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Indicators for Monitoring Undergraduate STEM Education

Report Overview for the
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Committee Charge

- Identify objectives for improving undergraduate STEM education
- Outline a framework and set of indicators to document the status and quality of undergraduate STEM education at the national level over multiple years
- Phase 1: Identify objectives and a conceptual framework for the indicator system; review data sources and monitoring systems; release interim report for public comment
- Phase II: Develop indicators of the status of the objectives; identify measures and the feasibility of including them in existing data collections; discuss research needed to fully develop the indicators

Committee Members

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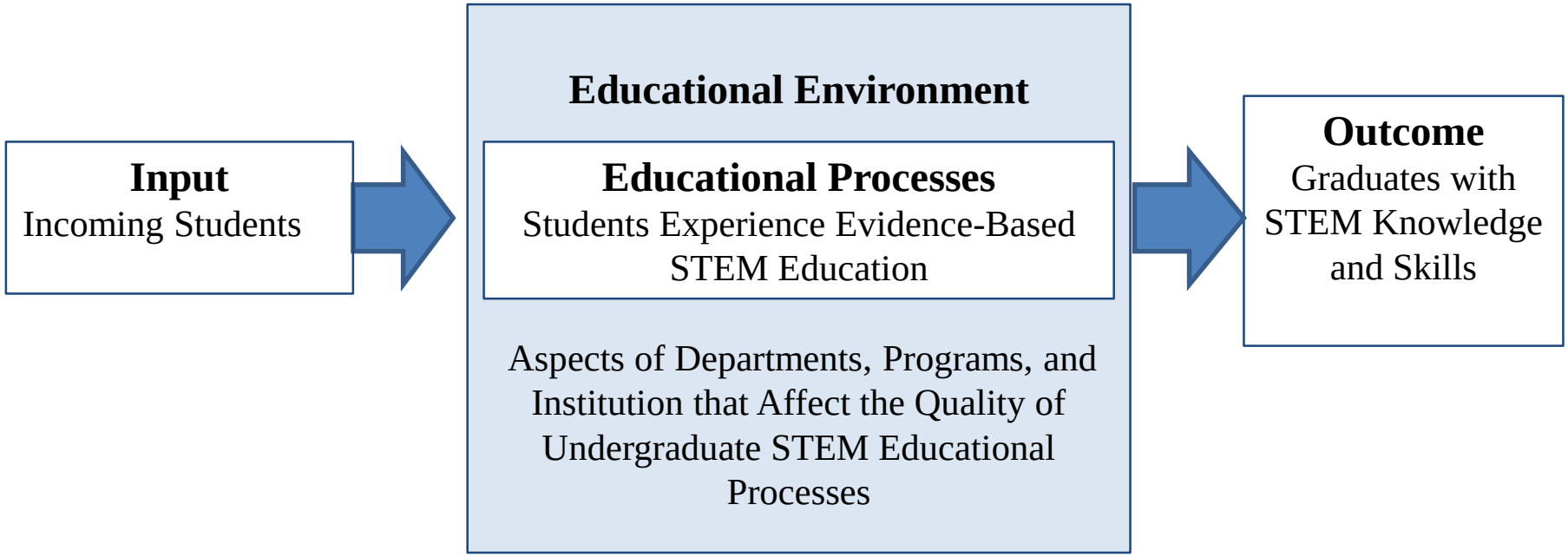
Conceptual Framework

Societal Context: Global Competition, Increasingly Diverse Students, Accountability Pressures, Changing Technology (outside the basic framework)



Summary

2 phases

1 vision

6 conclusions

3 goals

11 objectives

21 indicators

Vision

All Students would…

- Have access to and exposure to high-quality STEM education to support development of STEM literacy
- Have the STEM background to address global, societal, economic and technological challenges
- Have the STEM background to be successful in the careers of today as well as those of tomorrow

Conclusion 1: Goals

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 the different disciplines.

Why Measure Educational Practices instead of Learned Concepts and Skills?

- The goal is student mastery of STEM concepts and skills.
  - Educational practices serve as a proxy, backed by research
- Difficult to measure directly at the *national* level and across disciplines
  - what key concepts and skills would be tested?
  - key concepts and standardized tests exist for some disciplines.
  - National standardized tests incompatible with U.S. system of higher education.
- As science advances, new concepts emerge.

What are Evidence-based Educational Practices?

- Practices meeting at least one of the following:
  - The preponderance of published literature suggests that it will be effective.
  - The practice is built explicitly from accepted theories of teaching and learning *and* is faithful to best practices of implementation.
  - The practice has locally collected, valid, and reliable evidence based on a sound methodological research approach that suggests it is effective.

