary in the amount of time instructors are spending on various kinds of activities in the classroom? Is there a relationship between these activities and student success?
- How well are students doing in their progression/retention/completion in STEM courses? How does this success rate compare across groups, over time, and with similar programs at peer institutions? How do the progression/retention/completion rates for students broken out by relevant demographic categories vary between departments and with peer institutions?
- What resources support instructional improvements and what effects do these efforts have on reducing the gap in student achievement across demographic groups? What is the relationship between student achievement data and instructional practices, and how can these data further inform changes in instructional practices?
- In what ways do deans use data on student progression/retention/completion to inform discussions with department chairs and instructors to facilitate program improvement?
- How do deans make clear that they expect evidence-based pedagogy from potential new faculty hires?

PEDAGOGY

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DEPARTMENTS

- **Do all of the courses in the department have articulated learning goals, and are these made clear to students? What process exists to ensure that individual course learning goals connect to learning goals for the program, major, and department?**
- **What are the demographics of students in the department? What are the progression/retention/completion rates for students in the department or major broken out by relevant demographic categories? How do these compare with other departments and what steps are being taken to improve these rates?**
- **What actions has the department chair taken to encourage instructors to take advantage of both on-campus and off-campus (e.g., through relevant disciplinary societies) resources and professional development related to pedagogy? How many instructors have taken advantage of these resources and what notable improvements have occurred as the result?**
- **What resources are available to instructors in the department for encouraging all students to succeed, and what steps have been taken to ensure all instructors take advantage of these resources?**
- **To what extent do departmental instructors have access to learning spaces that support evidence-based pedagogy? What training in the use of those facilities is available to instructors in the department?**
- **What is the department chair's and distinguished faculty members' support of evidence-based pedagogy? How well-known is this support to instructors and students?**
- **What are the biggest barriers to evidence-based pedagogy for instructors in the department and how is the chair working to address them? How often does the chair discuss these issues with the dean or other institutional leaders?**
- **How are all faculty who participate in annual/merit, promotion, and tenure evaluations educated about the meaningful inclusion of measures of teaching excellence in those processes? How closely does the chair review the outcomes of those processes to ensure teaching is indeed meaningfully included?**

PEDAGOGY

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CULTURAL CHANGE

COURSE LEVEL

- Are learning goals clearly stated on the syllabus? To what extent do students in the class understand the course learning goals? What steps has the instructor taken to ensure that class activities and assignments are linked to learning goals?
- How much time does the instructor spend on various kinds of activities in the classroom? How are these activities assessed?
- To what extent does the instructor understand the biases he/she may bring to the classroom, and what steps has the instructor taken to mitigate these to ensure that all students are succeeding?
- To what extent does the instructor take advantage of both on-campus and off-campus resources and professional development related to pedagogy?
- To what extent does the instructor participate in discussions about using data to help drive program improvement? To what extent are they aware of data about their students and courses?
- Does the instructor believe that meaningful measures of teaching will factor into their own performance, promotion, and tenure reviews? If so, do they have a clear understanding of how teaching fits into the overall review process? How frequently are these measures discussed with peers and those who will be evaluating performance?

DATA SOURCES & ANALYTICAL TOOLS

The following is a list of established and emerging data sources and analytical tools. This is a rapidly changing landscape, and new means are being developed to answer the questions we've identified. For a current list of analytical tools visit www.aau.edu/stem.

INSTITUTIONAL DATA & VISUALIZATIONS: Institutions possess a wealth of data on students and their performance that may be used to help understand and improve teaching and learning. New visualization tools can help reveal patterns in data and may be useful for driving discussion and decision-making at multiple levels within an institution. Visualizations can also be a mechanism for increasing access to data. Some data concerning student demographics, student performance, and retention/progression/completion can be found in national data sets.

