

The National Academies of **SCIENCES • ENGINEERING • MEDICINE**

With sponsorship from the National Science Foundation, the National Academies of Sciences, Engineering, and Medicine is convening a public symposium to explore ambitions for the future of undergraduate STEM education and identify steps for achieving them.

Prior to the symposium, the National Academies held an idea competition to engage stakeholders with diverse perspectives. Entrants submitted a statement or video addressing some aspect of the symposium's focus: *What should undergraduate STEM education look like in 2040 and beyond to meet the needs of students, science, and society? What should we do now to prepare?*

Entries were evaluated based on their potential to contribute to and advance discussion at the symposium. Entries were also judged on originality and future orientation. Below is one of the winning submissions.

"Putting Equity at the Front: A Choose Your Own Adventure Approach to Engineering Education"

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Engineering is a pathway to a stable career with direct employability after earning an undergraduate degree and yet it is perhaps the most rigidly structured, and consequently exclusionary STEM majors. If we put equity at the forefront, we could eliminate the hurdles to entering and pursuing engineering degrees that are based on privilege-laden K-12 education systems and long-standing University structures. If we put equity at the forefront, we would meet in-coming students where they are, focus on asset-based approaches to engineering education, and focus on students as humans rather than commodities to be produced by a system that has failed many engineering learners for over a century. While there are multiple ways to accomplish an equity-first approach, we will use the notion "choosing your own adventure" in engineering education to illustrate a potential process to design changes based on an equity and social justice mindset from the start.

In a "choose your own adventure" book there are multiple endings and multiple ways to get from a start to an end. To imagine why this approach is needed in engineering, consider two different potential engineering students planning to pursue aerospace engineering degrees. One student, raised in a wealthy household, has had the best pre-college engineering preparatory courses offered in high school and tutoring to maximize scores on SAT entrance exams. Another student, who entered the military after high school specializing in aircraft maintenance, has always struggled with standardized tests like the SAT and now hopes to attend school part-time while working full-time. The first student would seem academically well-prepared for engineering coursework because they have high scores and "book smarts". By the same measure, the second student, despite their deep knowledge of aircraft, will appear less prepared and may not gain

admission to their desired institution or degree track. In reality, both students might make excellent aerospace engineering students and engineers. They are just starting at different places and the current engineering curricula are not ready for either of them. Imagine the first student opting out of calculus courses that repeat concepts learned in high school to emphasize practical, hands-on courses, and imagine the second student taking a few shortcourses to brush up on specific aspects of calculus not used during their time in the service while minimizing the hands-on courses. Even better, what if the second student could receive credit for their life experiences in lieu of courses?

In our current reality, both students would be channeled into the existent rigid system and be forced to conform to the system rather than the system working for them. Both students would likely be required to take multiple calculus courses typically taught through the math department which are completely devoid of engineering context. The second student might even need to take some remedial calculus classes before they can start engineering courses. This could put the second student semesters behind, which adds significant financial and time burdens. One might ask why engineering education is so rigid; the answer is simple: The course structure is designed to function in the University systems that created it rather than being designed from a truly student-centered perspective. At present, most courses force fit a term structure and all last the same number of weeks because this tidies up faculty workload and credit counts. Additionally, course content is based in-part on what can be covered in a term. No one stops to contemplate whether that content is required for each and every student. If students need half of the content, why can they not just take modularized courses that address the gaps in their education and get credit for other knowledge (e.g., life experience) they bring to college?

Essentially, the proposed approach of a “choose your own adventure” is the opposite of current engineering education curriculum that has strict entry expectations and is tightly bound, with nearly singular course completion pathways accompanied by rigid pre- and co-requisites. The high credit requirements, narrow focus, and structural rigidity of engineering curricula are highly problematic from an equity perspective and are not student-focused. For example, offering courses once per year promotes fiscal efficiency within the University (fewer instructors needed when fewer courses are offered) rather than supporting student needs. If an equity perspective was adopted, courses would not only be restructured, but they would also be offered when the students need them such that “getting out of sequence” and consequently losing time would not be reality for students. To design from an equity perspective, we should ask: What purpose does rigidity serve in engineering education? Why can students not choose what courses to take while considering their own background, knowledge, and skills without being penalized in time and money toward degree completion?

Accomplishing the goal of an equity-first and student-centered engineering curriculum will not be an easy task. The work associated with the “Engineer of 2020” only sought to change the outcome but not the system itself. We are calling for the opposite approach of changing the system to yield better outcomes. Changing curricula that have been in place for decades, and perhaps centuries, requires a dismantling of the current system. For example, boundaries could blur during negotiations over home Departments for concept-based modules. Perhaps even more challenging,

stakeholders (Universities, employers, K-12 educators, ABET, etc.) will have to redefine engineering and what it means to do engineering to enable the valuing of life experiences and other non-book forms of knowledge. However, it is imperative that we start this work now to make significant strides by 2040.