STEM SHIFTS

How science, technology, engineering and math instruction is changing higher education

By Jennifer L.W. Fink

What began as a push to increase the number and diversity of students studying STEM has evolved into a full-scale effort to improve teaching and learning at The University of Arizona.

In 2013, the college was selected as one of eight initial project sites for The STEM Undergraduate Initiative, a project of the Association of American Universities designed to enhance STEM successes in higher ed.

At the time, there was increasing awareness that STEM fields are populated primarily by white males, and there was a desire to build a sustainable, diverse pipeline of scientists, engineers and mathematicians. So Arizona focused its institutional attention on introductory science courses—the so-called gateway classes that provide the foundation for STEM careers.

Now, faculty across all disciplines deliver more interactive and collaborative instruction, and remodeled classrooms invite hands-on exploration and experimentation.

As the university begins an ambitious strategic planning process under its new president, Robert Robbins, faculty expect these STEM-inspired practices to lead to a strong emphasis on the student experience and teaching and learning throughout the college, says Jane Hunter, director of academic resources and special projects.

Arizona’s experience with the power of STEM is not unique. There are several ways STEM education is, more broadly, changing college campuses around the country.

Increased emphasis on the quality of undergraduate instruction

"Twenty years ago, especially at research universities, a lot of faculty would see their primary job as research, and teaching as something they had to do," says James Fairweather, professor emeritus of higher adult and lifelong education at Michigan State University.

"I'd say the attitude of faculty toward teaching today is more positive. I don't think they see it as the drudgery of their job."

That shift began with efforts to improve STEM education, as professors and administrators realized many students failed to complete or progress past introductory science courses, says Fairweather, the author of "Linking Evidence and Promising Practices in Science, Technology, Engineering, and Mathematics (STEM) Undergraduate Education," a status report for The National Academies’ National Research Council Board on Science Education.

Campus leaders had this realization: Helping students succeed in large undergraduate courses such as Chemistry 101 not only bolsters the STEM pipeline, but also increases student and family satisfaction.
Fewer lecture halls, more collaborative learning spaces
For decades, most introductory science classes convened in large lecture halls. The science of learning, however, says that students progress further when they are engaged and supported while exploring scientific concepts. Asking students open-ended questions and encouraging hands-on experimentation is one way educators can engage and support learners.
In an effort to improve student outcomes in STEM courses, some universities have moved science instruction to collaborative learning spaces.

Impact of STEM at The University of Arizona

The University of Arizona’s science and engineering library converted a room where it had kept journals into a collaborative learning space featuring moveable tables and chairs. It can accommodate 264 students.

One professor piloted a more interactive version of his chemistry class in the room with outstanding enrollment results. “By the end of that first semester, we’d held eight different courses in that space,” Hunter says. “By the following fall, we had permanently transformed that room into a collaborative learning space.” Within a year, the university had five collaborative learning spaces; by fall 2018, there will be 30.

Both students and faculty show a strong preference for these updated classrooms. “When we transform a traditional classroom into a collaborative learning space, we usually reduce the number of seats. But even though we have fewer seats, we end up teaching nearly as many students in those classrooms,” Hunter says. “They’re popular, so we fill them up—all of a sudden, people think, ‘I’ll take the 8 o’clock class, ‘I’ll teach a class at 4 in the afternoon.’

The collaborative spaces are frequently used for non-STEM classes too.

Shift toward evidence-based instructional practices
Researchers who wanted to improve student outcomes in introductory STEM courses began by digging into the scientific literature about human learning. They uncovered a slew of information about effective and not-very-effective teaching practices, and then led efforts to adapt these practices into science, technology, engineering, and mathematics instruction at the university level. “Students learn best when learning is hard and when they grapple with concepts at a deeper level of thinking,” Hunter says.

Getting faculty to adopt evidence-based teaching practices—such as building meaningful relationships with students and encouraging discussion and hands-on experimentation—has not been easy. Early in his efforts to improve STEM education, Fairweather realized that evidence of student success wasn’t enough.
Culture change is required to truly shift institutional thinking on teaching and learning, and that’s exactly what Fairweather sees happening now, in part due to the activities of the AAU Undergraduate STEM Education Project.

As large, research-heavy institutions adopt new instructional practices and share information, other colleges get inspired to follow suit.
Fairweather says, “It’s harder for an institution to say they can’t do something if they can see that a peer has done it.”

Improved faculty PD
Professors and institutions examining STEM outcomes have stumbled across some troubling information. At The University of North Carolina at Chapel Hill, for instance, researchers realized that about 1 in 3 black students earned a D or F in Biology 101 while only 1 in 14 white students earned similar grades. Few professors were equipped to address the problem.

Many institutions now devote more resources toward professional development. At Chapel Hill, Kelly Hogan, a STEM teaching associate professor and assistant dean of instructional development, regularly shares with other professors the inclusive teaching techniques she used to close the achievement gap in her biology classes—such as providing students with guided reading questions to answer as they read text, frequent quizzes to assess understanding, and referrals to peer mentoring and tutoring, as needed.

In another Chapel Hill initiative, professors with experience in evidence-based practices mentor their colleagues and provide feedback on teaching techniques.
Howard University in Washington, D.C., hosts regular faculty workshops to hone professors’ teaching skills, including a recent session about “Strategic Doing,” an initiative at Purdue University that teaches people how to collaborate more consistently. “We’ve had a couple of training sessions for faculty to get used to that concept, with the idea that they will then instill that concept into their courses,” says Gary Harris, associate provost for research and graduate studies at Howard.

Problem-solving and creativity emphasized across all majors
As educators have worked to improve STEM instruction, they’ve realized many of the skills prized within STEM fields—creativity, problem-solving and innovation, for instance—are valuable to all disciplines.

“‘The exciting things always happen at the interface of a discipline with technology when computer technology interfaces with political science or with medicine, ‘ says Harris, also a network leader for the Center for the Integration of Research, Teaching and Learning, an organization focused on advancing the teaching of STEM disciplines in higher education via online courses for postdocs and faculty. “The important thing is to give students a well-rounded enough education through which they can take advantage of that interface.”

The goal, he adds, “isn’t so much to create a bunch of people who can write code, but to give them an introduction to technology so they can apply it to their particular discipline.”

Jennifer L. W. Fisk is a Wisconsin-based writer.

Involvement in the Association of American Universities Undergraduate STEM Education Initiative grew into the UA Learning Initiative, which includes:

• Faculty Learning Communities: Groups of seven to 10 faculty members meet seven times throughout the semester to share best practices for teaching.

• SAIL (Student Advocates for Improved Learning): A two-course experience that teaches undergraduates the science of learning and how to apply that science to their own studies. The program also prepares undergrads to serve as SAIL Fellows, who meet with small groups of students to teach them evidence-based study strategies.

• Learning to Learn series: In-depth information about six proven learning strategies (including growth mindset, metacognition and spaced practice) presented online. Learning to Learn ambassadors—specialized trained instructors from across UA’s campus—also visit classrooms to spread these strategies.

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