

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.

"Teaching in an inclusive, global, digital society"

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Undergraduate STEM education in 2040 prepares highly diverse STEM students to become inclusive, lifelong learners that are highly adept at continuing to reinvent themselves, at home with ever-changing technology, and skilled at team learning in a global, digital society. To prepare students to function this way in 2040, STEM educators need to prepare students now for careers that do not even exist and that they and their students cannot currently even imagine. What do we need to do now to prepare our undergraduate STEM students to succeed and thrive in 2040? We need to stop preaching backward design only for our courses yet forget to employ it for producing an educational framework that builds skills that students can use as jobs evolve to be totally different in the future. Backward design involves setting goals *before* choosing what instructional methods (and forms of assessment) will be employed. Backward design is a perfect method for helping educators move forward to prepare our undergraduate STEM students to thrive in an ever-changing, fast-paced world because it focuses on student understanding and learning rather than on activities and instructional content.

So, what goals do STEM educators need to articulate to ensure that their students can thrive in their future careers and build satisfying future lives? **Firstly, educators need to ensure that students acquire *generalized skills* – encouraging flexibility and tolerance.** One only needs to look at the natural world to see why this is vitally important. In nature, a generalist species is able to survive

and thrive in a wide variety of environmental conditions because they are adept at making use of many different resources (i.e., they are flexible), whereas a specialist species is only able to thrive in a very narrow range of conditions and they do poorly when conditions change. What type of generalized skills do our STEM students need to acquire from their educators?

1. Students need to **value lifelong learning** to allow them to reinvent themselves in their career journeys as they face the challenges of an uncertain future. Lifelong learning is essential for allowing them to acquire new skills quickly. Students need to be taught to resist a human tendency against trying new things, and to constantly search for growth opportunities by being open to acquiring different capabilities.
2. Students need to learn how to become acquainted with and reflect on their own thinking processes (**metacognition**) so they can understand how they solve problems and communicate that to others they may work with.
3. By practicing metacognition, students can recognize the degree of their own **growth mindset** and educators can then help cultivate the development of mindsets important for students to be not only successful in school and careers but in life.
4. Students need **critical and problem-solving skills**. Thus, they need to learn how to use data and facts to come up with credible solutions to problems and to do this within a reasonable amount of time. Fact checking and the ability to ferret out credible sources of information are vital skills that need to be learned as well as quantitative and computer programming skills.
5. Students need to acquire **cultural sensitivity and cross-cultural skills**. The STEM workforce is becoming more diverse. The ability to respect and value individual differences is crucially important. Science is often thought to be an unbiased and objective enterprise. Students need to be taught that gender and racial bias exists in STEM as it does in every other arena and that they must not simply strive to become sensitive to such biases, they need to actually be taught to become active anti-racist, anti-misogynist scientists that also support LGBTQ colleagues. That is, they must engage in the daily action that should follow intellectual awareness of such bias.
6. Students need to learn that understanding science and solving complex scientific problems requires an interdisciplinary approach and constructive collaboration. This approach requires **team learning**. For team learning to occur, students will need to learn how to employ empathic listening skills, that is, listening calmly and to what someone else has to

say even if they do not agree with it. Students need to become skilled at active listening. This skill is imperative to engage in constructive dialog. Students need to learn how to engage in constructive dialog and to encourage a diversity of views enabling the team to learn from each other.

The second main goal is that educators need to develop more realistic strategies to prepare students for the highly technical, ever-changing landscape of the future. How should they do this?

1. **Educators need to focus more on ensuring that students have a firm grasp on the overall, unifying themes of science** (e.g., evolution, central dogma, energy flow, thermodynamics, etc.) and how they percolate through all of the disciplines. Less is more here. By concentrating on important unifying themes of science rather than inundating students with more and more facts, educators can focus on providing students with real-world problems, case studies and data analysis exercises to drive home these central, unifying themes and their relevance to the real world and society.
2. **Educators need to focus on developing a consortium-approach to teaching and learning.** They need to develop a consortium of partners – all equally invested in educating STEM students as well as building bridges between educational institutions and the industries that are interested in employing them. This consortium approach extends to within each educational institution itself. Thus, biology students need to be taught by computer science department members about computers and programming; peer mentoring should be part of every class, etc.
3. **Educators need to focus on acquainting students with the importance of their work to societal needs and give their students a deep dive into understanding where various breakthroughs came from historically and what they might lead to in the future.** For example, how Henrietta Lacks' (without her consent) cancer cells ended up becoming the source of the HeLa cell line – a cell line which is one of the most crucial cell lines in medical research.