Examples of Evidence-based Practices Inside the Classroom

- Peer instruction
- Problem-based Learning
- Collaborative problem-solving
- Service learning
- Active learning that cognitively engages students
- Formative assessment with rapid feedback

Examples of Evidence-based Practices Outside the Classroom

- Internships
- Living-learning Communities
- Undergraduate Research (can also be "inside" the classroom)
- Mentoring and Advising
- Peer Tutoring
- Summer Bridge programs

Objectives for Goal 1: Increase Mastery of STEM Concepts and Skills

1.1 Use of evidence-based STEM educational practices inside and outside the classroom [process]

1.2 Existence and use of supports that help STEM instructors use evidence-based educational practices [environment]

1.3 An institutional culture that values undergraduate STEM instruction [environment]

1.4 Continuous improvement in STEM teaching and learning [process]

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Why strive for Equity, Diversity, and Inclusion?

To ensure that the undergraduate STEM educational system meets the needs of the nation and serves all people

- To be considered ***equitable***, institutions would provide all students with adequate support to enter, persist and successfully complete STEM coursework or degrees.
- To be considered ***diverse***, the pool of students participating and succeeding in STEM education would be representative of the demographics of the US college student population
- To be ***inclusive***, STEM learning environments would effectively engage and educate diverse learners and educators.

Objectives for Goal 2: Strive for Equity, Diversity, and Inclusion

- 2.1 Equity of access to high-quality undergraduate STEM educational programs and experiences [input]
- 2.2 Representational diversity among STEM credential earners [outcome]
- 2.3 Representational diversity among STEM instructors [environment]
- 2.4 Inclusive environments in institutions and STEM departments [environment]

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- Goal 1: Increase students' mastery of STEM concepts and skills by engaging them in evidence-based STEM educational practices and programs.
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- **Goal 3: Ensure adequate numbers of STEM professionals by increasing completion of STEM credentials as needed in the different disciplines.**

What are ADEQUATE numbers of STEM professionals?

- Will vary overtime and by occupations
- Will depend on progress toward Goal 1 as well as Goal 2

Objectives for Goal 3: Ensure Adequate Numbers

- **3.1 Adequate foundational preparation for STEM for all students** [process]
- 3.2 Successful navigation into and through STEM programs of study [process]
- 3.3 STEM credential attainment [outcome]

Adequate foundational preparation for STEM for all students?

- Represents the broad set of skills and knowledge (general education) required to succeed within the STEM classroom
- Supports development of STEM literacy and STEM credential attainment
- Students lacking foundational preparation may require developmental education courses to prepare for college-level
  - Statistics vary on the % of students requiring DE courses based on institution type, race, and first-time status and numbers of students requiring remediation maybe increasing due to changing demographics
  - Strengthening and monitoring developmental education maybe be necessary to ensure student progress to degree completion

Which Existing Data Could be Indicators?

Are the data . . . .

- Representative of the national universe of public and private, 2- and 4-year institutions?
- Representative of full- and part-time students' trajectories within and across institutions?
- Able to be disaggregated? (field of study, gender, race/ethnicity, ability status, first-generation status, SES)
- Aligned with the indicator content?
- Up to date?
- Publicly available?

What Are Sources of Potential Indicator Data?

Federal

- Integrated Postsecondary Ed. Data System (IPEDS)
- Beginning Postsecondary Education (1990/‘96, ’04/’09, ’12/’17)
- Nat’l Survey of Postsecondary Faculty (discontinued)

Proprietary

- National Student Clearinghouse
- HERI surveys of faculty, students
- National Surveys of Student Engagement (NSSE, FSSE, CCSSE)

Monitoring Systems

- Science and Engineering Indicators

Limitations of Current Data

- Cannot account for complex student trajectories
  - Lengthening time to degree; increasing mobility
- Representative data available only for full-time, first-time students
- Data on choice of academic major not collected consistently
- Data on quality of students' educational experiences are limited
- Data on training & qualifications of undergraduate instructors are no longer collected
- Degree completion can cover up to 6 years
- Certain groups and categories are not fully represented in data

Conclusion 2

- 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.

Conclusion 3

- To monitor the status and quality of undergraduate STEM education, recurring longitudinal surveys of instructors and students are needed.

Conclusion 4

- To monitor progress toward equity, diversity, and inclusion of STEM students and instructors, 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.

Conclusion 5: The availability of data for the indicators is limited; new data collection is needed for many of them

- No data are currently available for most of the indicators of engaging students in evidence-based STEM educational practices (Goal 1)
- Various data 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 fields of study.
- Federal data sources are available for some of the indicators of ensuring adequate numbers of STEM professionals (Goal 3). However, larger institutional and student samples are needed to allow finer disaggregation by field of study and demographic characteristics.

Conclusion 6

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 student and instructor data from longitudinal surveys
- Option 2: Expand current federal surveys of institutions, students, and instructors
- Option 3: Develop a nationally representative sample of student unit record data, supplemented with student and instructor data from proprietary surveys

Questions?