The Engineering Mindset - Blueprint for Change

Volume 1

Institutional Guidelines for Implementing Change in Undergraduate Engineering and Engineering Technology Education

A report of a national task force organized by the American Society for Engineering Education and the National Academy of Engineering, with support from the National Science Foundation, Division of Engineering Education and Centers, and Directorate for Engineering

June 6, 2025
Washington, DC

Engineering Mindset
INCLUSIVE MINDSET FOR THE FUTURE

For more information on the Vision and Change in Undergraduate Engineering and Engineering Technology Education Initiative, see
https://mindset.asee.org/

This material is based upon work supported by the National Science Foundation under Grant No. DUE-2212721.
Any opinions, findings, interpretations, conclusions, or recommendations expressed in this material are those of its authors and do not represent the views of the National Academy of Engineering, American Society for Engineering Education, or National Science Foundation.

ISBN XXX-X-XXX

ASEE and NAE Report Collaboration

Founded in 1893, the American Society for Engineering Education (ASEE) is a nonprofit organization of individuals and institutions committed to furthering education in engineering and engineering technology. ASEE is the lead organization for this report, an effort that began when Sheryl Sorby was President of ASEE in 2020. Sheryl challenged the profession to review the state of undergraduate engineering and engineering technology education in preparing engineers. A 10-member Steering Committee was formed. At the urging of the National Science Foundation (NSF), the Steering Committee began working with the National Academy of Engineering (NAE). The NAE is a part of the National Academies of Sciences, Engineering, and Medicine, a private, independent, nonprofit institution created by the federal government in 1863 to “provide independent, objective advice to inform policy with evidence, spark progress and innovation, and confront challenging issues for the benefit of society.” The mission of the NAE is to “advance the welfare and prosperity of the nation by providing independent advice on matters involving engineering and technology and by promoting a vibrant engineering profession and public appreciation of engineering.” The collaboration between ASEE and NAE led to this report with support from the NSF.
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Table of Contents

Blueprint for Change

Executive Summary

Volume 1 of the Blueprint Report presents a comprehensive framework for transforming undergraduate engineering and engineering technology education in the United States. It builds on the 2024 *Engineering Mindset Report* and provides **institutional-level strategies** to implement its recommendations. The goal is to create a **student-centered curriculum, increase access and success for underserved students, and create a future-ready engineering education system** that broadens access and aligns with societal and technological needs.

Key Themes and Recommendations in the Blueprint Report include:

1. **Flexible Program Structures**
    - Modular curricula
    - Competency-based assessments
    - Multiple pathways to degree completion
2. **Evidence-Based Pedagogy**
    - Active, inclusive teaching methods
    - Faculty development and recognition
    - Integration of real-world, hands-on learning
3. **Inclusive Learning Environments**
    - Equity-focused policies
    - Support for underserved students
    - Emphasis on socio-technical and ethical dimensions
4. **Institutional Policy Reform**
    - Revise tenure and promotion to reward teaching innovation
    - Align accreditation (ABET) with modern educational goals
    - Advocate for flexible financial aid policies
5. **Strategic Partnerships**
    - Collaborate with industry, community colleges, and liberal arts programs
    - Engage K-12 systems to build early engineering literacy
    - Create regional alliances and national networks
6. **Cultural and Mindset Shift**
    - Promote engineering as a creative, inclusive, and socially impactful field
    - Remove artificial barriers (e.g., overemphasis on calculus)
    - Foster lifelong learning and adaptability

The Implementation Framework of the Blueprint Report includes:

- **Volume 1** targets institutional leaders (presidents, provosts, deans) and stakeholders (NSF, NAE, ABET, community colleges, K-12) with tactical guidance.
- **Volume 2** focuses on faculty-level implementation.
- The report includes:
    - Case studies
    - Success metrics
    - Policy templates

- Recommendations for aligning with ABET and NSF initiatives

Proposed NSF Programs

The most important stakeholder is the National Science Foundation because of its ability to effect large-scale change. Volume 1 of the Blueprint Report suggests that the NSF initiate two new programs to begin implementing the recommendations of the Mindset Report.

- **FUEL (Fostering Undergraduate Engineering Learning):** Regional hubs to drive systemic change.
- **TREES (Transforming and Re-engineering the Engineering Education System):** A research center to support long-term innovation.

The Blueprint for Change is a call to action for institutions to lead a national movement in reimagining engineering education. It emphasizes that **incremental change is insufficient** and that **transformational, systemic reform** is essential to meet the challenges of the 21st century.

Introduction

The United States is at a crossroads in engineering education, and perhaps throughout all of higher education. We can either continue to incrementally improve a system handed to us by our past or design a new system that addresses the challenges we face today and those we will encounter in the future. We need a shared commitment to create a transformed future for engineering education in our nation. We call for conditions in which engineering education programs can invent and demonstrate new teaching and learning systems that admit and support a more inclusive and diverse student population, realizing the full potential of every student. The challenges society and humanity face require the contribution and engagement of every person. It demands an engineering education system that fosters self-directed, lifelong learners who can collaborate, solve problems, and communicate in varied contexts with people from varied backgrounds and life experiences.

Our highly standardized engineering education system was designed to prepare graduates for a world of predictable jobs, stable careers, and homogeneous cultures. It is no longer acceptable for this essential discipline to depend on standardized test scores and uneven K-12 experiences as arbitrary means of sorting human potential in engineering. Broadening access is crucial to the future of the engineering profession. It is time to acknowledge the abilities and interests of the nation's diverse array of students, welcome them into engineering, and provide the support and thriving environments that empower them to become outstanding engineers. We need to develop "student-ready" programs instead of serving only "college-ready" students. Even the most dedicated engineering educators and leaders cannot make meaningful progress when constrained by an outdated system.

Our democracy, economic competitiveness, national security, and ability to address humanity's grand challenges largely depend on a re-engineered engineering education system that is inclusive, dynamic, and learner-centered. To achieve a more promising and sustainable future, our engineering education system must transform. The 2024 *Engineering Mindset Report*, published by ASEE and NAE, with support from the NSF [DUE 2212721], presents a forward-looking vision for revolutionizing and re-engineering engineering education. The vision outlined in this report aims to significantly enhance access to the engineering profession, ultimately fostering an engineering mindset suitable for the 21st century. By evaluating the current state of engineering education, the report identifies the most pressing challenges and limitations in how our system currently prepares engineers.

Each challenge in the report is addressed with specific, actionable recommendations designed to drive the transformational improvements needed to equip engineers for both present and future demands. The Blueprint for Change report outlines a tactical plan for a larger project aimed at transforming engineering education. The report consists of two volumes: Volume 1 is intended for institutions and entities that support engineering education, providing guidelines for helping faculty and engineering programs implement the recommendations in the Mindset Report. Volume 2 is designed for faculty and program leads to help them apply the Mindset Report recommendations directly to teaching and learning.

The Blueprint for Change is an action plan to ensure that the Mindset report is not merely read, put on a bookshelf, and forgotten, but is acted upon to produce authentic and lasting change.

The findings and recommendations in the Mindset Report are clustered around the following six themes:
1. Creating flexible program structures to remove barriers
2. Evidence-based pedagogy: Creating a student-centered engineering education
3. An accessible and diverse engineering education learning environment

4. Preparing campuses for a student-centered engineering education
5. Leveraging strategic partnerships
6. Engineering a new mindset for engineering education

A systemic approach is essential for effecting positive change in engineering education. Engineering college deans must be on board and supportive of the plan to implement changes in undergraduate education. Deans of mathematics and science also need to lend their support for the necessary changes in the basic sciences that are part of the engineering curricula. At many universities, the engineering program holds significant importance, so college presidents and provosts must also support these changes. Adequate funding is crucial to provide the necessary resources for these changes. This funding can come from federal agencies collaborating with foundations, industry support, and the universities' own financial investments. **For smaller engineering and engineering technology programs, we expect that following the recommendations of the Mindset Report will lead to enrollment growth, which in turn will generate revenue growth that can be used to finance this effort**.

Creating a Movement

The American Society for Engineering Education (ASEE) and the National Academy of Engineering (NAE), with support from the National Science Foundation (NSF), have undertaken the task of reviewing the current state of engineering and engineering technology education, resulting in specific recommendations outlined in the Mindset Report. We believe that a **movement** is needed in engineering education, affecting all programs, to ensure that the current engineering mindset changes and to fully implement the recommendations in the Mindset Report (Bertoline, 2024).

> We are at a crossroads in engineering education, and frankly, throughout all of higher education, where we can either continue to incrementally improve a system handed to us by our past or design a new system that addresses the challenges we face. We need a **shared commitment through a movement** to create a new future for engineering education in our nation**.** We call for conditions in which engineering education programs can invent and demonstrate **new teaching and learning systems** where we admit a more inclusive and diverse student population and **realize the full potential of every student.** The challenges society and humanity face require the contribution of every person. It requires an engineering education system that **leads to self-directed and lifelong learners** who can collaborate, solve problems, and communicate in varied contexts and with people from varied backgrounds and life experiences.

Creating a movement can lead to transformational change in undergraduate engineering education by fostering a collective effort to address systemic issues and innovate the curriculum. Here are several key ways this can be achieved:

1. Shared Vision and Goals

- **Unified Purpose**: A movement unites educators, students, industry leaders, and policymakers with a shared vision for enhancing engineering education.
- **Clear Objectives**: Establishing clear, actionable goals helps guide efforts and measure progress toward transformational change.

2. Collaborative Efforts

- **Interdisciplinary Collaboration**: Encouraging collaboration between different disciplines can lead to more holistic and innovative educational approaches.
- **Community Engagement**: Involving the broader community, including industry partners and local organizations, ensures that the education system is aligned with real-world needs and challenges.

3. Flexible and Inclusive Curriculum

- **Adaptable Program Structures**: Creating flexible program structures that accommodate diverse learning styles and backgrounds can remove barriers and make engineering education more accessible.
- **Student-Centered Learning**: Implementing evidence-based, student-centered pedagogies enhances engagement and retention, making learning more effective and enjoyable.

4. Strategic Partnerships

- **Industry Collaboration**: Partnering with industry can provide students with practical experience and insights into current technological trends and challenges.
- **Global Networks**: Building global networks allows for the exchange of ideas and best practices, fostering innovation and continuous improvement.

5. Cultural and Mindset Shift

- **Emphasizing the Liberal Arts**: Integrating liberal arts values, such as communication, teamwork, and ethical decision-making, into the curriculum prepares students for leadership roles and complex problem-solving.
- **Promoting Diverse Perspectives**: Creating a learning environment that values diverse perspectives and experiences, while recognizing the historical inequities and systemic biases within the U.S. educational system, enriches the learning experience for all (i.e., does not harm or hinder the learning of any group) and supports the critical thinking skills required to drive innovation.

By creating a movement, stakeholders can collaborate to redesign engineering education to better meet the needs of today's diverse, digital, and rapidly changing society. This collective effort will lead to a more flexible, inclusive, and innovative educational system that prepares engineers for the future.

Many in engineering education recognize these challenges and have worked toward creative solutions at their institutions and through collaboration. These leading institutions have already implemented several of the recommendations outlined in the Mindset Report. These efforts can scale and accelerate significantly if a national movement provides the support and motivation to others.

The Blueprint Report Background

The second phase of this Engineering Mindset project began in January 2024. Four hybrid convenings—online and at NAE headquarters in Washington, DC—were held. The convenings lasted 1.5 days, fulfilling the third goal of this grant: writing a blueprint for a tactical implementation plan for recommending changes in engineering education.

The topics and the focus of each convening for the blueprint were:

1. **Vision of Industry and Research in 2050, January 17–18, 2024.** This convening focused on describing the future vision of research and industry. The facilitators for this session included **Dr. Dorota Grenjner-Brzezinska,** University Distinguished Professor at The Ohio State University and PI for the NSF Engineering Research Visioning Alliance (ERVA), and Charles Johnson-Bey, ERVA co-PI. ERVA has a mission, vision, and aspirational goals that will impact the engineering research landscape over the next several years.

The mission of ERVA includes:

- Embrace **all engineering fields**, including emerging areas and those that overlap with other disciplines.
- Serve as a **catalyst and enabler** for the engineering community to identify new opportunities and priorities in engineering research that have the potential to address national and societal needs.
- Consider issues, challenges, and opportunities in engineering research, and source novel and unanticipated perspectives.
- Provide a resource for **rapid-response expert advice** to help inform cross-cutting engineering research initiatives.
- **Convene** experts from academia, industry, engineering societies, and other relevant stakeholder groups to consider issues, challenges, and opportunities in engineering research.

Creating an ERVA-like initiative could serve as a model for implementing the recommendations outlined in the Engineering Mindset Report.

The second Blueprint convening was with past and present leaders of ABET.

2. **Accreditation, March 19–20, 2024.** This convening focused on the accreditation process, the experience in bringing about broad change in engineering education through EC2000, and how to affect change in accreditation criteria. The facilitators for this session were **Mary Leigh Wolfe**, Emeritus Professor at Virginia Tech University**,** and **Dianne Chong,** formerly of Boeing (retired), and an ABET member. Wolfe has been an active volunteer and leader in ABET for 30 years, serving in various capacities, including program evaluator, team chair, Engineering Accreditation Commission (EAC) chair, Director, and President (2018–2019). She is currently serving as the inaugural chair of ABET's Inclusion, Diversity, and Equity Advisory (IDEA) Council. She is also a fellow of ABET, ASABE, and the American Institute for Medical and Biological Engineering (AIMBE). Dianne Chong has over 20 years of experience with ABET in various roles, including program evaluation, development, and review of general and specific criteria, as well as governance within ABET. She is an NAE member and has served on ABET as a program evaluator, commissioner, delegate, Director, and President. Dianne is currently serving as the immediate past president and is a member of ABET's IDEA Council.

To successfully implement the Engineering Mindset Report, ABET must collaborate with and facilitate the Blueprint for Change initiative. The Mindset Report offers specific recommendations for ABET and provides additional details in Volume 2 of the Blueprint Report.

The third Blueprint convening sought to identify which evidence-based change models are effective in higher education.

3. **Change in Higher Education, June 4–5, 2024.** Since the overarching goal of our work was to produce a report that is *acted upon* by colleges of engineering across the nation, it was important that the

members of the blueprint authoring team fully understood the theory and practice behind higher education change processes. The facilitators for this session were **Adrianna Kezar**, the Dean's Professor of Leadership, Wilbur-Kieffer Professor of Higher Education, and Director of the **Pullias Center for Higher Education** at the University of Southern California, and Dr. Kristi Shryock, the Frank and Jean Raymond Foundation Inc. Endowed Associate Professor of Multidisciplinary Engineering at Texas A&M University. Dr. Kezar is a national expert on change and leadership in higher education, and her research agenda explores the change process in higher education institutions and the role of leadership in creating change. Dr. Shryock is working to change the culture of engineering instruction and learning in a way that impacts students with the knowledge, skills, and confidence to look beyond traditional boundaries.

Based on what we learned from Dr. Kezar and Dr. Shryock, the overarching framework for change needs to include the following components:

a. Faculty involvement
b. Alignment of groups and players to build trust
c. Deans, associate deans, and department chairs as key leaders
d. Institutional support
e. Networks of learning communities of faculty to implement and spread the reform
f. An intermediary group that serves as a focal point for the effort (not-for-profit)
g. Funding for a diverse set of pilot institutions to initiate the recommendations
h. The blending of the Satir Change Model and the Kubler-Ross Change Model (DANCE Model blending organizational change with individual change)
i. Sustainability of the change process

The fourth convening focused on faculty development. We recognize that the magnitude of the proposed changes will require faculty support, and they will need ample time and preparation.

4. **Best Practices in Faculty Development, September 18–19, 2024.** Since our primary goal is to effect change in how engineers are prepared, faculty professional development (PD) is a significant aspect of our blueprint. For faculty PD to be adequately described in our blueprint, we needed to understand what constitutes effective PD that ultimately leads to change for participants. The facilitator for this convening was co-PI **Jackie El Sayed,** a national expert with experience in faculty professional development in her role at ASEE.

Refer to Appendix 1 in Volume 2 of the Blueprint Report for a comprehensive professional development plan for faculty, as well as a support structure for curriculum innovation.

Engineering the Mindset

US institutions have much to be proud of in terms of how we educate engineers. While other fields have more recently discovered the value of high-impact learning experiences, all engineering baccalaureate programs have incorporated capstone experiences into their curricula. Many programs also include internships, real-world interactions and designs, team experiences, and writing and communication skills relevant to the field. For years, we have collaborated with professional societies, industry, government, and academic practitioners to establish minimum requirements for the accreditation of engineering, engineering technology, and related fields. Our graduating students are highly sought after.

Even with so much to be proud of, we must continue to strive for even further improvement. Technology drives changes in society, and society, in turn, presents new opportunities and challenges for technology. Consequently, our engineering and technology graduates affect the cultural ecosystems in which their systems and devices are deployed. Our current cultural and environmental ecosystems are changing at a rapid rate, and they will continue to change at the same pace or even accelerate in the future.

Educational programs in engineering, technology, and related fields should reflect these changes by evolving to consider global and societal aspects across the full lifecycle, from conception to product retirement. Society and technology are closely intertwined and impact each other. These rapid and far-reaching changes drive a need for more diverse engineering voices from a broader range of society who are better prepared to engage in the deeper considerations of the consequences and influences of their work. These voices are needed now more than ever. Stepping beyond historical failures to achieve broad impact and participation in engineering education requires long-term, intentional, and systematic changes.

The need to focus on and accelerate the evolution of engineering education and related fields is urgent. This is not because we need to prescribe the specifics of the programs for the next 20 years; rather, we need to engage in a transformational change process now, because:

1. The pace of change in technology and society demands that engineering faculty learn to adapt more rapidly.
2. The curricula must become more flexible and individualized to meet future needs.
3. We must broaden participation and pathways from novice to expert to reflect and engage all aspects of society.
4. The programs must help non-engineers to understand and use technology more responsibly.
5. The programs must not replicate systemic flaws that erect inappropriate barriers, fail to respect the perspectives of all communities and fields, and produce too many inflexible, non-agile professionals.

With these things in mind, we posit that the ‘fundamentals’ of engineering education will be focused on a mindset that weighs the impacts of society and technology on each other, along with the rigor and discipline to predict the performance of design and innovation of devices, systems, and processes in a well-balanced professional who serves the community and business. These fundamentals will be grouped into three major areas:

1. Service to the public good, highlighting the:
   - Historical failures as well as successes, and why they seemed acceptable in their time.
   - Current challenges and how they will impact the world’s future.
   - Professional ethics from diverse perspectives.
2. Engineering sciences and processes (supported by mathematics and sciences), so we go beyond trial and error in not only “doing no harm” but also “serving society,” including:
   - Mathematics is a tool and a language, not our mindset.
   - Science that informs and sets the possibilities and constraints, to motivate engineering.
   - Creating and innovating responsibly and inclusively as to what engineering is.
3. Educating people *for* change rather than training them *against* change, including:
   - Cognitive dissonance must be recognized and handled responsibly.
   - Understanding the effect of uncertainty and unknowns on decision-making.
   - Learning is fun.
   - Curiosity must be lifelong.

- Respect for perspectives is essential.

Therefore, we must develop faculty who teach using evidence-based practices to deepen these fundamentals, deliver more effective learning experiences, adapt content to current societal challenges, create more flexible and equitable pathways for evaluating and crediting competencies, and emphasize organizational structures that promote deeper learning. To achieve this, we must engage our partners in higher education.

Transformational Advancement

The Engineering Mindset Report suggests that incremental changes to engineering education are insufficient to keep pace with technological and societal advancements. Incremental change is not enough to overcome systemic racism and increase the diversity of those seeking to become engineers. It is time for transformational change in engineering education that will lead to systemic improvements to overcome the challenges faced by the engineering profession. The overarching goal of the Engineering Mindset Report is to *transform undergraduate engineering education to improve students' access, preparation, persistence, and graduation, and reward innovation in teaching.*

Improve Access

The entry-level engineering curriculum is currently dominated by higher-level math (calculus and above) and science courses, which create an entry barrier for many students. Many students are steered away from engineering due to a lack of math proficiency or a lack of opportunities to even take higher-level math and science courses in their school district. Some ways to address the curricular issues are:

- Incorporate math in context with engineering.
- Re-examine admission barriers related to math.
- Create multiple pathways for students through math and science courses.

Engineering is one of the least diverse disciplines in STEMM, with a disproportionately low representation of women and other historically underserved populations. However, the projected demographics of future student populations in higher education are changing, and attracting more women and underserved students to the engineering discipline is critical. In addition, more diverse teams have been shown to demonstrate greater creativity and innovation, which are essential for U.S. innovation and competitiveness. The Engineering Mindset Report calls us to:

- Transform engineering education to improve access, preparation, and support systems, leading to improved student persistence and graduation.
- Modernize institutional structures to address cultural issues that hinder our progress toward an “engineering for all” system that fosters U.S. superiority in innovation, national security, and economic competitiveness.

Improve Preparation

Engineering is one of the most rigorous curricula in higher education. This rigor makes it difficult to incorporate new topics, such as emerging technologies. Additionally, teaching emerging technologies is usually dependent on the teacher. We must be preparing engineering students for the world of the future. The report calls us to:

- Create an engineering curriculum with greater flexibility and the ability to personalize the degree to a student’s interests.
- Gain support from industry for teachers on the inclusion of emerging technologies and industry needs.
- Incorporate ethics and societal context into problem-solving challenges.

Improve Student Persistence
Mental health concerns came to the forefront during the COVID-19 pandemic and continue to be a major concern on higher education campuses today. Secondary teaching and learning are uneven across school districts, and students need support to learn critical skills. To improve persistence, we must create life skills support and peer-support/mentoring networks to provide a sense of belonging.

Improve Graduation
There are current shortages in the engineering workforce and talent in technological fields. We need to improve graduation rates to help fill these gaps. To do this, we must develop and implement novel approaches to engineering education that are not only relevant but urgently needed to help fill these workforce gaps.

Reward Innovation in Teaching
Engineering education research points to the need to modernize the way we teach students today. We should reward innovation in teaching by cultivating and encouraging programs and faculty who:

- Incorporate active learning.
- Incorporate meaningful projects that are of interest to all students.
- Reimagine institutional policies and structures to support innovation in teaching and learning.

Guidance for Implementing the Mindset Report Recommendations

The Blueprint for Change report provides guidelines on implementing the recommendations from the Engineering Mindset Report. Creating a movement aimed at elevating undergraduate engineering and engineering technology education to a new level of excellence is a significant undertaking. It will require alignment among local, state, and national stakeholders to ensure we graduate the best-prepared engineering professionals. The Blueprint Report provides guidelines for all stakeholders as a starting point to facilitate the implementation of the Mindset Report recommendations. Consider the Engineering Mindset Report as the strategic plan for the future of engineering education, and view the Blueprint Report as the tactical plan to ensure that this vision for engineering education, as defined by the 34 recommendations, is realized.

The Blueprint Report is divided into two volumes: Volume 1, Institutional Guidelines for Implementing Change in Undergraduate Engineering and Engineering Technology Education, and Volume 2, Faculty Guidelines for Implementing Change in Undergraduate Engineering and Engineering Technology Education.