- Integrated Postsecondary Education Data System (IPEDS)
- Educational Analytics at Center for Educational Effectiveness at University of California Davis
  - Curriculum flow and student progression
  - Learner profiles (e.g. "Know Your Students" / "Know Your Class Infographics")
  - Departmental Diagnostic Dashboard
- Student Learning and Analytics at Michigan (SLAM)
- Data Analytics to Study Student Pathways and Outcomes (DASSEE) at University of Colorado Boulder
- Digital Innovation Greenhouse at the University of Michigan
  - Ecoach—Personalized Messaging to Students
- Institute for Research on Innovation & Science
  - Pilot work to integrate information on all enrolled students with Census data open the possibility of comprehensive analysis and reporting on career outcomes for students at all levels.

OBSERVATION PROTOCOLS: Observation protocols are especially relevant to understanding classroom behavior of instructors and the effects on student behavior and learning.

- Classroom Observation Protocol for Undergraduate STEM (COPUS)
- Generalized Observation & Reflection Protocol (GORP)
- Observing Patterns of Adaptive Learning (OPAL)
- Observation Protocol for Learning Environments (OPLE)
- Reformed Teaching Observation Protocol (RTOP)
- 3D Learning Observation Protocol (3D LOP)

RUBRICS: Rubrics can help institutions, schools, departments, and instructors assess their own progress across a range of relevant areas.

- Department Evaluation of Faculty Teaching Rubric at University of Kansas
- Liberal Education and America's Promise (LEAP) Initiative VALUE Rubrics
- Partnership for Undergraduate Life Science (PULSE) Rubric

FRAMEWORKS: Frameworks provide individual institutions and groups of institutions a shared model and common approach to advance a cycle of continuous and systemic improvement.

- AAU Framework for Systemic Change in Undergraduate STEM Education
- Bayview Alliance Driver Diagram
- Increasing Student Success in STEM: A Guide to Systemic Institutional Change
- Science Math Teaching Imperative (SMTI) Framework
- StratEGIC Toolkit
- Towards a Framework for Assessing and Promoting Teaching Quality at CU-Boulder

STUDENT LEARNING ASSESSMENTS: Assessments of various kinds help to quantify student learning.

- Concept inventories developed by disciplinary societies
- Individual course assessments
- Student Assessment of their Learning Gains

SURVEYS: Surveys are useful to understand the attitudes, practices, opinions, and perceptions of both instructors and students. Institutions already use a range of surveys, both internal and external. Many also provide information that may aid in promoting change.

- AAU Survey of Instructor Practices
- Bay View Alliance Driver (BVA) Teaching Practice Survey
- Consortium on Financing Higher Education (COFHE)
- Describing Instructional Practice and Climate: Two New Instruments
- Higher Education Research Institute (HERI) Freshman Survey
- National Survey of Student Engagement (NSSE)
- Project Ownership Survey
- Student Experience in the Research University (SERU) Survey
- Teaching Practices Inventory

ADDRESSING CROSS-CUTTING CHALLENGES

Efforts to assess the quality of undergraduate teaching and learning face several types of challenges, including the collection of data, variations in the ways universities have organized student data, as well as the rules and regulations on data governance, stewardship, sharing, and use. This section highlights several of the identified challenges and provides guidance for and examples of moving conversations about measuring teaching and learning forward. Ultimately, documenting institution-level effects of STEM education reforms requires finding "ways to defuse the potential conflict between locally useful classroom-level information and broader measures of program effects."[1]

- Each campus organizes data collection differently, including the location where data reside. Aggregating and joining data sets that are managed by different units within an institution may be challenging for technical, political, and institutional reasons. Particular types of information are also subject to different levels of restriction in terms of sharing and use (e.g., financial aid data versus academic performance data). Although the development of a single model for organizing data is unlikely, the partitioning of data sets in idiosyncratic ways is counterproductive to effective institutional decision-making, and makes cross-institutional comparisons much more difficult. Campuses have recognized this difficulty, and it would be advantageous for campuses to explore new ways to link data sets to support timely decision-making that benefits the institution while still protecting privacy.

  For example, the Student Data Matching Tool under development by the CREATE for STEM Institute at Michigan State University aggregates data and provides an interface for asking how a "treatment" (such as an undergraduate research experience) affects an outcome variable (such as graduating GPA) when students are matched on certain factors (e.g., Pell eligibility, race/ethnicity, gender).