Reference
Bertoline, G. (Ed.). (2024). *The inclusive engineering mindset: A vision for change in undergraduate engineering and engineering technology education*. American Society for Engineering Education. https://mindset.asee.org/

Volume 1

Strategies for Institutions

Introduction

Volume 1 of the Blueprint Report provides guidelines for institutions involved in engineering education to facilitate the implementation and sustainability of the Mindset Report's recommendations. This Blueprint for Institutional Change presents a comprehensive framework designed to transform undergraduate engineering and engineering technology education nationwide. With an emphasis on fostering inclusive, student-centered learning environments, this report outlines strategic guidelines and implementation plans for institutions to lead this change effectively. From revising tenure and promotion processes to prioritizing teaching innovation, collaborating with accreditation bodies like ABET, and advocating for financial aid flexibility, each section of the report provides actionable steps to align educational policies and practices with the evolving demands of the engineering profession. By promoting institutional accountability and access, the report aims to catalyze a shift in engineering education that supports long-term success for all students.

Preparing Campuses for a Student-Centered Engineering Education

The goal is for the recommendations in this report to be understood and implemented at campuses nationwide. Champions, both individuals and groups, will undertake the task of integrating the recommendations at their respective campuses. Some teams may also decide to spontaneously write proposals to request funds for salaries and expenses to undertake larger-scale transformations. However, these types of organic initiatives are typically localized and do not usually lead to mass transformation across regions.

Another approach is to make the Mindset report the "go-to guide" for necessary work on all campuses. This work is already integrated into the college budget, including salary lines and expenses, and also has external deadlines. An example is the ABET continuous improvement cycle, along with the ABET self-study development and site visit process. By creating a crosswalk between the Mindset report recommendations and the ABET processes, teams already engaged in ABET work will have a quick-start guide to address common discrepancies as they arise.

The Mindset quick start go-to guide will need example case studies. These should show how exemplary engineering programs are currently incorporating the Mindset recommendations. The guide should capture and list these exemplars. Campuses that use the Mindset guide should present their work at the ABET symposium and the ASEE conferences.

Additionally, the Mindset quick start guide should be easily accessible via open-source sites with keywords that facilitate its discovery. ASEE will add it to its publication resources. Additionally, ASEE can facilitate a national community of practice, providing a forum for discussion and peer mentoring across campuses.

Section 1: Aligning Promotion & Tenure with The Future of Engineering Education

Introduction

The Engineering Mindset Report provides a framework for modernizing promotion and tenure (P&T) requirements to support educational innovation while maintaining academic excellence. The following sections present the background and rationale for modifying promotion and tenure criteria in engineering education to recognize teaching excellence. This can enhance scholarly work without compromising scholarship, serving as a valuable addition to faculty contributions.

WHY CHANGE P&T NOW?

In Chapter 2 of the Mindset Report, several critical factors are highlighted, underscoring the urgent need for change in engineering education and practices.

The **persistent lack of access in engineering** remains a significant challenge. Despite various initiatives, the field continues to struggle with inclusivity, which limits the range of perspectives and innovations that diverse teams can bring. This lack of access affects the quality of solutions and hinders industry's ability to attract and retain talent from underserved groups.

G**rowing workforce demands** are putting pressure on educational institutions to produce graduates who are technically proficient, adaptable, and ready to tackle complex, real-world problems. The rapid pace of technological advancement means that engineers must continuously update their skills and knowledge to stay relevant.

Moreover, there is a **need for new engineering competencies**. Traditional engineering skills are no longer sufficient; engineers must now be equipped with interdisciplinary knowledge, including data science, sustainability, and systems thinking. This shift requires a fundamental change in how engineering education is structured and delivered.

The **failure of incremental changes** has shown that small adjustments are insufficient to address these challenges. A more radical overhaul is necessary to create an educational environment that fosters innovation, inclusivity, and excellence.

Finally, the **competition for students demands educational excellence**. With more options available to prospective students, institutions must strive to offer top-tier education that meets current industry standards and anticipates future needs. This means investing in cutting-edge facilities, curricula, and teaching methods to attract and retain the best and brightest minds.

RECOGNIZE TEACHING INNOVATION

Chapter 4 of the Mindset Report focuses on the critical importance of recognizing and fostering teaching innovation within educational institutions. To achieve this, it is essential to engage and **support faculty in systematic professional development** and evaluate their educational innovations through scholarly approaches.

One key aspect is to **document evidence-based teaching practices**. By systematically recording and analyzing these practices, institutions can identify what works best in different contexts and share these insights with the broader educational community.

Additionally, it is essential to **prioritize curriculum development that utilizes competency-based assessment**. This approach ensures that the curriculum is aligned with the skills and knowledge that students need to succeed in their careers, making education more relevant and effective.

Another crucial element is the creation of **inclusive learning environments**. Recognizing and rewarding faculty who excel in this area helps promote a culture of inclusivity where all students feel valued and supported.

Supporting **educational research and scholarship** is also vital. By encouraging faculty to engage in research, institutions can foster a culture of continuous improvement and innovation in teaching practices.

Finally, recognizing **the importance of experiential learning partnerships** is essential. These partnerships provide students with hands-on, practical experience that enhances their learning and better prepares them for the workforce.

EXPAND DEFINITIONS OF SCHOLARSHIP

Chapter 6 in the Mindset Report emphasizes revising **tenure and promotion processes** at all levels—department, college, and university—to reward faculty efforts, innovation, and risk-taking in teaching. This revision aims to broaden the definition of scholarship to encompass a wider range of aspects of educational excellence.

One key component is to **recognize the Scholarship of Teaching and Learning (SoTL)** as a valued form of engineering scholarship. By recognizing SoTL, institutions can highlight the importance of research focusing on teaching practices and student learning outcomes, encouraging faculty to engage in scholarly inquiry that directly impacts their educational methods.

Additionally, it is crucial to **value educational research publications**. These publications contribute to the body of knowledge in education, demonstrating a faculty member's commitment to advancing the field through rigorous research.

Another important aspect is **recognizing successful educational grant funding**. Securing grants for educational projects supports innovative teaching practices and reflects a faculty member's ability to attract resources that benefit the institution and its students.

Furthermore, **promoting the development of modular curriculum materials** is essential. Modular materials offer flexibility and adaptability in teaching, enabling personalized learning experiences that better meet students' diverse needs.

Finally, the revised processes should **include an assessment of their impact on student success metrics**. By considering how faculty contributions positively affect student outcomes, institutions can ensure that their promotion and tenure decisions are aligned with their ultimate goal of fostering student success.

SUPPORT EDUCATIONAL LEADERSHIP

Chapter 6 in the Mindset Report advocates for reimagining institutional policies to better support innovation in teaching and learning. This involves creating an environment where educational leadership is acknowledged and rewarded, fostering a culture of continuous improvement and excellence.

One key aspect is **valuing departmental change initiatives**. Departments that actively pursue innovative changes in their teaching practices and curricula should be acknowledged and supported. These initiatives can lead to significant improvements in student learning and engagement.

Additionally, it is important to **recognize curriculum innovation**. Faculty members who develop and implement new, effective curricula play a crucial role in advancing education, ensuring that students are equipped with the skills and knowledge necessary for their future careers.

Leveraging strategic partnerships (Chapter 7) is another essential element. Collaborations with industry, other educational institutions, and community organizations can provide valuable resources and opportunities for both students and faculty. These partnerships enhance the educational experience and foster a more dynamic learning environment.

Institutions should **recognize leadership in professional development** within their policies. Faculty who lead these efforts help elevate the overall quality of teaching and learning at the institution. Their contributions should be recognized and rewarded.

It is crucial to **reward the mentoring of junior faculty**. Experienced faculty who mentor their junior colleagues play a vital role in building a supportive and collaborative academic community. Their efforts help ensure the continued growth and development of the institution's educational leadership.

BENEFITS TO YOUR INSTITUTION

The Mindset Report highlights several key areas where your institution can benefit from targeted improvements and strategic initiatives.

There is a documented need for **improved student recruitment and retention** (Chapter 2). By implementing strategies that attract and retain both domestic and international students, your institution can ensure a steady influx of talent and maintain a vibrant academic community. This involves creating an engaging and supportive environment that meets the diverse needs of students.

Enhancing **educational quality through evidence-based teaching** (Chapter 4) is critical. By adopting teaching practices grounded in research and proven to be effective, your institution will enhance the quality of education it provides. This benefits students and strengthens the institution’s reputation for academic excellence.

Increased faculty satisfaction and retention (Chapter 6) is another crucial aspect. Supporting faculty through professional development, recognition, and a positive work environment can lead to greater job satisfaction and reduced turnover rates. This stability is crucial for maintaining a strong and cohesive academic team.

Furthermore, **enhanced industry alignment** (Chapter 7) ensures that the curriculum and educational practices are closely linked to industry needs. This prepares students for successful careers and nurtures partnerships that can offer valuable resources and opportunities.

Achieving a **competitive advantage through innovation** is also emphasized. By continuously innovating in teaching methods, curriculum design, and institutional policies, your institution can distinguish itself in the competitive landscape of higher education.

Finally, the report highlights the significance of **external funding opportunities**. Obtaining funding through grants and partnerships can offer the essential resources needed to support innovative teaching and learning projects and initiatives, further enhancing the institution’s capabilities and impact.

MEASURING SUCCESS

Chapter 6 of the Mindset Report outlines a comprehensive approach to measuring success in education. By tracking key metrics, institutions can ensure they meet their goals and continuously improve.

One important metric is **student retention and completion rates**. Monitoring these rates helps institutions understand how effectively they support students throughout their academic journey and identify areas where additional assistance may be necessary to ensure student success.

Diversity metrics are also crucial. By tracking the diversity of the student body and faculty, institutions can evaluate their progress in fostering an inclusive environment and identify opportunities to enhance further equity and representation, which is crucial for successful engineering design.

Student learning outcomes offer valuable insights into the effectiveness of educational programs. By evaluating these outcomes, institutions can ensure that students acquire the knowledge and skills needed to succeed in their careers and personal lives.

Tracking **faculty innovation efforts** is another key aspect. Recognizing and supporting innovative teaching practices and research initiatives will help foster a culture of continuous improvement and excellence in education.

Measuring **industry partnership outcomes** is crucial. These outcomes can showcase the value of collaborations with industry partners and ensure that the curriculum stays relevant to current industry needs.

Finally, **teaching effectiveness** is a critical metric. By evaluating the effectiveness of teaching methods and practices, institutions can ensure they provide high-quality education that meets the needs of their students.

IMPLEMENTATION SUPPORT

The Engineering Mindset Report offers comprehensive support for implementing its recommendations, ensuring that institutions can effectively adopt and benefit from the proposed changes.

The report provides **detailed recommendations for each chapter**. These recommendations are designed to address specific challenges and opportunities within each area of focus, offering guidance on how to proceed.

Success metrics (Chapter 6) are outlined to help institutions track their progress and measure the impact of their initiatives. By monitoring these metrics, institutions can ensure they meet their goals and achieve meaningful improvements.

Throughout the report, **case studies** are included to illustrate successful implementations and provide real-world examples of how recommendations can be applied. These case studies offer valuable insights and practical lessons that can inform and inspire similar efforts.

Assessment frameworks (Chapter 4) are designed to help institutions evaluate their teaching practices and educational outcomes. These frameworks provide structured approaches to assessment, ensuring that evaluations are comprehensive and effective.

The report includes **implementation strategies** (Chapters 8–9). These strategies provide step-by-step guidance on implementing the recommendations, addressing potential challenges, and offering solutions to ensure successful adoption.

To implement a recommendation for revising tenure and promotion processes to reward effort, innovation, and risk-taking in teaching, we need a comprehensive approach that addresses all levels of academic administration and considers multiple stakeholders. Incorporating this work through existing institutional faculty governance processes could streamline the effort.

Addressing Recommendation 4.1: Revise tenure and promotion processes at the department, college, and university levels to reward effort, innovation, and risk-taking in teaching.

In the context of engineering education, where innovation and real-world problem-solving are central to the discipline, faculty need to be encouraged to bring the same creativity and rigor to their teaching that they bring to their research. However, traditional tenure and promotion processes often undervalue pedagogical innovation, which inadvertently discourages faculty from adopting novel instructional strategies, integrating emerging technologies, or engaging in interdisciplinary teaching practices. Recommendation 4.1 calls for a careful revision of these processes at the department, college, and university levels to explicitly recognize and reward faculty who demonstrate effort, innovation, and risk-taking in their teaching. By aligning institutional incentives with the evolving demands of engineering education, this approach aims to foster a culture that values excellence and innovation in both teaching and learning.

Innovative teaching in engineering can take many forms. For example, faculty may implement **project-based learning (PBL)** to incorporate or simulate real-world engineering challenges, encouraging students to apply theoretical knowledge in practical, team-based contexts. Others may adopt **flipped classroom models**, where students engage with lecture content outside of class and use in-person sessions for collaborative problem-solving and hands-on activities. The integration of **emerging technologies,** such as virtual and augmented reality, digital twins, or AI-driven simulations, can also enhance student engagement and deepen conceptual understanding. Additionally, **interdisciplinary teaching** that bridges engineering with fields like business, design, sociology, philosophy, or environmental science prepares students for the complex, interconnected challenges they will face in their careers.

To support these efforts, tenure and promotion guidelines should include clear criteria for evaluating teaching innovation, such as the development of new curricula, the use of evidence-based instructional practices, and contributions to educational research or scholarship of teaching and learning (SoTL). Peer review processes should be adapted to assess the impact and quality of these innovations, and institutions should provide professional development opportunities to help faculty develop as educators.

By revising tenure and promotion processes to encompass the full range of faculty contributions to engineering education, institutions can cultivate a more inclusive and innovative academic environment—one that values not only what is taught, but how it is taught.

Building a Framework to Reward Teaching Innovation in Engineering Education

Transforming tenure and promotion processes to meaningfully reward innovative teaching requires a comprehensive, multifaceted approach. This transformation must go beyond policy revision to include cultural change, stakeholder engagement, and sustained institutional support. The following strategic framework outlines a series of coordinated actions designed to ensure that innovative teaching is not only recognized but actively encouraged across all levels of the academic enterprise. From assessing current practices and developing clear evaluation criteria to piloting new approaches and aligning hiring practices, each step is essential to building a system that values and sustains pedagogical excellence in engineering education.

1. **Thorough Assessment of Current Practices and Stakeholder Engagement**
   The process begins with a deep analysis of existing tenure and promotion policies, practices, and outcomes. This includes gathering input from a broad range of stakeholders—faculty, department chairs, deans, students, and academic affairs leaders—to understand current perceptions and barriers to recognizing teaching innovation. This step ensures that any changes are grounded in institutional realities and informed by those most affected.
2. **Development of New Policies and Specific Criteria for Evaluating Teaching Innovation**
   Based on the assessment, institutions must craft clear, actionable policies that define what constitutes teaching innovation. These criteria should encompass the use of evidence-based instructional practices, the development of new curricula, the integration of technology, interdisciplinary teaching, and contributions to the scholarship of teaching and learning (SoTL). The goal is to create a shared understanding of excellence in teaching that is rigorous, inclusive, and aligned with institutional values.
3. **Training and Support for Both Faculty and Evaluators**
   To ensure fair and consistent application of the new criteria, both faculty and evaluators need targeted training. Faculty should be supported in documenting and presenting their teaching innovations effectively, while evaluators must be equipped to assess these contributions with nuance and equity. Workshops, mentoring programs, and resource toolkits can help build this capacity.
4. **Implementation of a Pilot Program to Test and Refine the New Approach**
   Before full-scale implementation, a pilot program will allow institutions to test the revised processes in selected departments or colleges. This phase will provide valuable feedback on the clarity, feasibility, and impact of the new criteria and procedures. Lessons learned can be used to refine the approach and build broader buy-in.
5. **Efforts to Shift Institutional Culture to Value Teaching Innovation More Highly**
   Policy change alone is insufficient without a parallel shift in institutional culture. Leadership must actively promote the value of teaching innovation through public recognition, awards, and strategic messaging. Creating communities of practice and celebrating teaching excellence can help normalize and elevate innovative pedagogy.
6. **Allocation of Resources to Support Innovative Teaching**
   Faculty need time, funding, and infrastructure to experiment with new teaching methods. Institutions should invest in teaching and learning centers, provide grants for pedagogical research, and offer course releases or stipends for faculty engaged in significant instructional redesign. These resources signal a tangible commitment to teaching excellence.
7. **Strategies for External Validation and Continuous Improvement**
   External validation—such as peer-reviewed publications on teaching, awards from professional

societies, or adoption of innovations by other institutions—can strengthen the credibility of teaching contributions. Institutions should also establish mechanisms for ongoing assessment and refinement of the revised tenure and promotion processes to ensure they remain effective and equitable.

8. **Integration with Hiring Practices to Ensure Alignment Throughout the Academic Career Pipeline**
   To sustain long-term change, hiring practices must also reflect the institution's commitment to teaching innovation. Job postings, interview questions, and evaluation rubrics should include criteria related to pedagogical creativity and effectiveness. This alignment ensures that new faculty are selected and supported based on a holistic view of academic excellence.
9. **Addressing Potential Challenges and Maintaining Balance with Other Academic Priorities**
   Finally, institutions must anticipate and address potential concerns, such as the perceived trade-off between research and teaching and the risk of overburdening faculty. Clear communication, transparent processes, and a balanced approach that values all aspects of academic work are essential to maintaining faculty morale and institutional integrity.

Implementing these recommendations will require significant commitment from university leadership and buy-in from faculty across disciplines. It's a complex process that will likely unfold over several years, with ongoing refinement based on feedback and outcomes.

Career Framework for University Teaching

In addition to revising P&T criteria, universities can begin to develop a career framework for university teaching. A starting point might be the one presented on the Advanced Teaching website:

> *The Career Framework for University Teaching is designed to guide and support the career progression of academics on the basis of their contribution to teaching and learning. Offering both a structured pathway for academic career progression and an evidence base on which to demonstrate and evaluate teaching achievement, the Framework provides a resource that universities can adapt to their academic career structures and progression points. It can be used at each stage of the academic career, including appointment, professional development, appraisal and promotion. (Advanced Teaching, n.d.)*

Good teaching is both an art and a science. In higher education, faculty spend years preparing for research careers but devote very little, if any, time to mastering the science and art of effective teaching. This lack of preparation negatively impacts not only the students but also the faculty, especially early in their careers. It is common practice at research-intensive universities to grant release time to faculty members to develop their research; however, little attention is given to preparing faculty to be effective teachers.

To address this gap in faculty preparation, a comprehensive plan is essential to support faculty in becoming effective teachers, recognize outstanding faculty, and define and evaluate teaching achievements at all stages of the academic career ladder. This can be achieved by creating a structured pathway to guide career progression based on academic contributions to university teaching and learning, along with an evidence base to assess and demonstrate teaching achievements during hiring, promotion, professional development, and annual reviews.

Reference

Advancing Teaching. (n.d.). *Career framework*. https://www.advancingteaching.com/framework

Section 2: Implementation Plan for Reimagining Institutional Policies to Support Teaching and Learning Innovation

In this section, we present a comprehensive implementation plan designed to transform institutional policies, fostering an environment that supports and encourages innovation in teaching and learning. Acknowledging the dynamic nature of education and the necessity for continuous improvement, this plan offers a strategic framework to guide institutions in reimagining their policies.

The plan emphasizes the importance of aligning institutional goals with innovative teaching practices, ensuring that policies not only support but actively promote educational excellence. By focusing on key areas such as faculty development, curriculum innovation, and student engagement, this implementation plan aims to create sustainable and impactful change.

Through detailed recommendations, success metrics, and practical strategies, this section provides a roadmap for institutions seeking to enhance their educational practices and outcomes. By embracing these changes, institutions can better prepare students for the challenges of the future, foster a culture of continuous improvement, and maintain a competitive advantage in the ever-evolving landscape of higher education.

Addressing Recommendation 4.2: Reimagine institutional policies that support innovation in teaching and learning.

To implement recommendations for reimagining institutional policies that support innovation in teaching and learning, we need a comprehensive approach that addresses various aspects of the academic ecosystem. Institutions can turn to existing learning and development centers and faculty governance committees to spearhead this initiative.

Enabling Innovation Through Strategic Policy Reform in Higher Education

To foster a culture of sustained educational innovation, institutions must take a holistic and strategic approach to policy reform. This involves not only revising individual policies but also aligning them with broader institutional goals and the evolving needs of students and faculty. The following framework outlines a comprehensive roadmap for enabling and scaling innovation in teaching and learning. It begins with a thorough audit of existing policies and active stakeholder engagement, and extends to defining clear innovation goals, addressing key policy areas, allocating resources, and implementing mechanisms for quality assurance and continuous improvement. By embedding innovation into the institutional fabric—from curriculum design to student engagement—this approach ensures that policy becomes a powerful enabler of transformative educational practices.

1. **Comprehensive Policy Audit and Stakeholder Engagement**
   The foundation of effective reform is a clear understanding of the current landscape. Institutions must conduct a comprehensive audit of existing academic and administrative policies to identify barriers to innovation. This process should be inclusive, involving faculty, students, administrators, and external partners to ensure that diverse perspectives inform the reform agenda.
2. **Defining Clear Innovation Goals Aligned with Institutional Strategy**
   Innovation efforts must be guided by a shared vision. Institutions should articulate specific, measurable goals for teaching and learning innovation that align with their broader mission and strategic priorities. These goals might include increasing interdisciplinary learning, expanding access through flexible delivery, or enhancing student engagement through experiential learning.

3. **Addressing Multiple Policy Areas to Enable Innovation**
   A wide range of policy domains must be addressed to create an environment conducive to innovation. These include:
   - **Curriculum flexibility** to support modular, interdisciplinary, and competency-based learning.
   - **Teaching modalities** that embrace hybrid, online, and experiential formats.
   - **Assessment practices** that prioritize authentic, formative, and student-centered evaluation.
   - **Faculty development** policies that support continuous pedagogical growth.
   - **Technology integration** guidelines that promote effective and ethical use of digital tools.
   - **Collaboration frameworks** that encourage cross-departmental and external partnerships.
   - **Student engagement policies** that empower learners as co-creators of their education.
4. **Allocation of Resources and Professional Development to Support Innovation**
   Policy reform must be backed by tangible support. Institutions should allocate funding, time, and infrastructure to enable faculty and staff to experiment with new approaches. Professional development programs should be expanded to build capacity in areas such as instructional design, digital pedagogy, and inclusive teaching.
5. **Revision of Recognition and Reward Systems to Encourage Innovative Teaching**
   Faculty are more likely to invest in innovation when it is recognized and rewarded. Institutions should revise promotion, tenure, and award criteria to explicitly value contributions to teaching innovation, curriculum development, and educational leadership.
6. **Development of New Quality Assurance Processes**
   As teaching practices evolve, so too must the mechanisms for ensuring quality. Institutions should develop new frameworks for evaluating the effectiveness of innovative practices, incorporating both qualitative and quantitative data and prioritizing continuous improvement over compliance.
7. **Addressing Intellectual Property and Open Education Policies**
   Innovation often involves the creation of new educational content and tools. Clear policies on intellectual property and open educational resources (OER) are essential for supporting faculty creativity while ensuring equitable access and appropriate attribution.
8. **Adjusting Student Policies to Support Flexible and Innovative Learning**
   Student policies must also evolve to support new learning models. This includes revising attendance, grading, and credit transfer policies to accommodate flexible schedules, self-paced learning, and non-traditional pathways.
9. **A Phased Implementation Strategy with Continuous Improvement Mechanisms**
   Finally, institutions should adopt a phased approach to implementation, allowing for iterative testing, feedback, and refinement. Continuous improvement mechanisms—such as pilot programs, feedback loops, and regular policy reviews—ensure that reforms remain responsive and effective over time.

Implementing these recommendations would require significant commitment from university leadership and buy-in from faculty, staff, and students across the institution. It’s a complex process that would likely unfold over several years, with ongoing refinement based on feedback and outcomes.

This plan provides a framework for institutions to systematically review and revise their policies to create an environment that truly supports and encourages innovation in teaching and learning. It recognizes that policy change needs to be comprehensive, touching on all aspects of academic life to create a cohesive ecosystem for innovation.

Section 3: Advocating for Financial Aid Flexibility

Addressing Recommendation 4.4: Work with and advocate to federal and state governments to increase flexibility in financial aid regulations, including scholarships for year-round and part-time learning.

Access to higher education is increasingly shaped by the flexibility of financial aid systems to meet the diverse needs of today's learners. Traditional financial aid policies—largely designed around full-time, semester-based enrollment—often fail to accommodate the realities of modern students, many of whom balance education with work, family responsibilities, or nontraditional academic pathways. This is particularly true in disciplines such as engineering, where students may engage in co-op programs, internships, or modular learning formats that do not align neatly with conventional academic calendars.

Recommendation 4.4 calls for institutions to actively collaborate with and advocate to federal and state governments for reforms that increase flexibility in financial aid regulations. This includes expanding eligibility for scholarships and aid to support **year-round learning**, such as summer courses or accelerated programs, as well as **part-time enrollment**, which is critical for adult learners, working students, and those returning to education after a break.

Such advocacy efforts should focus on several key areas:

1. **Year-Round Pell Grants and Scholarship Access**
   Institutions should support policies that allow students to access federal and state aid across all academic terms, including summer and intersession periods. This enables students to maintain momentum in their studies, graduate more quickly, and better align their education with internship or co-op opportunities.
2. **Support for Part-Time and Nontraditional Students**
   Many financial aid programs are structured to favor full-time students, leaving part-time learners with limited options. Advocating for aid models that scale based on credit load or learning intensity can help ensure equitable access for all students, regardless of their enrollment status.
3. **Flexibility for Modular and Competency-Based Learning**
   As institutions adopt more flexible learning models—such as microcredentials, stackable certificates, and competency-based education—financial aid systems must evolve to support these formats. This includes recognizing alternative credit structures and allowing aid disbursement based on demonstrated learning rather than seat time.
4. **Institutional Partnerships and Policy Coalitions**
   To amplify their voice, institutions should form coalitions with peer institutions, professional associations, and advocacy groups. These partnerships can help shape policy proposals, provide data to support reform, and facilitate meaningful dialogue between policymakers and the changing landscape of higher education.
5. **Student-Centered Policy Design**
   Finally, institutions should ensure that students are included in the conversation. Gathering input from diverse student populations can help identify the most pressing financial barriers and inform advocacy strategies that are responsive to real-world needs.

By championing more flexible and inclusive financial aid policies, institutions can help remove systemic barriers to access and success. This approach not only supports equity and affordability but also aligns financial aid systems with the evolving nature of higher education—one that is increasingly personalized, modular, and lifelong.

Section 4: Modernizing Engineering Education: A Roadmap for Access, Success, and Accountability

Introduction

Engineering education stands at a pivotal crossroads, facing the challenge of evolving in response to rapid technological advancements, shifting workforce demands, and the growing imperative to serve a broader and more diverse student body. To remain relevant and impactful, institutions must reimagine how they prepare students, not only to master technical skills but also to thrive in dynamic, interdisciplinary, and socially responsive environments.

Modernizing Engineering Education: A Roadmap for Access, Success, and Accountability outlines a strategic vision for transforming engineering programs to be more accessible, adaptive, and outcomes-driven. This roadmap emphasizes expanding opportunities for underserved learners, supporting student success through innovative teaching and learning practices, and ensuring accountability through transparent, data-informed decision-making.

Central to this transformation is **Recommendation 4.5**, which calls on institutions to explore and adopt a new paradigm—one that supports an *engineering mindset* rooted in curiosity, creativity, resilience, and ethical responsibility. This mindset must be cultivated not only in students but across institutional culture, fostering a shared commitment to accountability in expanding access and addressing disparities in participation and outcomes. By embedding this mindset into curriculum design, faculty development, and institutional policies, engineering programs can more effectively prepare graduates to lead in a world that demands both technical excellence and social responsibility.

Together, these efforts form a comprehensive strategy to modernize engineering education, ensuring it is not only technically rigorous but also equitable, responsive, and aligned with the needs of a changing society.

Addressing Recommendation 4.5: Explore and adopt a different paradigm to support an engineering mindset that fosters a culture of accountability in access and diversity.

A culture of accountability that is rooted in shared equity and leadership is one that values transparency, communication, setting clear expectations, courage, humility, honesty, vulnerability, comfort in being uncomfortable, and self-accountability. Fostering this culture as part of the institutional mission enhances student success by providing a welcoming learning environment.

To implement a recommendation for exploring and adopting a different paradigm to support an engineering mindset that fosters a culture of accountability in access and diversity, we need a comprehensive and transformative approach.

1. Cultivating an Engineering Mindset for Accountability

To modernize engineering education, institutions must adopt a new paradigm that promotes an engineering mindset—one that values curiosity, creativity, ethical responsibility, and resilience. This mindset should be embedded throughout the curriculum, faculty development, and institutional culture. It must also be tied to a culture of accountability, where access and success for underserved students are not just goals but shared responsibilities. Institutions should develop metrics to track progress and ensure that all students receive the support necessary to achieve their full potential.

2. Expanding Access Through Flexible Pathways

Modern learners require flexible, modular, and personalized educational experiences. Institutions should:

- Offer multiple entry points into engineering programs (e.g., transfer pathways, bridge programs).
- Expand online, hybrid, and evening/weekend course options.
- Develop stackable credentials and micro-pathways that allow students to build toward degrees over time. These strategies are especially critical for underserved populations who may face barriers to traditional full-time, on-campus programs.

3. Supporting Student Success with Inclusive Pedagogy and Advising

Success in engineering education must be supported through:

- Active, evidence-based teaching practices that engage diverse learners.
- Proactive advising and mentoring systems that guide students through academic and career pathways.
- Early alert systems and data-informed interventions to support students at risk of attrition. Faculty and staff should receive ongoing professional development to implement inclusive, student-centered practices that promote a sense of belonging and persistence.

4. Aligning Financial Aid with Modern Learning Models

Financial aid systems must evolve to support year-round, part-time, and modular learning. Institutions should:

- Advocate for federal and state policy changes that expand eligibility for aid across flexible formats.
- Design institutional aid programs that support nontraditional learners.
- Ensure that financial aid policies do not unintentionally penalize students for pursuing innovative or accelerated pathways.

5. Embedding Equity and Accountability into Institutional Policy

Equity must be operationalized through policy. Institutions should:

- Conduct equity audits of academic policies, admissions, and student support services.
- Set clear goals for improving access and outcomes for underserved students.
- Publicly report progress and use data to drive continuous improvement. Accountability structures should be transparent and tied to institutional planning and resource allocation.

6. Modernizing Curriculum and Assessment

Curricula should reflect the realities of modern engineering practice. This includes:

- Integrating interdisciplinary learning, ethics, sustainability, and global perspectives.
- Emphasizing project-based, experiential, and community-engaged learning.
- Using authentic assessments that measure applied knowledge, teamwork, and problem-solving.
- Curriculum reform should be iterative and informed by feedback from industry, alumni, and students.

7. Strengthening Industry and Community Partnerships

Partnerships are essential for relevance and impact. Institutions should:

- Collaborate with industry to align curricula with workforce needs.
- Create co-op, internship, and research opportunities that provide real-world experience.

- Engage with local communities to co-design projects that address societal challenges and promote civic responsibility.

8. Investing in Faculty Development and Recognition

Faculty are central to educational transformation. Institutions should:

- Provide ongoing professional development in pedagogy, technology, and inclusive teaching.
- Revise tenure and promotion criteria to reward innovative teaching and its impact on students.
- Foster communities of practice that support collaboration and knowledge sharing.

9. Building a Culture of Continuous Improvement

Modernization is not a one-time effort; it requires sustained reflection and ongoing adaptation. Institutions should:

- Establish feedback loops with students, faculty, and partners.
- Use data dashboards to track progress on access, success, and accountability objectives.
- Pilot new initiatives, evaluate outcomes, and scale what works.

Section 5: NSF, ASEE, and NAE Collaborate on Creating a New Engineering Program Ranking System Focused on Access and Success

Introduction

In a forward-thinking proposal, we recommend that the National Science Foundation (NSF), the American Society for Engineering Education (ASEE), and the National Academy of Engineering (NAE) collaborate to develop a new ranking system for engineering programs. This proposed system would prioritize access and success, ensuring that educational institutions are recognized not only for their academic excellence but also for their commitment to inclusivity and student achievement.

The proposed collaboration aims to shift the focus from traditional metrics to more holistic criteria that reflect the diverse needs of the student population. By emphasizing access, the ranking system would highlight programs that effectively support underserved groups, providing pathways to engineering careers for all students. Success metrics would evaluate how well programs prepare students for professional and personal growth, considering factors such as graduation rates, employment outcomes, and student satisfaction.

This new ranking system signifies a major advancement in promoting equity and accountability in engineering education. Through detailed criteria and transparent evaluation processes, the NSF, ASEE, and NAE would establish new standards for what defines a top-tier engineering program. Institutions that excel in these areas would not only enhance their reputation but also contribute to a more inclusive and dynamic engineering community.

Addressing Recommendation 4.6: Track Data That Matters.

Determining and tracking metrics that align with desired outcomes is crucial for understanding what is effective and identifying where gaps still exist. What follows is a starting point for discussions to create a system and process for reporting data that matters in the context of the Mindset Report and its recommendations.

Institutional educational data are collected and reported annually to the U.S. Department of Education's National Center for Education Statistics (NCES) Integrated Postsecondary Educational Data System (IPEDS). IPEDS gathers information from every college, university, and technical and vocational institution participating in federal student financial aid programs. This data is made available to students and parents through the College Navigator college search website and to the general public through the IPEDS Data Center.

The NSF's National Science Board also produces insightful reports on national trends, including The State of the U.S. Science and Engineering 2024, The STEM Labor Force: Scientists, Engineers, and Skilled Technical Workers, and Research and Development: U.S. Trends and International Comparisons.

Within educational institutions, institutional research departments and Registrars' offices track internal data and can provide valuable, program-specific institutional data and trends.

Here are some key steps for institutions of higher education to effectively report admissions data, retention, and graduation rates for underserved groups:

1. Define underserved groups:

- Identify which groups are considered underserved at your institution (e.g., racial/ethnic minorities, first-generation students, low-income students).

2. Collect comprehensive data:
    - Gather demographic information during the application and enrollment processes.
    - Ensure data collection methods are consistent and compliant with privacy laws.

3. Track key metrics:
    - Admissions Data:
        - Application rates: Track the number and percentage of applications from each underserved group.
        - Acceptance rates: Calculate the percentage of applicants from each group who are offered admission.
        - Yield rates: Measure the percentage of admitted students from each group who actually enroll.
    - Retention Rates:
        - First-year retention: Monitor the percentage of students from each group who return for their second year.
        - Year-to-year retention: Track retention between each subsequent year of study.
        - Term-to-term retention: Consider tracking retention between semesters or quarters for more granular data.
    - Graduation Rates:
        - 4-year graduation rate: Percentage of students from each group who graduate within 4 years.
        - 6-year graduation rate: Often used as a standard measure, especially for public institutions.
        - Extended graduation rates: Consider tracking 8-year or 10-year rates for non-traditional students.
    - Additional Metrics:
        - Academic performance: GPA, credits earned, participation in honors programs.
        - Engagement: Participation in student organizations, study abroad, and internships.
        - Post-graduation outcomes: Employment rates, graduate school enrollment.

4. Disaggregate data:
    - By Specific Underserved Groups:
        - Race/Ethnicity: Break down data for specific racial and ethnic groups (e.g., Black/African American, Hispanic/Latino, Native American).
        - Socioeconomic status: Consider categories based on family income or Pell Grant eligibility.
        - First-generation status: Separate data for first-generation college students.
        - Gender: Include categories beyond binary gender classifications.
        - Disability status: Track metrics for students with disabilities.
        - Veteran status: Disaggregate data for student veterans.
    - Intersectionality:
        - Combine multiple demographic factors (e.g., race and gender, first-generation and low-income).
        - This approach can reveal more nuanced patterns and disparities.
    - Geographical Factors:
    1. Urban vs. rural backgrounds
    2. In-state vs. out-of-state students
        - International students from different regions
    - Academic Programs:
    3. Break down data by college, school, or department within the institution.
        - Track representation in STEM fields vs. humanities and social sciences.

- Entry Pathways:
    - Distinguish between new first-year students and transfer students.
    - Track outcomes for students entering through special admission programs.
- Time-based Analysis:
    - Cohort tracking: Follow specific groups of students over time.
    - Year-over-year comparisons: Analyze trends and changes across academic years.
- Comparative Analysis:
    - Compare metrics for underserved groups with those of the overall student population.
    - Benchmark against peer institutions or national averages.
- Statistical Significance:
    - Ensure that sample sizes are sufficiently large for meaningful analysis.
    - Use appropriate statistical tests to determine whether the differences between groups are significant.
- Data Visualization:
    - Use charts, graphs, and dashboards to clearly illustrate disaggregated data.
    - Consider interactive visualizations that allow users to explore different demographic breakdowns.
- Narrative Context:
    - Provide written explanations to accompany disaggregated data.
    - Discuss factors that may influence observed patterns or disparities.

By thoroughly tracking these metrics and carefully disaggregating the data, institutions can gain valuable insights into the experiences and outcomes of underserved groups. This comprehensive approach enables more targeted interventions, policy adjustments, and support services to enhance equity and inclusion in higher education.

Ranking System: Success in Teaching Underserved Groups

The nation needs to prioritize having higher education institutions report the performance of underserved students in their engineering programs. ASEE or another credible organization should create a ranking system based solely on the access and success of underserved and first-generation students. This ranking system should be reported annually and communicated widely.

Creating a ranking system for higher education institutions based on their access to and success in teaching underserved groups is a complex task that requires careful consideration of multiple factors. Here’s an approach to developing such a system:

1. Key Metrics (60% of total score)

a. Enrollment/Access (15%)

- Percentage of underserved and first-generation students enrolled compared to the regional demographic
- Growth in enrollment of underserved and first-generation groups over time

b. Retention (20%)

- First-year retention rate for underserved and first-generation students
- Overall retention rate for underserved first-generation students

c. Graduation (25%)

- 4-year and 6-year graduation rates for underserved and first-generation students
- Time to degree completion for underserved and first-generation students

2. Academic Success Indicators (20% of total score)

- GPA of underserved and first-generation students compared to the overall student body
- Participation rates in honors programs, research opportunities, and internships
- Post-graduation outcomes (employment rates, graduate school enrollment)

3. Campus Climate and Support (15% of total score)

- Diversity of faculty and staff
- Availability and funding of support programs for underserved and first-generation students
- Campus climate survey results from underserved and first-generation students

4. Financial Support (5% of total score)

- Availability of scholarships and grants for underserved and first-generation students
- Average debt at graduation for underserved and first-generation students compared to the overall student body

Calculation Method

1. For each metric, calculate a score from 0–100 based on performance relative to peer institutions or national averages.
2. Apply the weights listed above to each category.
3. Sum the weighted scores to get a final score out of 100.

Data Collection and Verification

- Require institutions to submit standardized reports annually
- Conduct random audits to ensure data accuracy
- Use third-party verification for key metrics where possible

Ranking Categories

- Create separate rankings for different types of institutions (e.g., large public flagship, smaller public, private, community colleges)
- Provide overall rankings as well as rankings by specific underserved groups and first-generation students

Transparency and Updates

- Publish full methodology and data sources in multiple outlets to get national exposure
- Update rankings annually
- Allow for a feedback and appeal process for institutions

This framework evaluates institutions based on access and success in teaching underserved groups. This system takes into account various factors that contribute to the enrollment, retention, and success of underserved and first-generation students.

Key aspects of this ranking system include:

1. **Emphasis on outcomes**: The system heavily weights retention and graduation rates, which are crucial indicators of an institution's success in supporting underserved and first-generation students.
2. **Holistic approach**: Beyond just enrollment and graduation, the system considers factors like campus climate, financial support, and post-graduation outcomes.
3. **Relative performance**: Scores are calculated based on performance relative to peer institutions or national averages, allowing for fair comparisons.
4**. Transparency**: The methodology is clearly defined, and data sources are to be published, ensuring transparency in the ranking process.
5. **Flexibility**: Separate rankings for different types of institutions acknowledge the diverse landscape of higher education.

This system aims to provide a comprehensive evaluation of how well institutions are serving underserved groups and first-generation students. However, it's important to note that any ranking system has limitations and potential biases. Regular review and refinement of the methodology would be necessary to ensure its continued relevance and fairness.

Section 6: Reimagining Registration and Admissions Systems for the Future of Engineering Education

Introduction

The Engineering Mindset Report calls for transformative changes that intersect crucial registrar and admissions functions. As engineering education evolves to meet the demands of a rapidly changing world, the systems that support it must also adapt.

The Engineering Mindset Report emphasizes the necessity for a comprehensive overhaul of registrar and admissions processes to align with the evolving landscape of engineering education. This transformation is crucial to ensure that these systems can effectively support the dynamic needs of both students and institutions.

Registrar Functions: The registrar's office plays a pivotal role in managing student records, course registration, and academic progress. To keep pace with changing demands, registrars must adopt more flexible and efficient systems. This includes integrating advanced technologies such as artificial intelligence and data analytics to streamline administrative tasks, provide personalized academic advising, and enhance the overall student experience. By doing so, registrars can better support diverse learning pathways, including interdisciplinary courses, online learning, and experiential opportunities.

Admissions Functions: Admissions processes must also evolve to reflect a more holistic approach to evaluating applicants. Traditional metrics, such as standardized test scores, are no longer sufficient to capture the full potential of prospective students, especially those from underserved or disadvantaged backgrounds. The report advocates for including alternative criteria such as personal statements, portfolios, interviews, and extracurricular achievements. These measures can provide a more comprehensive view of an applicant's capabilities, creativity, and potential for success in engineering programs.

Intersection of Registrar and Admissions Functions: The intersection of registrar and admissions functions is crucial for creating a seamless and supportive educational environment. By aligning these processes, institutions can ensure that students are not only admitted based on a holistic evaluation but also receive ongoing support throughout their academic journey. This alignment can lead to improved student retention and success rates, as well as a more inclusive and diverse student body.

Adapting to Change: As the demands of the engineering profession continue to evolve, so too must the systems supporting education. This includes embracing innovative practices, fostering a culture of continuous improvement, and ensuring that policies and procedures remain flexible enough to adapt to future challenges. By implementing the transformative changes outlined in the Engineering Mindset Report, institutions can better prepare students for the complexities of the modern world and maintain their competitive edge in the field of engineering education.

Admissions Contributions to Increase Access

An admissions system that better measures potential, creativity, and problem-solving is needed to level a very uneven K-12 learning experience. Evaluating potential and creativity in applicants to engineering programs, particularly those from lower-performing K-12 schools, requires the use of diverse and holistic measures. Here are some effective criteria to consider:

1. **Problem-Solving Skills:** Assessing how students approach and solve open-ended problems can reveal their creativity and innovative thinking. This can be done through specific problem sets or project-based assessments (Belski, 2017).
2. **Portfolios:** Encouraging students to submit portfolios showcasing their creative projects, designs, or any relevant work can provide insight into their practical skills and creative potential (Ragusa, 2014).

3. **Interviews:** Conducting interviews enables evaluators to gain a deeper understanding of the student's thought processes, creativity, and potential, beyond what is captured in written applications (Ragusa, 2014).
4. **Creativity Tests:** Utilizing standardized creativity assessments, such as those that measure divergent thinking and the ability to generate novel ideas, can be beneficial (Belski, 2017).
5. **Extracurricular Involvement:** Participation in activities that require creative thinking, such as robotics clubs, art projects, or community initiatives, can demonstrate a student's creativity and potential (Ragusa, 2014).
6. **Letters of Recommendation:** Recommendations from teachers or mentors who can speak to the student's creative abilities and potential can provide valuable insights (Ragusa, 2014).
7. **Personal Statements:** Essays that allow students to discuss their creative experiences, challenges they've overcome, and their aspirations can highlight their potential and innovative thinking (Ragusa, 2014).
8. **Competitions and Awards:** Recognizing achievements in competitions, hackathons, or other events that require creative problem-solving can be a strong indicator of a student's potential (Ragusa, 2014).

By incorporating these measures, engineering programs can more accurately assess the potential and creativity of applicants, ensuring a diverse and dynamic student body.

Reimagining for Registrars

One critical area ripe for transformation is the registration system. Reimagining registration systems for the future of engineering education involves creating more flexible, efficient, and student-centered processes that enhance the overall educational experience.

Modern registration systems should be designed to accommodate diverse learning pathways, including interdisciplinary courses, online learning, and experiential opportunities. By leveraging advanced technologies such as artificial intelligence and data analytics, these systems can provide personalized recommendations, streamline administrative tasks, and ensure students can easily navigate their academic journeys.

Furthermore, a reimagined registration system can support greater inclusivity and accessibility. By removing barriers and simplifying processes to support innovative curricula, institutions can ensure that all students have equal opportunities to succeed regardless of their background or circumstances.

This initiative aims to create a seamless and supportive environment where students can focus on their learning and development, rather than being bogged down by administrative hurdles. By embracing innovation in registration systems, engineering education can better prepare students for the challenges and opportunities of the future.

KEY IMPACTS FOR REGISTRARS' OFFICES TO CONSIDER:
Chapter numbers refer to The Engineering Mindset Report.

FLEXIBLE PATHWAYS (Chapter 3)
Create curricula and support structures that provide more seamless transitions.

- Multiple entry points into programs
- Alternative prerequisite structures
- Transfer pathway improvements
- Credit for prior learning
- Modular course registration

COURSE SCHEDULING INNOVATIONS (Chapter 3)
Modularize the engineering curriculum to allow students to flexibly choose their pathways.

- Support for shorter course modules
- Flexible scheduling options
- Variable-credit assignments
- Non-traditional term structures
- Hybrid delivery modes

TRANSFER-STUDENT SUPPORT (Chapter 7)
Form strategic partnerships with community colleges to bring about change.

- Improved articulation processes
- Streamlined credit evaluation
- Partnership documentation
- Multiple pathway tracking
- Transfer student success metrics

ASSESSMENT SYSTEMS (Chapter 3)
Assess for competency (mastery) and employ formative assessments.