1 Fairweather, J., Trapani, J., and Paulsen, K. (2015). The roles of data in promoting institutional commitment to undergraduate STEM reform: The AAU STEM Initiative experience. In *Transforming institutions: 21st century undergraduate STEM education*, ed. G. Weaver. West Lafayette, IN: Purdue University Press.

- The development of common data definitions, standards, formats, and methodologies to the extent possible by the community would greatly facilitate sharing, aggregation, and comparison of data. On many campuses there is a reluctance to adopt wholesale tools and techniques developed elsewhere. Custom-designed assessment tools can generate local buy-in for the purposes of educational reforms but can make even cross-college or department comparisons within a campus difficult. One goal of *Essential Questions & Data Sources* is to develop guiding principles to allow for meaningful sharing and comparisons within and across universities. Even agreeing on common file formats for data when using similar tools could be an important step forward.

  - BIG Academic Alliance
  - Association of American Universities Data Exchange (AAUDE) common data definitions
  - Common Education Data Standards (CEDS) developed by the U.S. Department of Education

- Researchers and academic administrators should be clear about the kinds of analysis they seek to perform with institutional and student data, and distinguish research, evaluation, and assessment. Although these distinctions are sometimes nuanced, often they are more generic. Using some type of common definitions and formats can help institutions develop consistent guidelines for how to respond to different types of data requests.

  - One useful framework has been put together by the University of Wisconsin. It distinguishes academic research, institutional research, program evaluation, and student learning assessment based on criteria such as intent, funding source, performer, type of data used, and publication and dissemination of results. Such a framework can intersect with campus data governance models to help institutions become more systematic in how data are shared with researchers and academic administrators.

- Institutional Review Board (IRB) roles and oversights differ among campuses. To the degree possible, campuses should find ways to allow IRBs to expedite review of studies that seek to improve educational performance using de-identified campus based student data for research, evaluation, and assessment purposes.

- Much mythology has sprung up around FERPA, the Family Educational Rights and Privacy Act, which sets guidelines for protecting the privacy of student education records. FERPA is often invoked as a reason to prohibit sharing of information. Limitations in data sharing as the result of FERPA should be clarified and made consistent within, and to the extent possible between, institutions. Adhering to FERPA guidelines need not mean over-compliance.

    - In collaboration with the U.S. Census Bureau and the Universities of California, Michigan, and Texas, Institute for Research on Innovation & Science (IRIS) is conducting a pilot project to effectively link, rigorously analyze, and responsibly share data on student career outcomes and instruction that are derived from a variety of restricted administrative records. The membership FAQ and MOU address many questions related to data protection and sharing.

- Researchers and academic administrators attempting to provide key information to institutional decision-makers are often unable to carry out this task because individual-level data are often separately housed on campus. De-identifying partitioned data sets would make within-institution (including cross-college and cross-department) analyses possible. Campuses might experiment with tactics for de-identification that preserve privacy while minimizing issues of campus jurisdictions in terms of questions that can be asked and answered with campus data.

- The measurement of student learning and related outcomes to assess institutional level performance is rapidly evolving. Many metrics and measures are in a nascent stage. Institutions can help lead the charge on developing and sharing information. Sharing across institutions for internal benchmarking purposes is helpful to foster change. From the perspective of AAU, a higher education association that works with federal policymakers, aggregations of data across institutions can be useful for documenting impact, but institutional and personal anonymity must be maintained.

RESOURCES

A Visual Approach to Helping Instructors Integrate, Document, and Refine Active Learning

American Association for the Advancement of Science: Describing & Measuring Undergraduate STEM Teaching Practices

Facilitating Innovation in Science Education through Assessment Reform

Committee Discussion Document for the National Academy of Sciences Board on Higher Education & Workforce Quality in the Undergraduate Experience, December 4, 2015.

Developing Institutional Learning Analytics 'Communities of Transformation' to Support Student Success

This report is based upon work supported by the National Science Foundation under Grant No. DUE WIDER – 1256221 "Metrics to Shift Institutional Culture Towards Evidence-based Instructional Practices."