- Competency-based grading support
- Alternative grading schemes
- Progress tracking systems
- Mastery documentation
- Flexible completion timelines

CRITICAL SYSTEMS CONSIDERATIONS:

STUDENT INFORMATION SYSTEMS
Chapter 6 highlights the need for:

- Flexible prerequisite enforcement
- Multiple pathway tracking
- Progress monitoring capabilities
- Competency documentation
- Transfer credit processing

DEGREE AUDIT SYSTEMS
To support recommendations in Chapter 3:

- Multiple pathway options
- Modular course tracking
- Competency verification
- Transfer equivalencies
- Alternative completion routes

DATA COLLECTION & REPORTING
Chapter 6 emphasizes tracking:

- Student progression metrics
- Access and success indicators
- Transfer student success

- Completion pathways
- Time to degree metrics

COLLABORATION OPPORTUNITIES:

PARTNER WITH:
- Engineering departments (Chapter 6)
- Community colleges (Chapter 7)
- Student support services (Chapter 5)
- Academic advisors (Chapter 3)
- Industry partners (Chapter 7)

POTENTIAL CHALLENGES TO ADDRESS:
The report acknowledges:
- System constraints
- Policy limitations
- Resource needs
- Implementation timing
- Change management

NEXT STEPS:
1. Review current systems for flexibility.
2. Identify potential barriers.
3. Explore system modifications.
4. Partner with engineering faculty.
5. Plan staged implementation.

References

1. Belski, I. (2017). *Engineering creativity – How to measure it?* Paper presented at the AAEE2017 Conference, Manly, Sydney, Australia. Australasian Association for Engineering Education. https://aaee.net.au/wp-content/uploads/2018/09/AAEE2017-Belski-How*to*measure*engineering*creativity.pdf
2. Ragusa, G. (2014, August 4–5). *Creativity and propensity for innovation in engineering*. Paper presented at the Epicenter Research Summit, Stanford University. http://epicenter.stanford.edu/documents/sessiona2.pdf

Section 7: Leveraging Strategic Partnerships

Something hit me very hard once, thinking about what one little man could do. Think of the Queen Elizabeth — the whole ship goes by and then comes the rudder. And there's a tiny thing at the edge of the rudder called a trim tab. It's a miniature rudder. Just moving the little trim tab builds a low pressure that pulls the rudder around. Takes almost no effort at all. So I said that the little individual can be a trim tab. Society thinks it's going right by you, that it's left you altogether. But if you're doing dynamic things mentally, the fact is that you can just put your foot out like that and the whole big ship of state is going to go. So I said, 'Call me Trim Tab.'

—Buckminster Fuller

Fostering Strategic Partnerships

Partnerships will be needed to revolutionize engineering, engineering technology, and related fields. Change cannot be achieved solely by educators changing what, when, or how they teach the students; such change incrementally improves our students' experiences and learning outcomes. Engineering education is an extensive, distributed system with many stakeholders; any revolution will fail without undertaking the hard work of creating strong partnerships across many stakeholder groups.

Addressing Recommendation 5.2: Foster partnerships among accreditation agencies, academia, and industry councils that focus on engineering in a societal context.

Many groups have a stake in the field of engineering education. All these groups, and others not listed here, will need to be engaged in any substantive systemic changes:

- Industry: i.e., entities of all types that hire engineers, technologists, and professionals in related fields.
- Professional societies related to engineering.
- Professional societies related to education, including those involved in administrative functions.
- Federal and state fiscal and governance support—states are an essential but underutilized resource.
- University and program accreditation organizations and agencies.
- Entities that develop student information and student learning systems.
- Entities that develop course teaching materials in both public and private spaces.
- University leaders at the Board and System levels who have fiduciary oversight and control.
- University administrators at all levels, including Deans and program or department leaders.
- Faculty and advisors.
- Students and parents.
- Pre-college educators, administrators, and policymakers
- Community engagement entities such as scouting organizations, museums, and others.

The list of organizations above is too long to be tackled with a single effort. While it would be ideal to have a simple step-by-step process to develop necessary partnerships one at a time, the interdependence of these groups means that the emerging ideas and interactions needed for success prevent such a straightforward approach. The remainder of this section explores ideas for establishing the partnerships necessary to support systemic change.

The main strategy is to **foster** partnerships among engineering education stakeholders, including accreditation agencies, academia, and industry councils that focus on engineering within a societal context. We should establish excellent forums to support these collaborations, similar to how the World Economic Forum at Davos functions for economic policymakers, funding organizations, and high-level administrators.

Currently, while many groups work in engineering education, there is no central organization that seeks to understand the overall system and connect with related groups. Our recommendation is to develop a "network of networks" model to continuously engage the various groups that influence engineering education. Engaging all stakeholders is simply too much; there is an optimal size for groups to function effectively. The goal of these efforts is to include relevant nearby networks, such as CUPA-HR and enrollment management, which have their own networks, concerns, and professional societies.

The network-of-networks model can also be seen as an "admiral of the fleet" approach, where the admiral's role isn't to control each ship but to set the overall direction and communicate with ship captains about their concerns. (See Appendix 2, Framework for Transformational Change). In other words, involve stakeholders in a continuous value creation process, encompassing all ships in the fleet. The proposed network would include representatives from Deans, department heads, ABET, and other stakeholders. Additionally, non-engineering groups, such as regional accreditors and registrars, would also participate.

An immediate step is to establish a funded organization that focuses on involving adjacent groups to consult on engineering education issues, address implementation challenges, and share ideas from a wide range of perspectives before major implementation efforts begin. With status and access, this group would help coordinate agendas for engineering education among different stakeholders. Creating this organization will need more than just federal funding; it will also require partnerships with industry. An existing model is ERVA, but the new organization will focus on coordinating human development for future needs.

For example, there is an existing group that unites regents and trustees – the American Council of Trustees and Alumni (ACTA) (https://www.goacta.org/) – which helps Boards of Trustees address issues. This explains why trustees across different states and systems often agree on necessary changes in higher education. This report envisions a similar organization in engineering education. The proposed group would hold an annual conference or similar event to engage stakeholders and discuss trends in engineering education and their systemic effects.

There are additional examples where unique organizations have fostered collaboration among competitors. Examples of these include:

- ERVA cultivates collaborative partnerships between industry and academic researchers to recommend the necessary focus for funding.
- NACME promotes collaboration between industries and universities to broaden participation in engineering.
- GUIPRR-NAE facilitated a group that included government, industry, and philanthropic entities to engage in dialogue on issues related to engineering development and education.
- NSF ERC-funded centers bring together researchers from multiple campuses to collaborate on targeted challenges, advancing research contributions to societal value in partnership with relevant industries and communities.
- NSF Regional engines are regionally focused collaborations aimed at economic and workforce development, involving cutting-edge technological advancements that impact entire regions.
- Past NSF engineering education coalitions involved multiple, diverse engineering programs and industry advisors to innovate learning curricula and pedagogy.

The real challenge in this recommendation is finding a practical model and reasoning for forming essential partnerships. The model, consistent with the mindset report, should focus on expanding the partnership over time rather than excluding potential collaborators.

Section 8: Engaging with ABET to Support Curricular Innovation

Introduction
In today's rapidly evolving educational landscape, collaboration with accrediting bodies like ABET, which is the accreditation board for engineering and technology programs, is essential for fostering curricular innovation. This partnership ensures that engineering programs not only meet rigorous standards but also adapt to the changing needs of the industry and society.

ABET's focus on continuous improvement and quality assurance provides a robust framework for institutions to evaluate and enhance their educational practices. Through this partnership, institutions can ensure their programs remain relevant, competitive, and equipped to prepare graduates for future challenges.

Gathering stakeholders to update ABET definitions could foster new collaborative initiatives that emphasize the importance of innovation, transforming an antagonistic relationship into a more cooperative one. Outcomes might range from minor adjustments to more systemic changes.

Addressing Recommendation 4.3: Revise program accreditation requirements to align with the changing needs of our society.

This recommendation involves collaboration between industry, multiple institutional leaders, professional societies, and ABET to create a process more responsive to our society's changing needs.

This recommendation aims to strengthen ABET's support for innovations in engineering degree programs that follow the Engineering Mindset recommendations. ABET already offers innovation awards, has processes in place that allow programs to implement innovative practices, and conducts reviews to ensure that ABET's innovation goals align with program assessments. However, programs being reviewed often fear innovation because their confirmation bias magnifies negative experiences that colleagues or other programs may have had with program evaluation, including the interpretations of curricular compliance by ABET Program Evaluators (PEVs). We have an opportunity to improve programs' perceptions of ABET and better prepare PEVs and programs to foster innovation.

We recommend updating the ABET definitions in small but significant ways, establishing new collaborative initiatives to emphasize the importance of innovation, and transforming a confrontational relationship into one of greater collaboration and partnership that supports innovation in engineering education.

Action Items

1. Collaborate with ABET to create a culture that fosters risk-taking and innovation aligned with the Engineering Mindset recommendations.
    - Acknowledge and communicate ABET's efforts to improve the accreditation process in areas such as PEV onboarding, revising criteria, and being responsive to the engineering profession.
    - Engage the Mindset effort to continue and enhance the promotion of the ABET Innovation Award - great job, ABET! Expand the awards to highlight more innovative programs.

2. Collaborate with ABET to better understand and acknowledge the confirmation bias that faculty and institutions possess regarding ABET program evaluations.
   - Assist ABET in reviewing the accreditation process while considering the human impact of this process from the perspective of university faculty and administrators.
   - Work to promote those actively involved in Mindset activities who are transitioning into PEV roles, particularly for groups that are currently underserved.
   - Foster more transparency in and about ABET processes.
   - Propose the creation of an ABET Tiger Team to consult pro bono at the invitation of programs seeking innovation, assisting them in better preparing for the associated impacts on accreditation. This engagement could be included in the pre-visit materials that PEVs review.

3. Collaborate with ABET and professional societies to update the EAC Definitions to support innovation aligned with the Engineering Mindset recommendations.
   - Begin a conversation with the engineering criteria committee and a small team from Mindset/Blueprint.
   - Discuss moving away from a definition of college-level mathematics that assumes math starts with calculus, and focus more on the mathematics that evidence shows engineers need and use in their practice of engineering[1]. An example of such a change might be:

College-level mathematics consists of mathematics that requires a degree of mathematical sophistication (applicability that aligns with the practice of engineering and program outcomes) at least equivalent to that of introductory calculus. For illustrative purposes, some examples of college-level mathematics include calculus, differential equations, probability, statistics, linear algebra, and discrete mathematics.

- Discuss changing the definition of basic science to recognize that the practice of engineering in the 21st century increasingly addresses social and human problems, and engineers should have some formal training to support the attainment of program outcomes. An example of a revised definition is:

Basic science encompasses disciplines focused on acquiring knowledge or understanding of the fundamental aspects of natural or social phenomena. The natural sciences include chemistry, physics, life sciences, earth sciences, and space sciences. The social sciences comprise economics, sociology, psychology, and related human-centered disciplines.

- Engage with professional society accreditation committees to consider how the modified definitions of math and science might impact individual program criteria.
- Given the impact on equity in attaining an engineering degree, it would be beneficial to jointly revisit the assumption that all students entering engineering programs are prepared for Calculus.

An example of larger changes that could emerge later, after building trusting relationships, would be to address more fundamental questions about systemic change. For example, what if we assume that EC2000 has run its course and the shift to outcomes-based education needs to be fundamentally re-examined? In other words, is it time for another pivot in accreditation? If so, what would this look like? How would we broadly solicit ideas from the community at large to shift the direction of accreditation?

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[1] FYI - the NCEES Other Disciplines FE Exam includes ~10% on Math (including analytical geometry, trigonometry, and algebraic equations), ~7% on probability and statistics, ~5% on chemistry, ~7% economics, ~7% engineering ethics and societal impacts.

Another way to consider this recommendation for fostering partnerships is to recognize that we have constituencies at the local level through organizations like ABET, but we have not identified or understood which constituencies we need to connect with regularly for engineering education as a whole. In this context, constituencies include not only those whose needs we serve but also those whose assistance is essential for the large-scale changes required to shift mindsets. These efforts take a top-down approach to provide necessary engagement across the spectrum of constituencies, but more grassroots or bottom-up initiatives are also needed to sustain momentum.

For example, a parallel but essential effort would be to use the Engineering Mindset and Blueprint reports as artifacts to help individuals already engaged in evolving engineering education to self-identify the work they are doing. Then, we could hold an event, such as a conference, to invite those individuals to discuss their work and capture how it is being implemented. This type of community-building exercise is a necessary complement to the top-down efforts described previously. Such activities are already being carried out in integrative engineering (https://www.integratedengineering.org) and among some Deans.

Connecting top-down and bottom-up efforts is essential, as it creates opportunities for individuals to form partnerships and expand their local networks, thereby involving more people in broader discussions. An example is the various research initiation programs in engineering education that connect engineering faculty with experts in the field. This section is rich in actions that require high-level involvement, while other sections emphasize actions that individuals can undertake. Clearly developed pathways are necessary for those with an interest and who start at a local level to become more involved at progressively higher levels. Engagement should prepare individuals for administrative roles and facilitate their transition into these positions.

Addressing Recommendation 5.3: Facilitate discussion among ABET, NSPE, and academic institutions regarding the artificial divide between engineering and engineering technology.

Due to the challenges posed by the current siloed systems separating engineering and engineering technology, some students and engineers have faced difficulties in transferring between programs and in obtaining licensure and professional job opportunities. To address this divide, we suggest a different approach and recommend, at a minimum, a third option that distinguishes BS degree programs in engineering technology. There is also an opportunity to consider more competency-based models for degrees and licensure.

For example, BS programs in engineering and engineering technology are held to not only general criteria for either engineering or engineering technology by ABET, but also—if they include an adjective such as electrical, mechanical, or robotics—ABET works with the program to determine which specific degree criteria should apply. However, sometimes the curricular differences between engineering and engineering technology programs are relatively minor, and employers often hire graduates from either type for certain jobs, sometimes labeling these positions as engineering roles. Therefore, as noted in the Grinter report, engineering professionals may demand either theoretical and design skills or transformative and applied skills. ABET should avoid contributing to this siloing effect on students by not forcing them to choose between engineering and engineering technology, or specific program paths like electrical or mechanical, especially since future engineers will need to operate in increasingly integrated and convergent environments.

Currently, perceptions of prestige, status, and opportunities differ between degrees labeled as engineering versus engineering technology, and the perceived need to count only coursework labeled as engineering or technology is problematic. That is, even courses that cover the same topics for a significant portion of the course can only count toward one or the other degree plan, which creates barriers to degree completion that may be irrelevant to employers.

Addressing Recommendation 5.4: Create a new accreditation option specifically for BS degree programs in engineering technology or modify ETAC to include BS engineering technology programs.

BS Engineering Technology programs serve an essential and unrecognized role in preparing engineers. The best BS engineering technology programs are more similar to traditional engineering programs than they are to AS technology programs that prepare technicians. The unrecognized contributions of BS engineering technology programs in preparing engineers can be partially remedied if ABET were to modify the existing Engineering Technology Accreditation Commission (ETAC) requirements to include only BS engineering technology programs, rather than technicians. A new ABET accreditation option is needed for engineering technicians, which would utilize existing elements of the current ETAC program to evaluate and accredit associate degree and BS programs that do not meet the enhanced standards for BS engineering technology programs.

Another option is to have the Engineering Accreditation Commission (EAC) change/reduce the (outdated) one year of math and science. Current EAC student outcomes are heavily focused on design, whereas ETAC student outcomes emphasize application. That language could be modified while pleasing both parties. With these small changes, engineering technology graduates could be classified under EAC, and the licensure and U.S. Office of Personnel Management (OPM) issues described earlier would be resolved.

To implement a new accreditation option for BS engineering technology programs, a task force of experts from academia, industry, and accreditation bodies would be needed to develop proposals, ensuring stakeholder alignment. They would define program criteria focused on applied learning, practical skills, and industry relevance, while creating rigorous but flexible accreditation standards. Assessment methods would be designed, and the process would be piloted with volunteer institutions. Evaluators would be trained to ensure quality, and the new accreditation would be rolled out in phases. Continuous monitoring and collaboration with stakeholders would ensure ongoing improvements and broad recognition.

Section 9: NSF Support for the Engineering Mindset Initiative

The National Science Foundation (NSF) has long played a pivotal role in shaping the future of STEM education through its commitment to innovation, equity, and excellence. As the demands on the engineering workforce evolve, so too must the educational systems that prepare future engineers. The *Mindset Report* offers a timely and transformative vision for engineering education—one that centers on cultivating an engineering mindset characterized by creativity, ethical responsibility, resilience, and a commitment to continuous learning and accountability.

The NSF's support is critical to implement the recommendations of the *Mindset Report*, which provides a comprehensive roadmap for modernizing engineering education to better serve students, institutions, and society. By investing in this initiative, NSF can catalyze systemic change across higher education, expand access for underserved learners, and ensure that engineering graduates are equipped not only with technical expertise but also with the mindset needed to lead in a rapidly changing world.

Regional Alliances for Improving Engineering Education

A report by Singer, Schweingruber, and Brenner (Singer et al., 2024) highlights the importance of regional alliances for improving science education in the United States. They found that local collaborations among schools, higher education institutions, businesses, and community groups can achieve what top-down directives cannot.

Here's a summary of the key points from the Singer report:

1. The authors highlight the success of a regional alliance in southeastern Tennessee, where schools, businesses, universities, and community groups collaborated to enhance science teaching and learning.
2. The report draws from the National Academies' 2021 *Call to Action for Science Education*, which emphasizes the need for better and more equitable science education from K through 16.
3. Regional alliances for STEM opportunities, which involve K-12 schools, postsecondary institutions, informal education, businesses, and other stakeholders, are highlighted as a key strategy.
4. The approach aims to prepare a capable workforce and build foundational science literacy for everyone, regardless of their background or circumstances.
5. The report compares this approach to earlier national efforts aimed at improving science education, which often relied on top-down directives or changes to the curriculum.
    - Benefits of regional alliances include:
    - Strengthening teacher training
    - Ensuring lessons are relevant to students' lives
    - Collecting data for assessment and improvement
    - Creating a more engaged citizenry and an able workforce
6. Successful alliances often involve actions like developing supportive pathways in science learning, recruiting and retaining diverse teachers, providing resources, connecting people across sectors, and implementing accountability measures.
7. The authors stress the importance of coordinating between K-12 and higher education to create a seamless educational continuum.
8. The report suggests that regional alliances can help address teacher shortages and create collaborations with local industries.

9. This includes examples of successful alliances, such as the Defense Science, Technology, Engineering, and Mathematics Education Consortium (DSEC) and several state-level initiatives.
10. The authors recommend that various sectors, including state governments, philanthropies, and federal agencies like the National Science Foundation, support these alliances.
11. The report concludes that regional alliances offer a powerful way to improve science education and find common ground amid political polarization.

Building on the successful concept of forming regional alliances for science education, the NSF should develop programs that establish regional centers to promote the recommendations outlined in the Engineering Mindset Report. We suggest that the NSF establish two new programs, as described below, to support engineering and engineering technology programs in implementing the recommended changes outlined in the Mindset Report.

NSF FUEL Program: Fostering Undergraduate Engineering Learning

Changing the landscape of undergraduate engineering education is the foundational idea behind a new NSF program, Fostering Undergraduate Engineering Learning (FUEL). This program complements the NSF's Regional Innovation Engines Program and ERC programs, aiming to inspire enterprise-wide changes in undergraduate engineering and engineering technology education on a regional scale across the nation. The new NSF program will initiate a movement through a closely knit community of various higher education institutions, industry partners, national laboratories, research centers, and PK-12 school districts. Together, they will act as change agents essential for systemic, enterprise-wide improvement in engineering education across 10 regional sites.

FUEL is modeled after the NSF Gen-4 Engineering Research Centers (ERC) and the Regional Innovation Engine programs. These programs support innovative undergraduate engineering and engineering technology curricula and pedagogical initiatives that align with the recommendations of the Engineering Mindset and Blueprint Report. FUEL promotes high-impact learning innovations that aim to enhance effectiveness, foster diversity, and improve access, ultimately increasing the number of graduates and creating a better-prepared and more inclusive engineering workforce.

We recommend that NSF establish a new program to support up to 10 FUEL sites, which will be allocated regionally within the U.S. This initiative will enable every state to engage in advancing and expanding undergraduate engineering and engineering technology programs. Each FUEL site will encompass multiple universities, national labs, Department of Defense programs, NASA, nonprofits, businesses, PK-12 public, private, or charter schools, and other U.S. organizations. The program aims to catalyze and nurture learning innovation ecosystems across the U.S. to:

- Advance undergraduate engineering and engineering technology education.
- Cultivate partnerships across industry, academia, government, nonprofits, civil society, and communities of practice.
- Promote and stimulate economic growth and job creation.
- Spur regional talent and innovation.

Transforming and Re-engineering the Engineering Education System (TREES)

In addition to the FUEL program, ongoing convergent research is necessary to identify effective practices and policies that can transform educational institutions, allowing engineering programs to discover and implement innovative teaching and learning systems. ***The NSF should fund at least one Engineering Research Center (ERC) to support the overall goals of the Inclusive Engineering Mindset recommendations.***

The findings and recommendations in the *Engineering Mindset Report* are clustered around six main themes:

1. Creating flexible program structures to remove barriers to entry and completion
2. Creating a student-centered engineering education that relies on evidence-based pedagogies
3. Providing an accessible and diverse engineering education learning environment
4. Preparing campuses for a student-centered engineering education
5. Leveraging strategic partnerships
6. Engineering a new mindset for engineering education

These recommendations serve as the driving force behind the research center's goals and research thrusts. Addressing these challenges will remove existing educational barriers, increase access and success, and improve instruction, ultimately leading to better student outcomes and the next level of excellence in engineering education in our nation. This center, Transforming and Re-engineering the Engineering Education System (TREES), will become a foundational element for the success of *all* ERCs by preparing the next generation of engineering graduates with the capabilities to advance the engineering profession.

The primary goal of the center's convergent research program is to identify practices and policies to transform educational institutions so that engineering programs can discover and implement new teaching and learning systems where we admit a more inclusive and diverse student population and realize the full potential of every student, equipping them to meet the societal challenges of today and tomorrow. The three research thrust (RT) areas for the ERC are: (RT1) *Affordability and Accessibility* of Engineering Education, (RT2) *Pedagogy and Content for 21st Century Issues* to address disconnects between what is required and what is currently included, and (RT3) *Propagation Strategies* for Educational Innovations.

The gaps in the knowledge base identified by the Engineering Mindset team include:

- A weed-out mentality that excludes vast proportions of our society from engineering at a time when the need for engineering talent and diversity of thought is more critical than ever;
- A focus on introductory courses in mathematics and science, especially calculus, as the foundation of all engineering, which is then viewed as a proxy for identifying engineering student talent;
- An emphasis on technical competency and monetary profits rather than human impacts and social good;
- An education system that is inflexible, uninspiring, unwelcoming, and unattractive to many segments of our diverse population, despite research that shows the power and innovation that stems from diverse ways of knowing; and
- A reliance on professors who lecture at their students, despite extensive scholarship on the merits of student-centered, active learning pedagogies.

Despite the millions of dollars (perhaps billions) invested by the NSF and other organizations to enhance access to engineering education, our programs and educational institutions remain essentially unchanged. Through a comprehensive examination of engineering education and mindset, the TREES Center will conduct research and testbed studies to develop a systemic engineering education blueprint for the future. The significant system-wide change we envision in the training and ongoing support of engineers throughout their careers will necessarily require substantial investment, such as that available through the NSF ERC program. Small, locally focused engineering education "projects" face greater challenges in catalyzing systemic change. A national effort, informed by previous initiatives and emerging research, is needed to achieve the fundamental transformation our engineering educational system requires. The 10-year timeframe and the convergent research focus of an ERC will also allow us to conduct essential longitudinal studies, enabling us to truly identify promising practices that will advance our engineering education system into the future.

In conclusion, the Engineering Mindset Initiative, supported by the National Science Foundation, represents a bold and necessary step toward reimagining engineering education for the 21st century. Through the proposed FUEL and TREES programs, NSF has the opportunity to drive systemic, scalable, and sustainable change that aligns with the evolving needs of society, industry, and learners. By fostering comprehensive, innovative, and interdisciplinary approaches to teaching and learning, these initiatives will not only enhance the quality and accessibility of engineering education but also empower a diverse new generation of engineers to lead with purpose, creativity, and resilience. The time to act is now—transforming engineering education is not just a strategic imperative, but a national priority.

Reference

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Section 10: Collaborating with Colleges of Liberal Arts

Integrating liberal arts into undergraduate engineering education produces well-rounded engineers who are not only technically proficient but also socially and culturally aware. Integrating liberal arts into engineering education offers a wide range of advantages that enrich students' academic experience and better prepare them for the complexities of the modern world. Here are some key benefits:

1. **Enhanced Communication Skills**

Liberal arts courses emphasize writing, speaking, and critical reading, which help engineering students articulate complex ideas clearly and effectively—an essential skill in team settings, leadership roles, and when interacting with non-technical stakeholders.

2. **Broader Ethical and Social Awareness**

Courses in philosophy, history, and sociology encourage students to consider the ethical, cultural, and societal implications of engineering decisions. This fosters a sense of responsibility, helping engineers design solutions that are socially just and environmentally sustainable.

3. **Improved Critical Thinking and Problem-Solving**

Liberal arts disciplines train students to analyze problems from multiple perspectives, question assumptions, and think creatively—skills that complement the analytical rigor of engineering and lead to more innovative solutions.

4. **Greater Adaptability and Lifelong Learning**

Exposure to diverse fields cultivates intellectual curiosity and adaptability, preparing students to navigate career changes, interdisciplinary work, and the evolving demands of the global workforce.

5. **Stronger Leadership and Teamwork Abilities**

Understanding human behavior, motivation, and organizational dynamics—often explored in psychology, political science, or literature—can make engineers more effective leaders and collaborators.

6. **Increased Empathy and User-Centered Design**

Liberal arts help engineers develop empathy, which is crucial for designing technologies that truly meet users' needs, especially in diverse and underserved communities.

Strategies for Integrating Liberal Arts into Engineering

- Interdisciplinary Courses
  - **Engineering Ethics**: Courses that explore the ethical implications of engineering decisions can help students understand the societal impact of their work
  - **Societal Consequences of Engineering**: Introductory courses that study the societal consequences of engineering can set the tone for a holistic education
- Collaborative Projects
  - **Hands-on Activities**: Incorporate socially relevant, hands-on projects that require students to apply both technical and liberal arts knowledge
  - **Interdisciplinary Teams**: Encourage collaboration between engineering and liberal arts students on projects that address real-world problems.
- Integrated Curriculum
  - **General Education Courses**: Develop courses that combine liberal arts and engineering content, such as engineering ethics paired with hands-on engineering projects
  - **Writing and Communication**: Include writing exercises and communication skills training in engineering courses to improve students' ability to articulate technical concepts to a general audience
- Institutional Support

    - **Faculty Collaboration**: Promote collaboration between engineering and liberal arts faculty to design and teach interdisciplinary courses
    - **Support Networks**: Establish support networks for faculty and students to share best practices and resources
- Cultural and Historical Context
    - **Cultural History of Engineering**: Courses that explore the cultural history of engineering can help students appreciate the broader context of their work
    - **Public Technology Debates**: Engage students in debates around policy, management, economics, and environmental issues related to technology

Examples of Successful Integration

Lafayette College: Offers a unique A.B. degree program in Engineering Studies that bridges the gap between engineering and liberal arts, focusing on interdisciplinary skills to lead public technology debates

Harvey Mudd College: A liberal arts college with a strong engineering core where all students complete a broad core curriculum in humanities and social sciences.

University of San Diego: A private Catholic university that offers dual BS/BA degrees in Electrical, Industrial and Systems, Mechanical, and Integrated Engineering. All engineers complete a User-Centered Design course and the USD Core Curriculum, which includes extensive liberal arts courses, such as ethics, oral communication, and social science. The Integrated Engineering curriculum offers five technical concentrations, integrating the concept of a student's vocation with their engineering education. Concentrations include biomedical engineering, embedded software, sustainability, engineering and the law, and student-designed plans.

Purdue University: The Cornerstone Integrated Liberal Arts program is designed to enrich the undergraduate experience by integrating liberal arts into various disciplines, including engineering. This program offers a 15-credit-hour certificate that helps students develop critical thinking, communication, and cultural awareness skills.

Key Features of the Cornerstone Program:

- **Transformative Texts**: The program's gateway courses, SCLA 101 and 102, focus on transformative texts that have shaped human thought and history.
- **Interdisciplinary Approach**: Students engage with diverse perspectives and learn to appreciate the interconnectedness of different fields.
- **Skill Development**: Emphasis on reading closely, writing clearly, speaking confidently, and engaging with differing viewpoints.
- **National Recognition**: Cornerstone is recognized as a model for integrating liberal arts into higher education, with over 70 colleges and universities replicating its approach.

Here are some specific benefits of Purdue's Cornerstone program for engineering students:

- Enhanced Communication Skills
    - **Writing and Speaking**: Engineering students cultivate strong writing and speaking skills through courses that emphasize clear communication and effective argumentation.
    - **Articulation of Technical Concepts**: The program enables students to articulate complex technical concepts to non-specialists, a crucial skill for leadership roles and interdisciplinary

collaboration.

- Broader Perspective
    - **Critical Thinking**: Engaging with transformative texts and diverse perspectives enhances students' critical thinking skills, enabling them to approach problems from multiple angles.
    - **Cultural Awareness**: Exposure to cultural and historical contexts helps students understand the societal impact of engineering solutions.
- Interdisciplinary Collaboration
    - **Team Projects**: The program promotes collaboration among students from various disciplines, fostering a more holistic approach to problem-solving.
    - **Real-World Applications**: Students work on projects that require a combination of technical and liberal arts knowledge, preparing them for real-world challenges.
- Career Readiness
    - **Leadership Skills**: The ability to communicate effectively and think critically positions engineering students for career leadership roles.
    - **Adaptability**: The program's interdisciplinary nature enables students to become more adaptable and better prepared to navigate the complexities of the modern workforce.

By participating in the Cornerstone program, engineering students can become well-rounded professionals who are not only technically proficient but also adept at addressing complex societal issues from a broader perspective.

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Section 11: Community Colleges in Collaboration with Engineering Programs

Introduction

In today's educational landscape, collaboration between community colleges and engineering programs is essential for enhancing access and success for students. Community colleges serve as vital gateways to higher education, offering affordable and accessible pathways for a diverse range of students. By partnering with engineering programs, these institutions can provide students with the resources, support, and opportunities needed to excel in the field of engineering.

Such collaborations can help bridge the gap between introductory coursework and advanced engineering studies, ensuring students are well-prepared for the challenges of their chosen careers. Through joint initiatives, community colleges and engineering programs can develop seamless transfer pathways, align curricula, and provide joint advising and mentoring services. These efforts can significantly enhance student retention and completion rates while fostering a more inclusive and diverse engineering workforce.

Furthermore, these partnerships can harness the strengths of both types of institutions, merging community colleges' emphasis on accessibility and personalized education with engineering programs' focus on rigorous academic training and industry connections. By collaborating, community colleges and engineering programs can cultivate a supportive and dynamic educational environment that enables students to reach their full potential.

Addressing Recommendation 5.5: Form strategic partnerships with community colleges to bring about change, especially regarding credit transfer and increasing the viability of pathways to and through engineering degree programs.

"The Community-College Transfer System Is Broken. Who's to Blame?" by Huriya Jabbar and Lauren Schudde (2024), discusses the challenges in the community college transfer system and argues for a shift in perspective on addressing these issues. Despite the critical role of bachelor's degrees in accessing well-paying jobs, transfer rates from community colleges to universities remain persistently low. The authors argue that the issue is often misdiagnosed by focusing too narrowly on community colleges as the source of the problem. Campuses with engineering and/or engineering technology programs should collaborate with community colleges in their region to establish strategic partnerships that enhance the viability of pathways to engineering programs of study.

Based on six years of research in Texas, they argue that the transfer challenge is a broader issue in public higher education, not just limited to community colleges. The idealized "two plus two" transfer model rarely succeeds because of complex policies and institutional agreements. Universities often resist simplifying transfer processes, citing concerns about academic standards and independence, while community colleges lack sufficient authority to influence how credits are accepted, leaving students to contend with confusing and conflicting information. Although reforms like Guided Pathways offer some advantages, they mainly focus on community college-level changes, which are not enough. The authors argue that without government intervention, universities will keep the status quo, which disproportionately harms low-income students and students of color.

Key Actions to Improve Transfer Credit and Student Success

Engineering programs should collaborate with community colleges in their regions to enhance access and outcomes for students pursuing engineering degrees by first attending community colleges. Improving transfer outcomes for students transitioning from community colleges to four-year institutions requires a coordinated, multifaceted approach. The following key actions and recommendations outline a comprehensive strategy to streamline credit transfer, enhance student support, and foster institutional collaboration. These measures aim to create a more equitable and efficient transfer system that supports student success, aligns academic pathways with workforce needs, and ensures that all stakeholders—students, educators, institutions, and policymakers—work together toward shared goals.

Policy and Governance

- Guarantee admission to at least one public university for associate degree holders.
- Ensure associate degree credits apply toward a bachelor's degree.
- Mandate shared responsibility between community colleges and universities for improving transfer outcomes.
- Establish a coordinating body with representatives from:
    - Universities and community colleges
    - State agencies
    - Student advocacy groups
    - Industry partners

Institutional Collaboration

- Build strategic partnerships between community colleges and four-year institutions.
- Promote collaboration and alignment of institutional efforts through the coordinating body.

Curriculum and Credit Transfer

- Conduct comprehensive curriculum mapping to align courses and identify gaps.
- Develop clear articulation agreements for both general education and major-specific courses.
- Support "reverse transfer" to allow students to earn associate degrees post-transfer.

Technology and Tools

- Implement shared credit evaluation systems.
- Create student-friendly transfer portals.
- Provide accessible degree audit systems for advisors and students.

Advising and Student Support

- Offer transfer-specific training, mentoring, and orientation programs.
- Enhance advising services tailored to transfer students.
- Connect prospective transfer students with upper-division faculty advisors and peer mentors.

Career-Aligned Pathways

- Align academic programs with workforce needs.
- Regularly update pathways using feedback from industry partners.

Data and Evaluation

- Promote data sharing and analysis to track outcomes and identify best practices.
- Conduct continuous evaluation and allocate resources accordingly.

Campus Culture

- Foster a transfer-friendly environment to support student integration, engagement, and success.

Continuous evaluation, resource allocation, and fostering a transfer-friendly campus culture will be essential for sustaining these efforts, ensuring transfer students are integrated, engaged, and supported throughout their academic journey.

Successful Pathways Example

Iron Range Engineering (IRE), which offers an Integrated Engineering B.S.E. degree through Minnesota State University, Mankato, partners with community colleges across the nation to provide opportunities for students to flexibly transfer into an upper-division program. By working with students and community college faculty to advise students before they enter IRE, transfer students have an easy transition to upper-division learning. Through curricular flexibility and course offerings that address the range of challenges many community colleges face in providing all required lower-division courses, students can quickly complete a bachelor's degree and enter the engineering workforce. Through a pedagogy that incorporates work-based/co-op-based learning, students from locations without nearby engineering schools are able to learn closer to home if they choose. With an upper-division curriculum that addresses engineering design, professional skills, and technical competencies that allow for student choice through deep learning activities and student-led electives, Integrated Engineering students move from community colleges to a four-year degree that lets them become the engineers they want to be.

Section 12: Strategies for Aligning PK-12 and Engineering Education

At the core of this section lies a compelling vision for PK-12 engineering education, driving transformative efforts in environments where diverse engineering professionals thrive, grow, and learn. The recommendations outlined in this report are contingent on systemic changes in schools and communities. As articulated in the “Call for Action” section, educational systems must not only equip citizens to confront global challenges innovatively but also cultivate an engineering workforce that values and celebrates varied perspectives and backgrounds.

Addressing Recommendation 5.6: Foster broad collaborations to assist PK-12 educational systems in valuing and championing engineering learning.

Engineering in PK-12: Setting the Stage

Engineering education in PK-12 schools encompasses various approaches, each serving different yet often overlapping purposes. For example, engineering design activities are frequently used by educators to both: 1) integrate knowledge in relevant contexts for “STEM-branded” learning experiences, and 2) teach discipline-specific concepts—typically from science or mathematics—in active and engaging ways (AEEE and ASEE 2020; Grubbs and Strimel 2015; NASEM 2020; NGSS Lead States 2013). Engineering in PK-12 has also found a place in the technology education school subject, where courses are offered to impart general engineering literacy and design capabilities to students. However, these programs have become scarce, and the courses are typically offered as electives, limiting their reach to a broader student audience. In many states, engineering career pathways have been developed and offered through Career and Technical Education (CTE) offices, providing a scope and sequence of courses for students interested in pursuing an engineering-related career. Thus, young learners can find (somewhat limited) opportunities to engage deliberately with engineering during their typical school day (NAEP 2023). Individuals interact with the engineered world daily, but there remains a lack of education about how this world operates, how it is created, and the roles of the various professions involved in its creation.

Although evidence of engineering is widespread, educational experiences focused on understanding how engineering develops and evaluates technological solutions are notably lacking compared to related STEM areas. Many engineering learning experiences in schools are often treated as add-ons to regular activities, services for other disciplines such as science, or elective courses in career pathways. For all these reasons, the case for explicitly including engineering in PK-12 education is strong. Beyond addressing limited access to engineering fields, engineering learning can offer additional benefits. For example, it is naturally integrative, connecting different disciplines and perspectives through engineering tasks. There is evidence that these tasks help develop in-demand skills, such as creativity, collaboration, conscientious decision-making, persistence in problem-solving, and critical and systemic thinking (Lucas, Claxton, and Hanson 2014). Furthermore, the socially connected nature of the tasks used in engineering teaching and learning can create opportunities to link school communities, student interests, and engineering activities and professions (Cunningham et al. 2023).

But engineering has historically been an exclusive area of both study and professional practice. Regrettably, many of the nation’s youth lack intentional exposure to the concepts and practices necessary for engineering literacy during their typical school day. Evidence also indicates that low-income and underserved minoritized youth experience the least exposure to engineering coursework and score significantly lower on a national exam measuring technology and engineering literacy (IES et al. 2018). This haphazard exposure to engineering learning, often determined by ZIP Code, family income, and ethnicity, again highlights a need for a coherent PK-12 engineering educational approach. Such an approach should be based on a consistent operational definition of engineering learning and literacy components. Increasing opportunities for all students to engage in engineering learning can be a crucial step toward diversifying the workforce and advancing U.S. technological and innovative output. The following recommendations aim to help set the stage for an inclusive engineering mindset through systemic change in PK-12 engineering learning.

Clarifying Engineering's Place in Career and Technical Education

The current federal Career Clusters Framework (Advance CTE, 2024) utilized in CTE programs of study situates engineering primarily under Advanced Manufacturing and, to a lesser extent, Architecture and Construction. While these areas certainly involve and incorporate engineering practices, this categorization misrepresents the breadth and integrative nature of the engineering discipline. By restricting engineering to narrowly defined industrial or construction contexts, the framework limits its role as a core discipline with applications across multiple disciplines.

The limited classification will have tangible long-term consequences on engineering education and the workforce. It influences how states design their CTE programs of study, how funding is allocated, and ultimately how students perceive what "counts" as engineering. If engineering is seen only through the lens of manufacturing or construction, students may miss opportunities to connect with the broader spectrum of engineering pathways that underpin innovation and societal progress and allow them to connect with society.

To elevate engineering, stakeholders should revisit how engineering is positioned within the Career Clusters Framework. A more accurate representation would recognize engineering as a distinct discipline that intersects with, but is not limited to other career clusters. This clarity would help establish continuity between PK-12 engineering, postsecondary engineering programs, and the many professional fields that engineering graduates enter.

Communicate engineering as a discipline and a core component of PK-12 education. The uneven adoption and integration of engineering in PK-12 schools limit the discipline's ability to achieve the goals outlined in this report. Recognizing engineering as a defined discipline with distinct career connections that can be learned and refined over time is crucial. While engineering design activities can be used as a vehicle for integrated STEM instruction or teaching other disciplinary content in engaging ways, engineering as a discipline is much more than that. It extends beyond the practice of design to encompass concepts and practices that can be taught with increasing sophistication throughout students' educational journey. Given the current landscape of engineering in PK-12, it is imperative to be specific about the identity of the engineering discipline in a manner that steers clear of the polysemy and overshadowing broadness of the STEM acronym (STEM education practices may clash with the purpose and intent of engineering as a distinct discipline and professional area of practice in PK-12). In doing so, PK-12 engineering learning can be aligned to engineering as a unique discipline, with continual evaluation of whether engineering-related instructional activities are accurately depicted to children in a manner authentic to engineering-related professions.

A Framework for P-12 Engineering Learning

The *Framework for P-12 Engineering Learning* (ASEE 2020) provides a vision for a defined and cohesive educational foundation to support this recommendation. The framework defines engineering in PK-12 as a discipline with specific objectives that include (a) cultivating engineering literacy for all students, (b) enhancing the academic and technical achievement of students through the integration of concepts/practices across school subjects, (c) providing insights into engineering-related career pathways, and (d) developing a foundation for students who matriculate to a postsecondary program for an engineering-related career. These objectives can be scaffolded across learning experiences to move from general engineering literacy for all to preparing students for undergraduate engineering and engineering technology programs (Table 1). The scientific revolution created a need for PK-12 students to learn chemistry, physics, mathematics, biology, and the scientific discovery process. The technological revolution, built on math and science, requires PK-12 education to include engineering and computer science, as well as the engineering design process, which are foundational elements of a technological world.

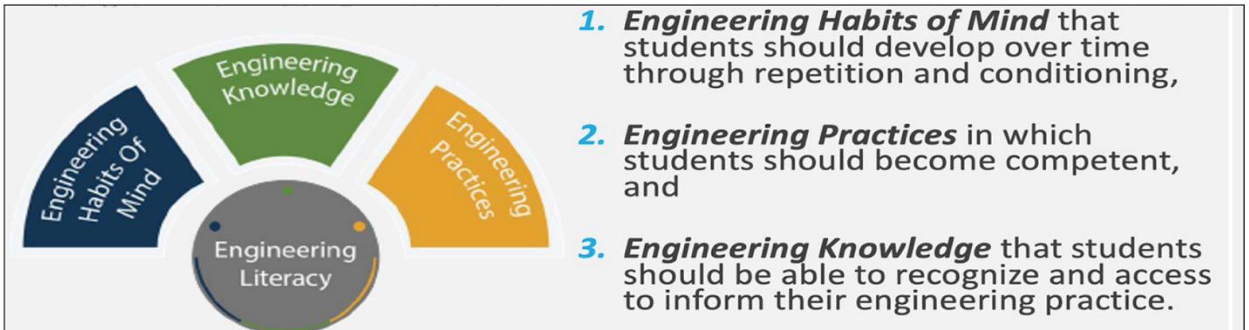
Table 1 Scaffolding of PK-12 learning objectives. Increasing complexity of PK-12 engineering learning objectives across the grades			PK-12 engineering learning objectives
			Develop a foundation for students who matriculate to a postsecondary program for an engineering-related career
			Enhance the academic and technical achievement of students through the integration of concepts/practices across school subjects
			Provide insights into engineering-related career pathways
			Cultivate engineering literacy for all students
Beginning (grades K-5)	Intermediate (grades 6-8)	Advanced (grades 9-12)	

To achieve these overarching educational objectives, the framework advocates for a three-dimensional model of engineering learning, focusing on

- **Engineering Habits of Mind** (e.g., optimism, persistence, creativity) that students should develop over time through repetition and conditioning;
- **Engineering Practices** (e.g., engineering design, materials processing, quantitative analysis, and professionalism) in which students should become competent; and

- **Engineering Knowledge Domains** (engineering sciences, engineering mathematics, and technical applications) that students should be able to recognize and access to inform their engineering practice (see Figure 1).

The goal of this approach is to develop engineering-literate individuals capable of: (1) recognizing and appreciating the influence of engineering on society and of society on engineering; (2) responsibly, appropriately, and optimally enacting engineering practices, whether independently or in teams, in personal, social, and cultural situations; and (3) addressing technological issues, under specified constraints, with an appropriate understanding of engineering concepts, which are scientific, mathematical, and technical in nature.



Literacy Dimensions	Main Components	
Engineering Habits of Mind	Optimism Persistence Conscientiousness	Systems Thinking Creativity Collaboration
Engineering Practices	Engineering Design Material Processing	Quantitative Analysis Professionalism
Engineering Knowledge Domains	Engineering Sciences Engineering Mathematics	Engineering Technical Applications

Figure 1. Three dimensions of engineering literacy for PK-12 engineering learning. Reprinted with permission from ASEE (2020).

While the primary goal of this framework is to promote general engineering literacy for all students, regardless of their career interests, engineering education can introduce more students to potential engineering-related career pathways (Miller et al., 2020). Therefore, clearly communicating engineering as a discipline must include discussion of different engineering-related careers and the relevant educational pathways to provide an understanding and foundation for those who may be interested in matriculating into a postsecondary program. Accordingly, the content and principles provided in this framework can be used to support students in moving beyond general engineering literacy and beginning a journey toward an engineering-related career. This includes career and technical education pathways as well as connections to first-year engineering programs. Within this context, it is important to acknowledge the dual significance of CTE pathways and college-preparatory coursework. CTE programs of study play an important role in linking education to workforce development, particularly through industry-recognized credentials (IRCs) and applied learning experiences that prepare students for immediate entry into technical professions. At the same time, there is a need to ensure that students have access to rigorous, college-preparatory engineering courses, often offered as an elective to students in a college-preparatory high school track, that mirror the expectations of undergraduate courses. Such courses help students prepare to thrive in postsecondary engineering programs. A comprehensive PK-12 engineering framework must support both pathways and acknowledge their contributions to student success.

Exploring what engineering is and discovering what engineering professionals do are important to building a solid understanding of engineering-related careers, how these careers relate to each other, and how they relate to the work performed in PK-12 classrooms. Students' perception of engineering and engineer-related professionals can influence their decision to study the discipline or pursue a related career path, whether in engineering, engineering technology, certain computer science areas, or even engineering education (Hammack et al. 2015). Each field concentrates on different aspects of the nature of engineering and technology, and students will select postsecondary institutions to major in these fields. To prevent students' misconceptions about the work performed by these professionals, it is important to distinguish between these career fields in PK-12 education.

Finally, the framework presents six guiding principles for the implementation of any PK-12 engineering teaching and learning initiatives:

- Keep equity at the forefront.
- Strive for authenticity in engineering.
- Focus on depth over breadth.
- Build on children's natural problem-solving abilities.
- Leverage making as a form of active learning.
- Connect with students' interests, culture, and experiences.

These guiding principles can help establish a foundation for an inclusive engineering mindset. For example, when clearly communicating engineering as a discipline, it can be said that PK-12 engineering learning activities are designed to connect with students' interests, culture, and experiences, helping to provide more personal connections to engineering practices and professions—potentially leading to broader interests in engineering careers.

Because the *Framework for P-12 Engineering Learning* was developed to serve as a starting point for providing some coherence and clarity in what PK-12 engineering could be, it can be used to begin defining the discipline in this space. Then, with the identity of engineering established at the PK-12 level, the discipline can begin to advance more collaboratively and be advocated for as a core component of educational systems in ways that increase the sophistication of engineering learning across the years of school. However, none of the efforts related to this recommendation will matter unless the positioning of engineering in PK-12 schools and the nuances of these positions across states are considered and leveraged to "carve out" different places for engineering to exist appropriately. This viewpoint leads to the next recommendation, which involves understanding the educational system and establishing organized efforts to champion engineering's place in schools and advance the discipline as a whole.

Transform the PK-12 educational system to value and champion engineering learning

What is essential is often invisible to the eye. In educational innovation, it is common to focus on the classroom curricula—the lessons, presentations, and activities that show what students are doing as part of their educational experience. Conventionally, PK-12 engineering education has provided resources with this narrow interpretation. Although numerous engineering curricular programs have seen strong regional implementation and successes, the broad adoption of engineering learning in PK-12 schools remains elusive. Curriculum creation and implementation are only a small part of the actions needed to integrate engineering learning as a core component of every child's education. Initiatives aiming to have a broad, sustained impact on engineering learning should target educational systems and policy.

The PK-12 educational system is complex and differs in many ways from undergraduate engineering and engineering technology education. Factors that influence the capacity, efficacy, and motivation of PK-12 engineering learning programs include federal legislation, state, school, and district policies and culture, as well as the relationships with and impacts of regional institutes of higher education and research infrastructure (NASEM, 2020). It is essential that efforts (a) take seriously the barriers facing teachers, administrators, and state-level coordinators with respect to resources such as funding, money, and knowledge; and (b) seek to transform policies to support and invest in removing these barriers.
The possibilities for out-of-school learning, such as afterschool programs, summer programs, camps, competitions, and festivals for introducing and engaging youth and their families in engineering learning also deserve attention. Increasingly, these spaces include STEM experiences as well as career exploration. The needs and opportunities of these spaces differ from school-based settings and programming should reflect this. However, given the number of children they serve, they do offer additional learning environments to engage students and families in engineering learning.

Historically lacking from policy creation and decision-making about STEM education and engineering learning opportunities are engineering leaders from industry and academia. Other STEM disciplines, such as the sciences and computer science, have seen sustained influence from professionals and leaders. The American Association for the Advancement of Science (AAAS) ushered in the development and implementation of science education benchmarks and standards. Code.org was instrumental in the proliferation of Computer Science for All initiatives and calls for computational thinking as a core component in PK-12 schools. Over the past decade, Code.org drafted and advocated several policies that states could adopt to make computer science foundational to PK-12 education. These efforts have resulted in the creation of legislation across many states that requires computational thinking and/or computer science educational experiences across the grade levels. While engineering professionals most certainly participated in these initiatives, there has not been a similar focused effort by the engineering enterprise to grow engineering learning.

A unified approach is needed to champion engineering learning for all students and achieve the goals outlined in this report. Without cultivating a future generation of engineers who are deep and diverse, the recommendations of future engineers are moot. Fortunately, the engineering enterprise is far-reaching, resilient, creative, and capable. Engineering remains a widespread industry in nearly every region throughout the country. Additionally, there are hundreds of engineering education institutions of higher learning with a wealth of engineering knowledge and close connections to regional communities. Initiated by the engineering professional societies (e.g., IEEE, ASME, ASCE) and in collaboration with organizations serving minoritized engineering populations (e.g., SHPE, NSBE, SWE, NCWIT, WEPAN) and the American Society for Engineering Education, engineering professionals in industry and academia should establish regional working groups to advance engineering learning for all children.

These groups can champion the guiding principles of the *Framework for P-12 Engineering Learning*:

- Seek insight and expertise from educational leaders, teachers, and community members in formal and informal settings.
- Identify regional actors that influence PK-12 education policy and decision-making. These actors may include legislators and executive branch staff, state and regional boards of education, teacher education programs, teacher associations, and education-focused organizations.
- Develop state policy recommendations for clarity, capacity, continuity, and access to engineering learning that can help to build and sustain a comprehensive system of teaching engineering, making it a foundational component of PK-12 education.

- Volunteer a collective voice toward education policymaking at the national, state, regional, and district levels. This may include participating in educational standard-setting committees, state and district school board focus groups, and regional educational advisory boards.

The engineering education community needs to leverage these capabilities and resources to transform how the PK-12 educational system values engineering learning. National funding agencies such as the National Science Foundation and the U.S. Department of Education, as well as private foundations like the United Engineering Foundation, should fund research on ways to converge, collaborate, and enact regional action mechanisms to ensure that all children have the opportunity to experience engineering learning.

Establish regional action mechanisms through engineering research initiatives and engineering education programs

Engineering research centers and engineering education programs focused on researching effective ways to impact regional educational policy regarding engineering learning could achieve three major advances:

- mobilize the engineering enterprise to engage, influence, advance, and transform PK-12 education for the benefit of society;
- articulate engineering-related career pathways to children; and
- build teacher capacity for engineering to meet the needs of PK-12 educational systems that value and champion engineering learning.

Mobilize the Engineering Enterprise

The absence of the collective engineering "mind" from PK-12 education decision-making is unacceptable. It is the responsibility of all members of society to ensure that our children receive an appropriate education. As discussed in the *Framework for P-12 Engineering Learning*, engineering offers novel approaches and opportunities largely absent from the current PK-12 educational system. The actions outlined in Recommendation 2 of this section would provide engineering education researchers and advocates with an initial roadmap to engage engineering professionals in PK-12 educational systems and policy.

Articulate Engineering-Related Career Pathways

Perhaps the most efficient and viable approach to ensure that students are engineering literate is to identify existing systems that support partnerships. For example, one school district has 100 technology and engineering education teachers across 25 high schools. Approximately 10 of them were traditionally trained through technology- and engineering-related postsecondary institutions. Each year, 15 new teachers are hired. The number of teacher preparation institutions has decreased drastically over the last several decades, and enrollment in current programs continues to decline. The challenges of PK-12 teacher recruitment, teacher preparation programs, and sustainable course scheduling suggest that a review of existing structures should be considered first. These systems should be strengthened, and best practices should be multiplied.

PK-12 Example: Project Lead The Way (PLTW)

With its network of nearly 13,000 schools, engineering programs can jumpstart their efforts to engage with K-12 students in meaningful ways, advancing the core principles from the Mindset Report that aim to increase access and success, ultimately leading to a greater number of engineers for our nation. Recommendation 5.6 from the Mindset Report states that engineering programs should foster broad collaborations to assist K-12 educational systems in valuing and championing engineering learning. This recommendation aligns well with the mission of Project Lead the Way.

Project Lead The Way (PLTW) is a non-profit organization that empowers PreK-12 students throughout the U.S. by providing transformative learning experiences in science, technology, engineering, and mathematics (STEM). It aims to equip students with the knowledge and skills needed to thrive in an evolving world and to prepare them for college and careers, particularly in STEM fields. Every engineering program should begin to engage with K-12 school districts in their region to foster collaboration and create a seamless pathway for high school graduates to enter their engineering program. Engineering programs can also encourage K-12 school districts that do not have PLTW programs to begin one.

During the 2024-2025 academic year, Project Lead The Way is serving a significant number of students through its diverse STEM programs in the United States, with a total of 2,363,216 participants. The PLTW Launch program for PreK-5 students has an enrollment of 859,961. At the middle school level, PLTW Gateway engages 927,565 students. In the high school pathways, PLTW Biomedical Science serves 214,117 students, PLTW Computer Science has 63,278 students, and PLTW Engineering programs impact 289,457 students, underscoring the organization's wide reach in providing hands-on STEM education. Additionally, 8,838 students are enrolled in PLTW's new, project-based, career-focused Algebra 1 supplement.

How it Works

PLTW develops and delivers a comprehensive PreK-12 curriculum encompassing three main pathways: Engineering, Biomedical Science, and Computer Science. These programs are used in elementary, middle, and high schools.

- **PLTW Launch (PreK-5)** taps into young students' exploratory nature through engaging, theme-based modules that introduce foundational STEM concepts.
- **PLTW Gateway (Grades 6-8)** offers units that allow students to explore various STEM fields, such as design and modeling, automation and robotics, and medical detectives, sparking interest and building a solid foundation for high school pathways.
- **PLTW High School (Grades 9-12)** provides specialized, multi-year sequences of courses in engineering, biomedical science, and computer science. These pathways are designed to give students in-depth knowledge and practical experience. Examples include "Principles of Engineering," "Human Body Systems," and "AP Computer Science Principles."

The Activity-, Project-, Problem-Based (APB) Approach:

A cornerstone of PLTW's instructional philosophy is the Activity-, Project-, Problem-Based (APB) learning model. This approach emphasizes hands-on, real-world applications of knowledge and skills.

- **Activities:** Students engage in structured, hands-on learning experiences to develop specific knowledge and skills.
- **Projects:** They then apply these skills to solve complex, real-world challenges, helping them to make meaningful connections.
- **Problems:** Finally, students tackle open-ended, authentic problems that require them to synthesize and apply what they've learned through the activities and projects. This often involves collaborative teamwork and mirrors professional practices.

The APB approach uses scaffolding to progressively build students' understanding and independence as they move from guided activities to more complex problem-solving scenarios. It aims to develop critical thinking, creativity, collaboration, ethical reasoning, and communication skills.

Industry and Higher Education Connections

Project Lead The Way (PLTW) actively engages industry and higher education partners to ensure its curriculum remains relevant and up-to-date. This collaboration takes several forms:

- **Advisory Roles:** Professionals from various industries and higher education institutions serve in advisory roles for PLTW. They provide insight into current industry trends, required skills, and advancements in their respective fields. This helps PLTW identify the knowledge and abilities that students will need for future careers and postsecondary education.
- **Curriculum Development and Review:** Industry experts and university faculty collaborate with PLTW educators and curriculum developers in the creation and revision of course content. This ensures that the curriculum aligns with real-world applications and academic expectations. For example, they may review course outlines, learning activities, and assessment methods to ensure they are rigorous and relevant.
- **Partnerships for Resources and Opportunities:** PLTW partners with companies and universities to provide students with real-world learning experiences. This can include internships, mentorships, guest lectures, site visits, and access to industry-standard tools and technologies. These partnerships expose students to potential career paths and provide valuable networking opportunities. For instance, companies might offer challenges or projects that students can work on, mirroring real-world scenarios. Universities may offer college/dual credit for PLTW courses or scholarships to PLTW graduates.
- **Professional Development for Teachers:** Industry professionals and higher education faculty often contribute to PLTW's professional development programs for teachers. They may lead workshops, share their expertise, and provide insights into the latest industry practices. This ensures that PLTW teachers are equipped with the knowledge and skills to deliver the curriculum and effectively connect it to real-world contexts. Professional development opportunities for PLTW teachers extend beyond the initial core training experience through continued in-person and online professional learning, as well as regional and national convenings hosted by PLTW and its partner institutions and organizations.
- **Alignment with Industry Standards and Certifications:** PLTW collaborates with industry organizations to align its curriculum with recognized standards and certifications. This ensures that PLTW programs equip students with skills valued by employers and can lead to industry-recognized credentials. For example, PLTW has partnered with the Robotics Education & Competition Foundation (RECF) to align its curriculum with RECF's Pre-Engineering and Robotics certifications.

In summary, PLTW uses a multifaceted approach to engage industry and higher education partners in its curriculum development and updates. This collaborative model ensures that PLTW programs remain current, relevant, and effectively prepare students for future academic and career success in STEM fields.

Teacher Training

PLTW places significant emphasis on teacher professional development. The primary mode of training is **PLTW Core Training**, an intensive and immersive program. Central to PLTW's success is its comprehensive approach to teacher preparedness, with distinct training protocols for each program level. Elementary school teachers in the PLTW Launch program undergo a two-day training session, while middle school teachers for each PLTW Gateway course typically engage in a five-day training. High school teachers who deliver the specialized Biomedical Science, Computer Science, and Engineering pathways participate in an intensive two-week training program per course. During the 2024–2025 school year, a dedicated cohort of 69,178 active teachers is implementing these programs: 42,323 in Launch, 12,175 in Gateway, 3,987 in Biomedical Science, 2,467 in Computer Science, and 8,226 in Engineering. Furthermore, PLTW cultivates a robust network of Master

Teachers. These experienced educators are pivotal in delivering the majority of the training to new PLTW teachers and provide critical ongoing support, fostering a vibrant national professional learning community. The training itself is characterized by:

- **Hands-on Experience:** Teachers often take on the role of students, working through the curriculum activities and projects themselves to gain a deep understanding of the content and the APB methodology.
- **Collaborative Learning:** Training is typically collaborative, allowing educators to network with peers and PLTW Master Teachers.
- **Focus on Facilitation:** The training prepares teachers to act as facilitators of learning, guiding students through the APB approach rather than primarily relying on direct instruction.
- **Credentialing:** Upon successful completion, teachers receive a certificate of completion, one Continuing Education Unit for every 10 contact hours, and credentials to teach the specific program for which they were trained.
- **Ongoing Support:** Beyond initial training, PLTW also offers ongoing support and resources to its teachers, including webinars and program enhancements.
- **In-person and Online Core Training:** PLTW Core Training sessions are offered both in-person and online, allowing educators to choose the option that best suits their needs. Online training provides the flexibility many educators need, while in-person sessions offer more opportunities to gain practical experience, build your network, and explore the curriculum.

In essence, Project Lead The Way provides a comprehensive framework for STEM education, combining a robust curriculum with a student-centered instructional approach and dedicated teacher training to foster engaging and relevant learning experiences.

Ways for Engineering Programs to Collaborate with PLTW

Bridging the gap between K–12 and higher education through programs like Project Lead the Way (PLTW) can have a powerful impact on broadening participation and deepening preparedness in engineering. Here are several practical and strategic ways undergraduate engineering programs and K–12 school districts with PLTW programs can collaborate to create a seamless and inclusive pipeline:

1. **Articulation Agreements & College Credit**
    - **Dual Credit Opportunities**: Engineering programs can evaluate PLTW courses for rigor and offer college credit or advanced placement based on performance or assessment. The American Council on Education reviewed and recommended college credit for seven PLTW high school courses. PLTW computer science students are also eligible to receive college credit for successful exam performance.
    - **Credit Transfer Pathways**: Develop clear articulation agreements that guarantee students who complete PLTW courses receive credit or place out of introductory college engineering courses.
2. **Summer Bridge Programs**
    - **Campus-Based Engineering Bootcamps**: Invite PLTW students to summer programs at the university to deepen technical skills, explore campus life, and connect with engineering faculty and mentors.
    - **Residential Camps with Credit**: Offer credit-bearing summer engineering experiences for high school juniors/seniors in PLTW programs.
3. **Co-Developed Curriculum & Projects**
    - **Curriculum Alignment**: Engineering faculty can help align university-level expectations with PLTW curriculum to ensure skill and conceptual continuity.
    - **Capstone Collaboration**: Engage university engineering students as mentors or project reviewers for PLTW senior capstones.
4. **Faculty and Teacher Exchange**

- **Faculty in the Schools**: Engineering faculty or graduate students can guest-teach or co-teach units in PLTW classrooms.
- **Professional Development for PLTW Teachers**: Offer PD workshops hosted by university faculty focused on new tech, lab techniques, or pedagogy.

5. Mentorship and Advising

- **Engineering Student Mentors**: Match undergrad engineering majors with PLTW high school students for virtual or in-person mentoring.
- **College Counseling**: University admissions and advising staff can host sessions on preparing a competitive engineering application, including what PLTW experiences to highlight.

6. Joint STEM Events and Competitions

- **Engineering Day**: Host a PLTW Engineering Day where K–12 students visit campus for design challenges, lab tours, and student panels.
- **Hackathons or Design Challenges**: Co-host interdisciplinary events with mixed teams of high school and college students.

7. Research and Pipeline Evaluation

- **Data-Sharing Agreements**: Collect and analyze data on PLTW students' performance and persistence in college engineering to assess and strengthen the benefits of PLTW experiences.
- **Grant Collaborations**: Jointly apply for NSF or DOE grants that fund STEM pipeline development and expanded access for students.

8. Parent Engagement

- Offer information sessions for parents about engineering careers and how PLTW can lead to them.

9. College Scholarships and Preferred Admissions:

- Provide scholarships and/or preferred admission to students upon successful completion of PLTW courses and associated end-of-course exams.

10. Graduate Credit for Educators:

- Provide graduate or continuing education credits to teachers for successful completion of PLTW Core Training. PLTW is an Accredited Provider by the International Association for Continuing Education and Training (IACET).

Engineering for US All (e4usa™)

Advancing PK-12 Engineering through Research and Community

Building upon 23 years of academic research, Engineering for US All (e4usa) represents a distinct model that centers research-based curriculum design, university partnerships, and long-term teacher support to create a sustainable and scalable ecosystem for engineering education. Funded throughout its development by the National Science Foundation, e4usa continues to contribute to the fundamental research on best practices in secondary school engineering education.

At the core of e4usa is a curriculum built in close collaboration with engineering education researchers and faculty. Rather than adopting existing STEM models, e4usa courses are grounded in evidence-based practices, ensuring alignment with both PK-12 learning needs and postsecondary engineering expectations. The curriculum consists of four complementary offerings: e4usa +Making, e4usa +Programming, e4usa +Design, and the e4usa Legacy course. These courses are designed to provide hands-on, integrative experiences that connect engineering to authentic societal and technical challenges.

A hallmark of e4usa curriculum is its use of thematic threads that are recurring concepts that cut across units and courses. These threads support students in connecting with engineering, developing ways of thinking, engineering practices, communication and professional skills, and technical knowledge. Collectively, they connect creativity and persistence with design and analysis while refining the technical competencies needed to thrive in today's workforce.

Yearlong Professional Development and Community of Practice

e4usa offers a sustained model of teacher development that extends far beyond initial training. Rather than relying on one-time workshops, the program provides educators with a yearlong cycle of professional learning that includes intensive summer professional development, monthly coaching, ongoing reflection, and participation in a national community of practice. Grounded in the Standards for the Preparation and Professional Development of Teachers of Engineering (Reimers, Farmer & Klein-Gardner, 2015), this approach reflects the understanding that teaching engineering requires continual growth and adaptation. Importantly, e4usa also prioritizes affordability, keeping both start-up and recurring costs low to ensure access for schools and districts with diverse funding capacities.

New e4usa teachers begin with a structured pathway that includes introductory summer professional development and specialized tracks such as +Making, +Programming, or +Design. These experiences provide hands-on practice with the curriculum, collaborative planning for community-based projects, and guidance on applying the MyDesign® Scoring Rubric and leveraging the Learning Management System. Support continues throughout the school year with targeted fall and winter sessions, ongoing coaching, and reflection opportunities. This progression equips educators with practical tools, fosters collaboration, and builds confidence in delivering engineering content to all students.

Returning teachers also have opportunities to extend and deepen their practice through shorter, flexible professional development offerings on topics such as MATLAB®, CAD, and MyDesign . Both new and experienced teachers benefit from the robust e4usa Hub, which hosts resources, organized discussion threads, and peer support. Monthly coaching, university and industry partnerships, and a national community of practice provide additional expertise and encouragement. Online socials and an End-of-Year Celebration further strengthen connections across the network, highlighting e4usa's commitment to fostering both professional growth and a sense of shared purpose among educators.

Assessment and College Credit Pathways

A defining feature of e4usa is its MyDesign portfolio and summative exam, which together function much like AP®-style assessments. This framework not only helps students document their growth in engineering literacy but also provides rigorous evidence of learning that can be recognized by universities. e4usa has established articulation agreements with 29 partner institutions to date, offering students the opportunity to earn college credit or placement.

It is also important to note that, while no AP® Engineering course currently exists, e4usa's summative assessment and portfolios have positioned the program as a potential foundation for such an offering. In fact, e4usa is actively engaged in discussions with the College Board to explore the creation of an AP® Engineering pathway, underscoring the program's national leadership in credit-earning engineering education at the PK-12 level.

In addition, e4usa is responsive to the growing emphasis on Career and Technical Education (CTE) among school districts. e4usa has developed programs of study that align with CTE requirements and provide students with opportunities to pursue industry-recognized credentials (IRCs). For example, the e4usa +Programming course is uniquely positioned to align both with the AP® Computer Science Principles framework and with the MATLAB® Associate IRC. This dual alignment creates a distinctive opportunity for students to earn college credit and workforce certifications in the same course experience. It also requires students to use computational thinking and coding in service to solving authentic engineering design problems.

The design of e4usa +Programming reflects the program’s broader sequencing of courses. It intentionally builds on the foundational experiences from +Making, allowing students to deepen their technical and design capabilities in a scaffolded manner. This framework provides a coherent progression across courses, enabling students to continue their growth in engineering as they advance through the e4usa curriculum.

Liaison Model: Bridging Classrooms and the Profession by Developing More Engineers

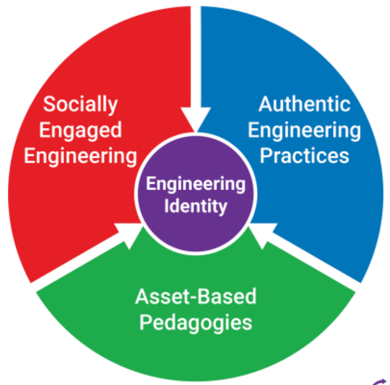
For many high school students, engineering has been perceived as a complicated, expensive, and intimidating field to enter. e4usa seeks to change that by offering the most teachable, affordable, research-driven, and widely scalable high school engineering program in the country. By removing traditional prerequisites and resource barriers, e4usa makes engineering education possible for students regardless of their prior experience. Only a co-requisite of Algebra 1 and basic classroom supplies are needed to begin. The same principle applies for teachers who want to teach e4usa , but have no prior engineering background - if you can teach, we can help you teach engineering. In turn, the curriculum delivers industry-relevant skills and experiences that are specifically designed for high school students of all grade levels and for teachers across subject areas.

Additionally, e4usa acknowledges that many students do not have engineers in their immediate social networks. To address this gap, the program’s liaison model connects classrooms with local engineers and faculty members, some many of whom have attended the same schools they are now mentoring. Each e4usa teacher is paired with a liaison who serves as a technical expert and link to the profession, providing feedback and real-world context for student projects. This structure ensures that engineering education is not siloed in classrooms but is authentically connected to professional practice, university research, and community needs.

Youth Engineering Solutions (YES)

It is important from early ages to nurture children’s problem-solving abilities. Youth Engineering Solutions (YES) at the Museum of Science, Boston, has worked for three decades to develop age-appropriate frameworks, research, and resources that support children, educators, and schools as they engineer. The team works closely with educators, engineers, and industry partners to develop high-quality, and standard-aligned preK-8 engineering and computer science curricula. Driven by a mission to engage all children in engineering and STEM, YES provides all its educational resources free-of-charge for download online.

The YES approach anchors all project resources. Working in teams, students design, test, and iterate original solutions to real-world challenges that are relevant to their lives and communities. Through collaboration, communication, and persistence through failure, they build engineering identities and learn they can shape their world.



YES Resources
YES develops and supports preK-8 curricula. Programs include:

Wee Engineer (preschool, TK) channels children's innate curiosity and creativity into structured problem solving. Children use familiar materials to figure out how to make something that solves a specific problem. Four unique design challenges that can be taught in any order build children's confidence and mastery.

YES Elementary (K-5) standards-aligned units ignite curiosity by engaging students in real-world engineering challenges. Using the Engineering Design Process, they innovate, make connections across STEM fields, and refine solutions through hands-on investigation—building critical thinking and resilience.

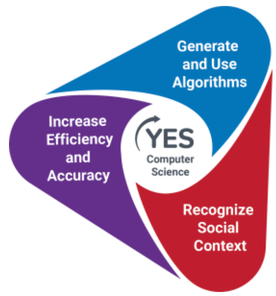
YES Middle School (6-8) engages students in hands-on engineering challenges and integrated computer science modules. As they work with peers to generate original solutions, youth see themselves as future STEM professionals.

YES Enrichment (K-8) challenges youth to tackle real-world problems using the Engineering Design Process. These units are specifically designed to support STEM specials, electives, makerspaces, clubs, camps, spring break, and summer programs.

YES STEM Event Activities (K-8) are easy-to-implement design challenges that engage children ages 4 to 12 and their caregivers in creative problem-solving while introducing them to the engineering design process. These flexible STEM experiences, designed for use in facilitated spaces with families or small groups such as STEM Family Nights or a library program, aim to demystify engineering and help families recognize how their everyday thinking and activities connect to the work of engineers.

In addition to connecting engineering, science, and mathematics, YES resources highlight the integration with computer science and careers.

YES Computer Science: The YES Computer Science Framework helps students to (a) develop understandings that computational tools can be used to solve problems efficiently and accurately, (b) understand and generate algorithms, and (c) recognize the human and socially embedded nature of computational tools and the biases that may exist in the tool itself and/or in the application and interpretation of the tool and its output. Computer science modules for middle school and elementary school encourage youth to experience how computational tools and algorithms can enhance their work.



YES Careers: For upper elementary and middle school units, we YES Careers Modules—resources that highlight careers from multiple subclusters of the National Career Clusters Framework. During the YES engineering unit, students explore how engineers address the real-world problem introduced in the unit. The Careers modules highlight other professionals who might also work on these challenges. Input from educators, middle and high school students, and industry informed the product. Resources include quizzes to identify potential careers, curated video playlists, “a day in the life” snapshots of careers, and family letters.

Professional Learning

The professional learning team supports educators as they implement YES curricular materials. YES learner-centered workshops build knowledge, strategies, and confidence in teaching engineering and computer science. Educators explore the curricular resources and pedagogical frameworks that define our high-quality materials. YES offers face-to-face as well as virtual workshops and webinars for educators and for STEM leaders. We also create resources that deepen educators’ knowledge of engineering instruction. Our Learning Library provides educators with free resources to refresh and improve their engineering education pedagogy. The library includes video from classrooms, student work artifacts, reflection questions, and more, to give educators a multimodal, online learning experience.

YES is using a national network approach—working closely with collaborators from education and industry across the country to support engineering education with local partners.

Reach

In 2024, YES reached 825,000 youth and 30,000 educators nationwide. YES resources were downloaded over 350,000 times.

Connection

The YES program partners with Engineering for US All (e4usa) for a PK-12 solution for schools.

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Section 13: Industry's Contribution to the Mindset Report

In today's rapidly evolving technological landscape, the collaboration between industry and academia has become more crucial than ever. The Engineering Mindset Report highlights the importance of fostering diversity, innovation, and practical skills within engineering education. Industry's contribution to the recommendations in this report is pivotal, as it bridges the gap between theoretical knowledge and real-world application, ensuring that future engineers are well-equipped to meet the challenges of tomorrow.

By actively engaging with educational institutions, industry can offer invaluable resources, mentorship, and opportunities that enhance the learning experience for undergraduate engineering students. This partnership not only drives curriculum relevance and innovation but also promotes diversity and inclusion within the field of engineering. Through internships, co-op programs, funding, and collaborative projects, industry plays a crucial role in shaping a dynamic and competent engineering workforce.

Successfully implementing the recommendations of the Engineering Mindset Report relies significantly on the active participation and support of industry. Together, academia and industry can foster a more inclusive, innovative, and practical engineering education that prepares students to excel in their careers and make meaningful contributions to society.

Industry support for undergraduate engineering programs is crucial for several reasons:

1. **Bridging the Gap Between Theory and Practice**: Industry involvement helps students apply theoretical knowledge to real-world scenarios, making their education more practical and relevant. This prepares students to tackle actual engineering challenges once they enter the workforce.
2. **Enhancing Employability**: By offering internships, co-op programs, and mentorship, industry helps students gain valuable experience and skills that make them more appealing to employers. This can lead to improved job prospects and a smoother transition from academia to industry.
3. **Driving Innovation**: Collaboration between industry and academia fosters innovation by merging cutting-edge research with practical applications. This can lead to the creation of new technologies and solutions that benefit both sectors.
4. **Ensuring Curriculum Relevance**: Industry input helps universities design curricula that align with current and future industry needs. This ensures that graduates have the skills and knowledge necessary to succeed in their careers.
5. **Providing Resources and Funding**: Industry can provide financial support, equipment, and other resources that enhance the learning environment. This can enhance the quality of education and provide students with access to the latest tools and technologies.
6. **Building Stronger Networks**: Partnerships between industry and academia help students develop professional networks that can be invaluable for their careers. These connections may lead to job opportunities, collaborations, and mentorship.

By supporting undergraduate engineering programs, industry invests in the future workforce and contributes to the overall advancement of engineering.

Industry can enhance undergraduate engineering education through several impactful strategies:

1. **Collaborative Curriculum Development**: Partnering with universities to co-develop curricula ensures that the education provided aligns with current industry needs and technological advancements.
2. **Internships and Co-op Programs**: Offering structured internship and co-op programs gives students practical, hands-on experience. These programs enable students to apply theoretical knowledge in real-world settings and gain valuable industry insights.
3. **Mentorship Programs**: Industry professionals can mentor students, providing guidance, career advice, and support. This can help students navigate their educational and professional paths more effectively.

4. **Funding and Scholarships**: Providing financial support through scholarships, grants, and funding for research projects makes engineering education more accessible and encourages innovation.
5. **Guest Lectures and Workshops**: Industry experts can deliver guest lectures and conduct workshops to share their expertise and insights on current trends and challenges in the field.
6. **Capstone Projects and Competitions**: Sponsoring capstone projects and engineering competitions provides students with the opportunity to tackle real-world problems and develop practical solutions.
7. **Resource Donations**: Donating equipment, software, and other resources to universities can enhance the learning environment and provide students with access to the latest tools and technologies.
8. **Continuous Professional Development**: Encouraging continuous learning and professional development for both students and faculty can help keep educational programs up-to-date with industry standards and practices.
9. **Industry-Funded Research Institutes:** Many German universities host research institutes that are funded by industry. These institutes focus on specific areas of interest to the sponsoring companies, providing students and faculty with access to cutting-edge technology and resources. (Gaedeke 2024)
10. **Innovation Hubs and Incubators**: Universities and companies collaborate to create innovation hubs and incubators that support startups and entrepreneurial initiatives. These hubs provide resources, mentorship, and networking opportunities for students and researchers.
11. **Industry Groups and Professional Societies**: The *Mindset Report* and the *Blueprint for Change Report* should be read and analyzed to determine how to best support the effort and become part of the movement to increase access and success of engineering programs.

Engineering programs should work more closely with industries in their region and nationally, and industry needs to make working with engineering programs a part of their company's strategic initiative. By actively engaging in these areas, industry can play a pivotal role in shaping a well-prepared, innovative, and diverse engineering workforce.

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Section 14: The National Academy of Engineering and *The Engineering Mindset Report*: A Convergence of Insights in Engineering Education

This report was prepared by David A. Butler, a member of the staff of the National Academy of Engineering (NAE), at the request of ASEE leadership and does not reflect the views or any official position of the NAE or The National Academies of Sciences, Engineering, and Medicine. Funding was provided through National Science Foundation Grant No. DUE-2212721

Summary

The American Society for Engineering Education (ASEE) and the National Academies of Sciences, Engineering, and Medicine, and in particular the National Academy of Engineering, have long histories of making

substantive contributions to scholarship on engineering education. The 2024 ASEE publication, *The Engineering Mindset Report. A Vision for Change in Undergraduate Engineering and Engineering Technology Education* puts forth a number of observations and recommendations for improving the teaching of engineering and building the pipeline of students who enter the field. This report highlights how those recommendations relate to findings in the National Academies' engineering education-related publications over the past 25 years, both to illustrate the persistent nature of the challenges in the field and to identify potential areas for synergistic dissemination activities in the future.

Engineering Education Research and the National Academies' Role

The academic study of engineering education and the means to improve it dates back more than a century in the U.S., with the establishment of the Society for the Promotion of Engineering Education (SPEE; a precursor to ASEE) in 1893 (Akira, 2017), and Charles Riborg Mann's 1918 treatise *A Study of Engineering Education* (Mann, 1918), generally considered as seminal events. Later landmark studies include SPEE's *Report of the Investigation of Engineering Education, 1923-1929* (1930), and its papers "Aims and Scope of Engineering Curricula" (1940) and "Report of the Committee on Engineering Education After the War" (1944), along with papers by ASEE in 1955 and 1968.

The National Academy of Sciences[2] and the National Academy of Engineering[3] (NAE) first examined challenges in the field in 1985 in a report titled *Engineering Education and Practice in the United States: Foundations of Our Techno-Economic Future*. This was followed by the establishment of the Board on Engineering Education under the National Academies' National Research Council (NRC) in 1991, along with its initial publications (NRC, 1993, 1995).

The dawn of the 21st century marked the beginning of an extensive and extended effort by the National Academies and NAE to address and advance engineering education. NAE inaugurated the Bernard M. Gordon Prize for Innovation in Engineering and Technology Education in 2001 to recognize institutions and individuals who foster "new modalities and experiments in education that develop effective engineering leaders" (NAE, 2025). NAE's *The Engineer of 2020: Visions of Engineering in the New Century* (2004) and, in particular, *Educating the Engineer of 2020* reports established a bold vision for the field. The latter report presented recommendations for enriching and broadening engineering education, improving student recruitment and retention, and enhancing the learning experience to ensure that graduates are equipped to address complex technical, social, and ethical questions raised by emerging technologies.

The National Academies and NAE have since conducted a number of workshops and consensus studies examining specific issues related to the topic, including means to encourage and expand participation in the field of engineering, increasing student retention, integrating ethics into engineering education, and the professional development of engineering students and faculty.

Many of these were sponsored by the National Science Foundation, with funding for others provided by various governmental agencies, research and charitable foundations, private entities, and professional organizations in education and engineering, including the ASEE. These publications are listed, along with embedded links to freely accessible PDFs of the texts, in Table 1.

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[2] The National Academy of Sciences was renamed the National Academies of Sciences, Engineering, and Medicine in 2015 and is referenced as "the National Academies" here.

[3] The National Academy of Engineering was established in 1964 under the charter of the National Academy of Sciences to provide a focus for engineering-related activities under the National Academy.

Table 1. National Academies Engineering Education-Related Publications 2004–2024

Publication title [hyperlinked] and type	Year
Emerging Technologies and Ethical Issues in Engineering: Papers from a Workshop	2004
The Engineer of 2020: Visions of Engineering in the New Century (consensus report)	2004
Enhancing the Community College Pathway to Engineering Careers (consensus report)	2005
Educating the Engineer of 2020: Adapting Engineering Education to the New Century (consensus report)	2005
Engineering Studies at Tribal Colleges and Universities (letter report)	2006
Developing Metrics for Assessing Engineering Instruction: What Gets Measured Is What Gets Improved (workshop proceedings)	2009
Ethics Education and Scientific and Engineering Research: What's Been Learned? What Should Be Done? Summary of a Workshop	2009
Engineering in K-12 Education: Understanding the Status and Improving the Prospects (consensus report)	2009
Lifelong Learning Imperative in Engineering: Summary of a Workshop	2010
Engineering Curricula: Understanding the Design Space and Exploiting the Opportunities: Summary of a Workshop	2010
Standards for K-12 Engineering Education? (consensus report)	2010
Lifelong Learning Imperative in Engineering: Sustaining American Competitiveness in the 21st Century: Sustaining American Competitiveness in the 21st Century (workshop proceedings)	2012
Infusing Real World Experiences into Engineering Education: A Resources Report	2012
Practical Guidance on Science and Engineering Ethics Education for Instructors and Administrators: Papers and Summary from a Workshop, December 12, 2012	2013
Educating Engineers: Preparing 21st Century Leaders in the Context of New Modes of Learning: Summary of a Forum	2013
Surmounting the Barriers: Ethnic Diversity in Engineering Education: Summary of a Workshop	2014
The Climate Change Educational Partnership: Climate Change, Engineered Systems, and Society: A Report of Three Workshops	2014
Educate to Innovate: Factors That Influence Innovation: Based on Input from Innovators and Stakeholders (workshop proceedings)	2015
Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs: A Resource Report	2016
Forum on Proposed Revisions to ABET Engineering Accreditation Commission General Criteria on Student Outcomes and Curriculum (Criteria 3 and 5): A Workshop Summary	2016
Engineering Technology Education in the United States (consensus report)	2017
Increasing the Roles and Significance of Teachers in Policymaking for K-12 Engineering Education: Proceedings of a Convocation	2017
Overcoming Challenges to Infusing Ethics into the Development of Engineers: Proceedings of a Workshop	2017

A New Vision for Center-Based Engineering Research (consensus report)	2017
Engineering Societies and Undergraduate Engineering Education: Proceedings of a Workshop	2017
Understanding Measures of Faculty Impact and the Role of Engineering Societies: Proceedings of a Workshop	2018
An Undergraduate Competition Based on the Grand Challenges for Engineering: Planning and Initial Steps: Proceedings of a Workshop	2018
Science and Engineering for Grades 6-12: Investigation and Design at the Center (consensus report)	2019
Building Capacity for Teaching Engineering in K-12 Education (consensus report)	2020
Sharing Exemplary Admissions Practices That Promote Diversity in Engineering: Proceedings of a Workshop	2023
Infusing Advanced Manufacturing into Undergraduate Engineering Education (consensus report)	2023
Connecting Efforts to Support Minorities in Engineering Education: Proceedings of a Workshop	2023

Notes:

- Additional National Academies publications, not cited here, address related issues in STEM education and the development of the engineering workforce.
- All of the listed reports are also available for free download in PDF format via the National Academies Press website (nap.edu).

The Intersection between The Engineering Mindset Report and the National Academies' Engineering Education Publications

In 2024, ASEE released *The Engineering Mindset Report: A Vision for Change in Undergraduate Engineering and Engineering Technology Education* (ASEE, 2024; hereafter referred to as the "ASEE report"). The NAE provided logistical and technical support for this report and served as the host institution for a series of in-person meetings of the report's authors. It did not, however, have a role in determining the report's recommendations, which are listed in Table 2.

Comparing the observations and recommendations offered with the content of the NASEM publications cited in Table 1 yields a number of areas of consonance—evidence of the long-standing nature of many of the issues in engineering education. These are identified below, categorized by the chapters of the ASEE report from which they are derived. Note that the consensus reports cited contain the findings, conclusions, and recommendations reached by expert committees of the National Academies, while the observations offered in proceedings are attributable to individuals who participated in the event being summarized.

Table 2. Recommendations offered in ASEE's *The Engineering Mindset Report* (2024)

#	Recommendation
1.1	Instead of a one-size-fits-all math requirement in the expected level of incoming math preparation, incorporate in-context mathematics across the introductory curriculum to help alleviate student inequities due to K-12, economic, first-generation, and other differences.
1.2	Modularize the engineering curriculum to allow students to flexibly choose their pathways through fundamental courses, and as a means to offer electives on important and emerging topics in engineering and engineering technology.

1.3	Assess for competency (mastery) and employ formative assessments using techniques such as "ungrading" instead of focusing on current grading and assessment practices.
1.4	Assess prerequisites to allow for maximum student flexibility and alternative pathways through the curricula.
1.5	Create student-centered paid internship and co-op programs integrated into engineering curricula that encourage, support, and recognize the value of work experiences.
1.6	Create curricula and support structures that provide more seamless transitions between engineering technology and engineering undergraduate degree programs while ensuring students are prepared with the necessary skills and knowledge to succeed in their chosen field.
2.1	Integrate hands-on and collaborative learning pedagogies that balance student ownership and choice and effectively working with others.
2.2	Implement methods to support learners both in and outside the classroom (e.g., through scaffolding, etc.).
2.3	Align time and evaluation with expected outcomes via inclusive assessment practices and continuous formative feedback.
2.4	Engage and support faculty in some form of systematic professional development and evaluation of their educational innovations through scholarly approaches.
2.5	Identify or create digital technology platforms to support alternative approaches to learning and evaluation.
3.1	Evaluate the systems in place in our engineering and engineering technology programs and make changes that will create a fair and equitable system for all students.
3.2	Offer professional development on positionality for faculty in order to raise awareness of one's identity and how it influences a person's teaching and everyday interactions.
3.3	Provide professional development for faculty and staff to foster the development of a mindset that centers on lifelong learning to support faculty's understanding of inclusive and equitable teaching practices.
3.4	Modify engineering curricula to emphasize a humanized socio-technical framework.
3.5	Expand user-centered design practices common within engineering to a whole student-centered design of learning environments (where whole means students' comprehensive identities and experiences are valued, included, and affirmed).
3.6	Integrate trauma-informed and healing-informed practices in engineering culture and education, with a focus on racialized trauma.
3.7	Accept that engineering is a body politic (political science definition related to power and privilege) and establish policies that define individual and collective accountability
3.8	Include professional development in the framework of historical events and structures that continue to shape societal inequities and integrate the impacts of engineering on human lives into the engineering curricula.

3.9	Create an engineering pedagogy that intentionally integrates antiracism into what is taught and how.
4.1	Revise tenure and promotion processes at the department, college, and university levels to reward effort, innovation, and risk-taking in teaching.
4.2	Reimagine institutional policies that support innovation in teaching and learning.
4.3	Revise program accreditation requirements to align with the changing needs of our society.
4.4	Work with and advocate to federal and state governments to increase flexibility in financial aid regulations, including scholarships for year-round and part-time learning.
4.5	Explore and adopt a different paradigm to support an engineering mindset that fosters a culture of accountability in access and diversity.
4.6	Track Data That Matters.
5.1	Integrate experiential learning for all students in a societal and professional context at the program level.
5.2	Foster partnerships among accreditation agencies, academia, and industry councils that focus on engineering in a societal context.
5.3	Facilitate discussion among ABET, NSPE, and academic institutions regarding the divide between engineering and engineering technology.
5.4	Create a new accreditation option specifically for BS degree programs in engineering technology or modify EAC to include BS engineering technology programs.
5.5	Form strategic partnerships with community colleges to bring about change, especially regarding credit transfer.
5.6	Foster broad collaborations to assist PK-12 educational systems to value and champion engineering learning.
6.1	Change the perception of engineering by promoting the idea that engineering is for everyone who wants to be a problem solver, not just those who excel in mathematics.
6.2	Remove artificial barriers to the engineering profession through a design-by-choice flexible engineering curriculum.

Notes:

- ABET: a non-governmental accreditation organization in the disciplines of applied and natural science, computing, engineering, and engineering technology
- NSPE: National Society of Professional Engineers
- EAC: Engineering Accreditation Commission

- PK-12: pre-kindergarten through 12th grade ("K-12" is used in some National Academies publications)

Create Flexible Program Structures to Remove Barriers

The first issue tackled in the ASEE report was impediments to entering the fields of engineering and engineering technology. Six recommendations were offered in this chapter (denoted 1.1–1.6 in Table 2), aimed at removing these impediments and achieving success in programs. A range of National Academies publications independently reached similar conclusions regarding the goals of increasing flexibility, involvement, and relevance within engineering programs. The ASEE report recommendations include incorporating mathematics into engineering contexts, modularizing curricula, adopting competency-based assessments, expanding experiential learning opportunities, and supporting seamless transitions between degree programs.

Integrating In-Context Mathematics into Curricula

The ASEE report recommendation to integrate mathematics into real-world engineering contexts, particularly in the introductory curriculum, is rooted in efforts to close preparation gaps that place a greater burden on some students. The National Academies report, *Enhancing the Community College Pathway to Engineering Careers* (2005), emphasizes the use of applied engineering examples in mathematics courses to improve accessibility for community college students. Similarly, *Engineering in K-12 Education* (2009) encourages connecting mathematical reasoning to engineering design to make math more meaningful. *Building Capacity for Teaching Engineering in K-12 Education* (2020) further supports teaching approaches that use students' backgrounds and lived experiences to contextualize learning, advocating for instruction that sees these varied circumstances as assets rather than deficits.

Modularizing Engineering Curricula for Flexible Pathways

Greater curricular flexibility, the subject of the ASEE report chapter's second recommendation, can be achieved through modularized program structures, which enable students to pursue electives in emerging fields and tailor their learning pathways to their individual goals. *Educating the Engineer of 2020* (2005) advocates using the flexibility within accreditation standards to design curricula that meet individual student needs and introduce engineering concepts early.

Engineering Curricula: Understanding the Design Space (2010) promotes modular structures that support inductive, integrated, and technologically rich learning. Engineering Technology Education in the United States (2017) and Infusing Advanced Manufacturing into Undergraduate Engineering Education (2023) both stress that modularization is essential for nontraditional learners, community college transfers, and those entering rapidly evolving sectors like advanced manufacturing.

Competency-Based Assessment and the Use of Formative Feedback

The shift toward competency-based education is supported by the ASEE report's Recommendation 1.3, which calls for competency-based assessment practices. A participant in the National Academies workshop, summarized in *Developing Metrics for Assessing Engineering Instruction* (2009), indicated that multidimensional evaluation systems that include formative assessments help both instructors and students track learning progress. Ten years later, the *Science and Engineering for Grades 6–12*… (2019) report endorsed embedded, reflective assessments that allow students multiple ways to demonstrate mastery. *Building Capacity for Teaching Engineering in K-12 Education* (2020) also supported assessment methods that emphasize feedback and growth, aligning with strategies like "ungrading" that reduce the inequities often associated with rigid grading systems.

Flexible Prerequisite Structures to Enable Alternative Pathways

Rigid prerequisite systems can create bottlenecks, particularly for transfer students and learners from backgrounds that are not typically associated with pursuing an engineering career, an issue addressed in ASEE report Recommendation 1.4. *Enhancing the Community College Pathway to Engineering Careers* (2005) and *Educating the Engineer of 2020* (2005) both advocate for articulation agreements[4] between 2- and 4-year programs and outcomes-based learning to support seamless transitions between institutions. *Engineering Technology Education in the United States* (2017) and *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) stress the need for curricular alignment and flexible structures that allow students to progress smoothly through their programs without unnecessary delays.

Integrating Paid Internships and Co-ops into Curricula

Experiential learning—especially when supported by paid opportunities—has been shown to enhance career readiness and alleviate financial barriers for students. Recommendation 1.5 calls for such programs. *Infusing Real World Experiences into Engineering Education* (2012) profiles nearly 30 programs that effectively integrate internships and co-ops, while *Educating the Engineer of 2020* (2005) and *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) both highlight the importance of connecting academic learning to industry practice. *A New Vision for Center-Based Engineering Research* (2017) notes that partnerships with industry can also support professional development, ethical decision-making, and the development of entrepreneurial skills through structured, work-based learning experiences.

Creating Seamless Transitions Between Engineering Technology and Engineering Degrees

This section's final recommendation notes that addressing the long-standing divide between engineering technology (ET) and traditional engineering programs is essential for broadening participation and responding to workforce needs. *Engineering Technology Education in the United States* (2017) directly calls for clearer alignment and awareness between ET and engineering degrees, promoting smoother transitions and shared learning outcomes. As already noted, *Enhancing the Community College Pathway to Engineering Careers* (2005) and *Educating the Engineer of 2020* (2005) stress the importance of articulation agreements and flexible curricula to facilitate these transitions. And *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) supports building structured pathways that connect hands-on ET education with advanced engineering careers.

Common Themes

The ASEE report and National Academies publications both provide arguments for redesigning engineering education to make it more flexible, aligned with real-world challenges, and more welcoming to a diverse range of students. Incorporating contextualized math instruction helps students from varied backgrounds engage meaningfully with technical content. Modularizing curricula and reassessing prerequisite structures create personalized pathways through the discipline. Competency-based assessment and flexible grading practices ensure that students are evaluated on their learning rather than outdated standards. Paid internships and co-ops enhance professional development, while strong pathways between ET and engineering degrees expand access and workforce readiness.

Evidence-based Pedagogy: Creating a Student-Centered Engineering Education

The ASEE report further notes that to create a more engaging and effective engineering education system, institutions must adopt a set of evidence-based strategies. The recommendations to achieve this include

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[4] An articulation agreement is a formal guarantee that courses taken at one institution will be recognized and credited when a student transfers to another institution.

integrating hands-on and collaborative pedagogies, supporting learners both inside and outside the classroom, aligning assessments with learning outcomes, providing systematic faculty development, and adopting digital platforms that support innovative teaching and evaluation. A range of National Academies publications also offer support for such practices and provide guidance for their implementation.

Integrate Hands-On and Collaborative Learning Pedagogies

The first recommendation in this chapter of the ASEE report is to integrate hands-on and collaborative learning pedagogies. This approach enhances student engagement, promotes teamwork, and makes engineering more meaningful. *Educating the Engineer of 2020* (2005) highlights the value of team-based projects, real-world problem-solving, and interdisciplinary case studies in retaining students and preparing them for professional practice. Similarly, *Science and Engineering for Grades 6–12…* (2019) advocates for centering instruction around engineering design and student inquiry, helping learners develop reasoning and problem-solving skills through artifact creation and collaborative discussion. In higher education, *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) recommends experiential learning models—such as capstone projects and internships—that place students in team-based, real-world environments.

Implement Methods to Support Learners

Supporting learners both in and outside the classroom, as noted in Recommendation 2.2, is also essential to broadening participation in engineering. *Engineering in K-12 Education* (2009) and *Building Capacity for Teaching Engineering in K-12 Education* (2020) both emphasize outreach and scaffolding[5], particularly for students from backgrounds traditionally considered outside of engineering. These reports recommend pedagogies that draw on students' identities and life experiences, as well as professional development for teachers to facilitate meaningful learning experiences. *Connecting Efforts to Support Minorities in Engineering Education* (2023) notes that cross-institutional mentoring and support networks are essential for student success, particularly for these groups.

Align Instructional Time and Evaluation with Expected Outcomes

Another priority, highlighted in ASEE report Recommendation 2.3, is aligning time and evaluation methods with desired learning outcomes through assessment and feedback practices relevant to the student. A participant in the workshop summarized in *Developing Metrics for Assessing Engineering Instruction* (2009) argued for multidimensional evaluation systems that include both formative and summative assessments, while another suggested separating professional development feedback from tenure and promotion evaluations to encourage instructional innovation. *Science and Engineering for Grades 6–12*… (2019) supports integrating assessment into daily learning, allowing students to demonstrate understanding in multiple ways and helping teachers adjust instruction in real time. *Overcoming Challenges to Infusing Ethics into the Development of Engineers* (2017) addresses the provision of continuous feedback and the alignment of assessment with institutional and societal goals, particularly in the context of ethics education.

Support Faculty in Professional Development

Faculty play a central role in implementing the strategies proposed in the ASEE report, and Recommendation 2.4 indicates that their development must be systematic and sustained. The *Developing Metrics for Assessing Engineering Instruction* (2009) proceedings address the involvement of faculty in the design of evaluation systems and using feedback to improve teaching practices. *Building Capacity for Teaching Engineering in K-12 Education* (2020) calls for long-term professional learning aligned with research-based methods, while the *Understanding Measures of Faculty Impact and the Role of Engineering Societies* (2018) proceedings expands the definition of faculty impact to include leadership, collaboration, and teaching, and with the aim of encouraging mentoring and annual reviews to support professional growth.

[5] Scaffolding is a teaching method in which the instructor gradually reduces support as students gain understanding and skills, enabling them to tackle tasks or concepts that are initially beyond their capacity.

Implementing Digital Technology Platforms to Support Alternative Learning Approaches

To enable innovative learning and evaluation approaches, Recommendation 2.6 states that institutions must also leverage digital technology platforms. This strategy is also advocated in multiple reports from the National Academies. *Educating Engineers: Preparing 21st Century Leaders in the Context of New Modes of Learning* (2013) explores how online platforms and lifelong learning models can expand access and promote flexible learning. *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) suggests using remote access to technologies and digital platforms for experiential learning. *A New Vision for Center-Based Engineering Research* (2017) recommends web-based dashboards and real-time tracking tools to enhance collaboration and monitor research outcomes. *Educate to Innovate* (2015) and *Sharing Exemplary Admissions Practices That Promote Diversity in Engineering* (2023) explore how digital tools, including artificial intelligence and data science, can support recruitment, retention, and innovation—but also caution that such tools must be used responsibly.

Common Themes

The ASEE report and National Academies publications independently provide blueprints for rethinking engineering education. They support hands-on and collaborative learning, promote support structures for students that align assessments with expected outcomes through continuous feedback, and call for sustained faculty development and digital innovation.

A Welcoming Engineering Education Learning Environment

Engineering and engineering technology education must evolve to reflect the growing heterogeneity of student populations and the complex societal challenges engineers are called to solve. The ASEE report and a number of National Academies publications tackle these issues by offering recommendations that include evaluating existing systems for shortcomings and equipping faculty to address them, updating curricula to reflect socio-technical realities, and transforming learning environments to better meet student needs.

Evaluate Existing Systems

The foundational Recommendation (3.1) of this chapter of the ASEE report is to evaluate the systems currently in place in engineering and engineering technology programs to ensure that they are meeting the needs of all students. The National Academies' *Surmounting the Barriers…* (2014) workshop proceedings identify persistent challenges such as unsupportive institutional cultures and learning communities, and insufficient financial support. *Engineering Technology Education in the United States* (2017) recommends further research to understand why certain populations thrive in programs while others do not, and to apply the knowledge gained to inform revised strategies. *Building Capacity for Teaching Engineering in K-12 Education* (2020) expands the scope of such efforts, calling for systemic changes beginning at the K-12 level.

Offer Professional Development

To advance such efforts, faculty must be supported through professional development (Recommendations 3.2 and 3.3). *Overcoming Challenges to Infusing Ethics into the Development of Engineers* (2017) emphasizes that faculty play a critical role in shaping the outlooks of engineering students, observing that training helps faculty connect technical instruction with the full range of dimensions of engineering practice. *Surmounting the Barriers…* (2014) also calls for professional development to improve classroom practices. In K-12 settings, *Building Capacity for Teaching Engineering* (2020) recommends providing sustained learning opportunities that help teachers develop effective strategies. *Educating the Engineer of 2020* (2005) emphasizes the importance of interdisciplinary teaching that bridges engineering with the broader implications of its applications.

Complementing this, faculty and staff must be provided with ongoing professional development opportunities that promote a mindset of lifelong learning and support the continuous improvement of teaching practices. The *Lifelong Learning Imperative in Engineering* workshop proceedings (2010, 2012) stress that engineers and educators alike should stay current with technological and societal changes. These proceedings highlight the importance of collaboration among academia, industry, and professional societies in delivering impactful learning experiences for educators. *Building Capacity for Teaching Engineering in K-12 Education* (2020) reinforces the value of long-term, research-informed professional development.

Modify Engineering Curricula

ASEE report Recommendation 3.4 notes that curricular reform is also essential. To truly prepare students for the challenges of the 21st century, engineering education must move beyond purely technical training and adopt a more comprehensive framework. *Educating the Engineer of 2020* (2005) similarly advocates for connecting engineering problems to real-world societal needs and preparing students to be adaptable lifelong learners.

The *Understanding the Design Space* (2010) workshop called for restructuring engineering programs around inquiry-based learning. More recently, *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) emphasizes the need to consider ethical and human dimensions in engineering design and encourages experiential learning. *Science and Engineering for Grades 6–12…* (2019) supports this shift by encouraging the use of locally relevant design challenges to engage students in real-world contexts.

Expand User-Centered Design Practices

Moving beyond curriculum content, ASEE report Recommendation 3.5 asserts that learning environments themselves must reflect a student-centered design philosophy. The National Academies' *Engineering in K-12 Education* (2009) report similarly recommends designing curricula that foster creativity, ethical thinking, and collaboration. *Building Capacity for Teaching Engineering in K-12 Education* (2020) and *Science and Engineering for Grades 6–12…* (2019) further call for pedagogies that build upon students' backgrounds.

Common Themes

In summary, the ASEE report and National Academies publications both identify priorities for reforming engineering education, including the evaluation of existing systems for areas of improvement, supporting the development of instructional staff, adopting a framework in curricula that integrates consideration of the full range of effects that engineering practice has on society, and implementing student-centered learning environments.

Preparing Campuses for a Student-Centered Engineering Education

The next chapter of the ASEE report argues that institutions must rethink long-standing policies and practices to create a more responsive and innovative engineering education system. A suite of National Academies reports supports a set of transformative steps that span faculty advancement, institutional policy, accreditation, financial aid, equity, and data-driven accountability. These evidence-based strategies aim to better align engineering education with the evolving needs of society and the changing demographics of students.

Revising Tenure and Promotion to Reward Innovation in Teaching

Reforming how faculty are evaluated is essential to encouraging educational innovation, and ASEE report Recommendation 4.1 advocates that this be undertaken. The workshop discussions summarized in *Developing Metrics for Assessing Engineering Instruction* (2009) underscore the need for multidimensional measures of teaching effectiveness and recommend separating formative and summative assessments to foster creativity without penalizing risk-taking. In the same vein, participants in the *Understanding Measures of Faculty Impact…* workshop (2018) called for expanding tenure and promotion criteria to include interdisciplinary collaboration, community engagement, and innovative teaching. And *Educating the Engineer of 2020* (2005) reinforces this direction, emphasizing the importance of recognizing faculty who enrich the undergraduate experience and promote lifelong learning through pedagogical innovation.

Reimagining Institutional Policies to Support Innovation in Learning

ASEE report Recommendation 4.2 emphasizes that engineering education must evolve to embrace new teaching models. Attendees at the *Educating Engineers: Preparing 21st Century Leaders* forum (2013) called for institutional policies that support flexible, interactive, and lifelong learning—especially through online and interdisciplinary approaches. In *Engineering Curricula: Understanding the Design Space* (2010), workshop participants examined modern instructional technologies and policies that enable collaboration among faculty, industry, and administrators. *Infusing Real World Experiences into Engineering Education* (2012)—a collaboration between the NAE and Advanced Micro Devices, Inc. in support of the AMD NextGen Engineer initiative—complements these ideas, demonstrating how real-world, hands-on experiences can be institutionalized when policies and resources allow for innovative program development.

Revising Accreditation Criteria to Reflect Societal Needs

Modern challenges require a modern engineering education, and Recommendation 4.3 proposes that this education better aligns with the needs of society. The *Forum on Proposed Revisions to ABET Criteria 3 and 5* workshop (2016) explored this idea, including updates to accreditation standards that reflect ethical responsibility and interdisciplinary collaboration. Reports such as *Engineering Technology Education in the United States* (2017) argue that accreditation must better represent hands-on, application-focused engineering pathways. Likewise, *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) advocates for standards that integrate advanced technologies and emphasize experiential learning relevant to national industries and workforce needs.

Increasing Flexibility in Financial Aid Policies

ASEE report Recommendation 4.4 addresses financial barriers that hinder students' ability to pursue an engineering education and calls for changes to state and federal policies. *Enhancing the Community College Pathway to Engineering Careers* (2005) endorses more adaptable financial aid policies that support transfer and completion. *Engineering Technology Education in the United States* (2017) echoes this, noting the appeal of engineering technology programs to nontraditional students who often require flexible aid.

Fostering Accountability

An engineering mindset that fosters a welcoming culture for all students is meaningless with systemic accountability for outcomes, the subject of Recommendation 4.5. The *Connecting Efforts to Support Minorities in Engineering Education* workshop (2023) proposes a groundwork for such accountability, outlining scalable solutions to existing problems such as cross-institutional partnerships and mentoring initiatives. Earlier, *Educating the Engineer of 2020* (2005) advocated for early outreach and meaningful engagement of students from backgrounds outside those typically associated with engineering, urging institutions to take proactive responsibility for integrating them into the scholarly community.

Tracking Data That Matters

Without meaningful information, progress is difficult to assess, and, in response, ASEE report Recommendation 4.6 plainly states, "Track Data That Matters". In the same spirit, *Enhancing the Community College Pathway* (2005) recommends consistent tracking of student outcomes, especially for transfer students. *Engineering Technology Education in the United States* (2017) highlights critical data gaps in tracking the technician workforce and calls for improved federal data systems. *Building Capacity for Teaching Engineering in K-12 Education* (2020) recommends updates to national surveys to better reflect K-12 teaching in engineering, while *Connecting Efforts to Support Minorities* (2023) emphasizes the importance of locating, accessing, and sharing data that evaluates recruiting efforts.

Common Themes

Several common themes emerge across the publications cited: rewarding innovative teaching in promotion and tenure processes; adopting policies that foster pedagogical experimentation and real-world learning; aligning engineering program standards with societal, ethical, and technological demands; expanding aid options for students; building systemic accountability to support participation in engineering education, and prioritizing the collection and use of meaningful data to guide reform and measure outcomes. Implementing these steps, the publications assert, can better prepare institutions, governments, and accrediting bodies to meet future challenges.

Leveraging Strategic Partnerships

The ASEE report then takes on measures to harness the power of strategic partnerships. The National Academies have long supported this approach. Multiple publications affirm the value of integrating experiential learning, fostering collaboration across institutions, and bridging the divide between engineering and engineering technology. Collectively, these outline a vision that prioritizes real-world relevance and systemic change in engineering education.

Integrating Experiential Learning in a Societal and Professional Context

ASEE report Recommendation 5.1 seeks to promote experiential learning. Several National Academies publications also emphasize the importance of embedding hands-on, real-world learning experiences within engineering education. *Educating the Engineer of 2020* (2005) advocates for the introduction of engineering design studies early in undergraduate programs to engage students through team-based exercises and real-world problem-solving tied to societal needs. This approach not only enhances learning but also improves retention and professional readiness. In *Infusing Real World Experiences into Engineering Education* (2012), 29 successful case studies are showcased as models of how experiential learning can be incorporated effectively. The report provides practical tools for scaling these approaches across institutions.

More recently, *Infusing Advanced Manufacturing into Undergraduate Engineering Education* (2023) highlights the transformative power of internships, capstone projects, and industry-sponsored learning. It encourages direct connections to advanced manufacturing technologies and stresses the need to ground learning in societal impact and professional practice.

Fostering Strategic Partnerships with Academia, Industry, and Accrediting Bodies

Recommendation 5.2 asserts that collaborative engagement across stakeholders is vital to aligning engineering curricula with evolving societal and workforce needs. Similarly, the *Forum on Proposed Revisions to ABET Criteria 3 and 5* (2016) emphasizes the importance of dialogue among ABET, academia, and industry to ensure that accreditation standards reflect both ethical responsibility and the societal impact of engineering. *Engineering Societies and Undergraduate Engineering Education* (2017), a workshop proceedings, highlights how professional societies can act as bridges between academia and industry, supporting initiatives like joint projects and national competitions that contextualize engineering within global challenges. *Understanding Measures of Faculty Impact* (2018) extends the partnership model by redefining success metrics to reflect faculty contributions beyond research output—such as community engagement and societal impact—through collaboration with engineering societies.

Addressing the Engineering–Engineering Technology Divide

A number of National Academies publications underline the importance of reconciling the divide between engineering and engineering technology programs, a subject addressed in ASEE report Recommendation 5.3. *Engineering Technology Education in the United States* (2017) notes the confusion about the roles and recognition of engineering technologists in the workforce, calling for better articulation and clearer distinctions in educational pathways. The *ABET Criteria Forum* (2016) and *Educating the Engineer of 2020* (2005) both support aligning curricula and enhancing collaboration to reduce systemic disconnects, especially for students transferring between programs or institutions.

Developing Accreditation Options for BS Engineering Technology Programs

Recommendation 5.4 calls for changes to accreditation standards to ensure that engineering technology graduates are fully recognized in the profession. *Engineering Technology Education in the United States* (2017) documents this issue, noting a National Survey of College Graduates survey that reported that only 12% of engineering technologists hold a four-year degree specifically in engineering technology, pointing to a need for clearer accreditation pathways.

Further, both the *ABET Criteria Forum* (2016) and *Educating the Engineer of 2020* (2005) advocate for increasing flexibility in accreditation to accommodate multiple educational models, such as BS degrees in engineering technology, that respond to evolving workforce needs.

Strengthening Community College Pathways

Community colleges play a pivotal role in broadening access to engineering education, a fact acknowledged by Recommendation 5.5's call for change in credit transfer policies. This aligns with *Enhancing the Community College Pathway to Engineering Careers* (2005), which advocates for articulation agreements and block transfers to smooth transitions for students. *Educating the Engineer of 2020* (2005) also supports this change, noting that nearly 40% of baccalaureate engineering graduates have community college experience, thus underscoring the need for strong institutional collaboration.

Supporting PK-12 Engineering Education Through Collaboration

Building a pipeline of future engineers begins in PK-12 education, and ASEE report Recommendation 5.6 calls for collaborations to foster it. *Engineering in K-12 Education* (2009) and *Standards for K-12 Engineering Education?* (2010) both recommend developing design-based curricula that promote systems thinking, creativity, and collaboration at these early education levels. Moving to the other side of the process, *Building Capacity for Teaching Engineering in K-12 Education* (2020) advocates for the creation of systemic teacher preparation programs, developed in partnership with higher education, professional organizations, and federal agencies. Teacher leadership is further championed in *Increasing the Roles and Significance of Teachers in Policymaking for K-12 Engineering Education* (2017), which encourages the integration of teachers into decision-making processes. Finally, the publications *Science and Engineering for Grades 6–12* (2019) and *Sharing Exemplary Admissions Practices That Promote Diversity in Engineering* (2023) indicate that such efforts need to start early.

Common Themes

The ASEE report and National Academies publications both reinforce a vision of engineering education that embraces experiential learning rooted in real-world, societal contexts; promotes partnerships across accreditation agencies, academic institutions, industry, and professional societies; bridges the engineering–engineering technology divide, ensuring aligned and respected educational pathways; expands accreditation to better include BS engineering technology programs; strengthens community college pathways through articulation and collaboration; and elevates K-12 engineering education via research-based pedagogy and strategic outreach. By addressing these areas, they offer actionable strategies for transforming engineering education that better prepare students to succeed in the field.

Engineering a New Mindset for Engineering Education

The final chapter of the ASEE report offers two recommendations aimed at changing the perception of engineering in the wider world and removing artificial barriers to the engineering profession, imperatives that have also been identified in many National Academies publications.

Changing the Perception of Engineering

The ASEE report Recommendation (6.1) to reframe engineering as a field for anyone interested in solving real-world problems—not just those who excel in mathematics—is echoed in numerous National Academies reports. *Engineering in K-12 Education…* (2009) promotes the early introduction of engineering habits of mind, such as creativity, collaboration, and systems thinking.

Such traits broaden the definition of who can succeed in engineering, making it a possible future path for more students. The report also pushes for the integration of design-focused curricula in K-12 education to make the subject more relatable. It suggests focusing on encouraging students who traditionally shy away from mathematics to shift the stereotype that engineering is only for those who are gifted in the discipline. *Surmounting the Barriers…* (2014) further underscores this issue by identifying perceptions of engineering as overly math-heavy as a deterrent to some students. It recommends outreach, learning communities, and curricula that emphasize the societal impact of engineering to attract and retain a broader spectrum of students.

In *Building Capacity for Teaching Engineering in K-12 Education* (2020), the focus is on pedagogies that relate to the lives students lead. This report emphasizes preparing teachers to present engineering as a creative and collaborative endeavor—not just a technical one—thus broadening its appeal to all learners.

Removing Artificial Barriers to the Engineering Profession

The recommendation to remove artificial barriers and create flexible, design-by-choice curricula (6.2) is also articulated by National Academies reports and proceedings. These publications advocate for more adaptable pathways, streamlined transfer opportunities, and curricula that reflect the realities of engineering practice. As already noted, *Enhancing the Community College Pathway to Engineering Careers* (2005) highlights the need to strengthen the transfer pipeline from community colleges to four-year institutions. *Educating the Engineer of 2020* (2005) also reinforces the need for flexible, outcome-based curricula and calls for the integration of interdisciplinary learning and community college pathways. The role of engineering technology programs in this goal is detailed in *Engineering Technology Education in the United States* (2017). The report describes these programs, especially those at the two-year level, as hands-on, application-oriented, and vital for creating alternative pathways into engineering careers.

Common Themes

The ASEE report and National Academies publications, therefore, concur on the substance of two core principles:

- Engineering should be presented as a collaborative, creative, and socially impactful field that is open to all students, regardless of mathematical ability or background.
- Institutions should adopt flexible, student-centered curricula that support multiple entry points into the profession, facilitate seamless transfer, and incorporate experiential learning aligned with real-world demands.

By implementing these, educational institutions can better attract, support, and retain a robust population of future engineers—ultimately strengthening both the engineering profession and its capacity to serve society.

Concluding Observations

As the numerous areas of consonance between the ASEE report and the National Academies' reports and proceedings on engineering education over the past 25 years make clear, there are many persistent and unresolved problems in the field and, equally, many agreed-upon means to address them and make strides that will result in better educational opportunities for all and a stronger engineering profession. This highlights the potential for future synergistic dissemination opportunities that showcase these areas. The coming years will present opportunities not only to promote and implement the recommendations that the bodies have put forward, but also to address new challenges that will arise from technological advances and social changes.

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