BY MARGARET LOFTUS

whet their appe-tite

Down-to-earth illustrations – like an exploding sausage – are among techniques shown to stimulate learning and student retention.

CASTING ABOUT for everyday examples to drive home a thermodynamics principle, University of Louisville mechanical engineering Prof. Ellen Brehob looked no further than the drinking fountain outside her classroom. Short of lugging a refrigerator to class, she figured a water cooler would best illustrate the vapor-compression refrigeration cycle. "If you leave the water running, you can feel the cool air coming out," she explains. Maintenance people forbade her from removing the front panel, but she got her pick of campus drinking fountains in various stages of disrepair. For her students, the demonstration proved more effective than equations and lectures, Brehob says. "This gave them a better visual idea of what these parts in the schematic could actually look like."

Far from a gimmick, Brehob's MacGyver-like move reflects an evidence-based approach now gaining traction among engineering educators — and support from the National Science Foundation. Studies show that using familiar examples, as opposed to theoretical or abstract ones, increases the likelihood that students will retain the lesson and ultimately persist in engineering majors. The power of commonplace connections to lift learning seems so promising that NSF sponsors a program to encourage the practice. Modeled after the Cooperative Extension Service in state land-grant institutions, Engaging Students in Engineering — or ENGAGE — aims to help engineering schools improve retention, particularly among underrepresented students, by applying proven strategies in several targeted courses, including physics, fluids, and introduction to engineering. "Essentially, it's getting research on retention off the shelves and into the undergraduate experience," says Susan Metz, the program's principal investigator and director of special projects in engineering education at Stevens Institute of Technology. "We bridge research and practice."

Not an Overhaul

LAUNCHED LAST YEAR, ENGAGE works with teams of engineering faculty to implement three classroom strategies known to boost learning. The first involves incorporating "everyday examples" into lectures, so that students see how complex concepts apply to skateboards, appliances, or Silly Putty. The other two techniques help forge engineering knowledge and identity by improving students' spatial visualization skills and increasing interactions with faculty. The effort, advanced through seminars and webinars by top researchers in each strategy, is meant to enhance rather than overhaul the curriculum, says Metz. "We provide resources and technical assistance to help schools jump-start the initiatives at their own institutions," she explains, noting that the research and webinars are available to any school seeking to launch its own initiative.

So far, 10 engineering schools have signed on, with another 10 participants to be announced next year. Most are big universities, allowing ENGAGE to reach the greatest number of students. Each school fields a four-person team to spearhead the effort; a $12,000 grant provides seed money to kick off activities, most of which are sustainable at little or no cost. Louisville Prof. Brehob, for instance, won a $500 stipend to embed real-life examples into her lessons, but resourcefulness netted the drinking fountain for free.

What distinguishes ENGAGE from similar initiatives is its reliance on proven research. Consider the everyday-examples component. It does not require faculty to change the way they teach, only that they include illustrations from daily life, notes Metz. "Instead of using weaponry and pipes, use musical instruments or skateboards," she explains. "In a way, it's so simple, but complexity comes in getting people to use them and adapt them."

What Turns Students Off

MICHIGAN STATE UNIVERSITY mechanical engineering Prof. Eann Patterson, who consults on the real-life-examples initiative, understands that complexity. He initially developed the strategy as part of an NSF project examining how the engineering curriculum is constructed and its effect on underrepresented minorities. His team found that most students were turned off by the examples typically used to illustrate principles. "If you open an undergrad textbook in any subfield, it is filled with hundreds of examples that all look the same," says Patterson. "If you go into a dynamics textbook, there are lots of bouncing balls and things on springs. It's not very imaginative." Real components or real devices rarely get mentioned, so students without some engineering experience can be left in the dark. "People think if you make the project simple, it will be easier, but our research shows that you don't have to do that," concludes Patterson. "Students will work on something quite hard if it really engages their attention." To help faculty find that "wow" factor, Patterson's team published a series of booklets with lesson plans and solutions using real-life examples. Among them: frying up a pan of sausages in class until their casings burst, memorably illustrating Mohr's circle for stress.

ENGAGE participants can draw from these materials or, like Brehob, dream up their own examples. Another University of Louisville mini-grant recipient, chemical engineering Prof. Gerold Willing, is using Silly Putty and rubber balls to help explain the concepts of molecular weight and material properties. "It's not something that a lot of people pick up on easily," he says. "This way they've got something to picture in their head." At Purdue University, mechanical engineering Prof. Eric Nauman has used everything from amusement park rides to moving sidewalks in teaching his students about friction. "In reviews for the class, students were more interested in the material and said they were able to apply it better," he says. "From my perspective, it's a success, because if nothing else, I'm teaching them how to look at the world around them in a different way." (ASEE's deputy executive director, Robert Black, is an ENGAGE advisory board member, as is incoming Executive Director Norman Fortenberry. Society staff assisted in preparing early publicity materials for the project.)

So far, ENGAGE's most measurable component involves improving student spatial visualization skills. In her work at Michigan Tech, ENGAGE consultant and mechanical engineering Prof. Sheryl Sorby,

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director of the department's engineering education and innovation research group, found that visual/spatial skills are crucial to success in undergraduate engineering coursework. In one study, students who scored poorly (18 or below) on an initial spatial skills assessment test and took a one-credit course to improve their skills averaged a 3.04 GPA in their first semester of engineering. That compares with a 2.6 average for peers who skipped the course. Using Sorby's ENGAGE materials, Virginia Tech engineering education Prof. Richard Goff invited low scorers on the spatial skills test administered during summer orientation to enroll in a 10-week booster course. Participants raised their post-course score to an average of 21.4, up from 16.3.

The research is compelling about the gender divide, too. On average, says Sorby, 10 percent of men who take the test score an 18 or less, compared with one third of women. The spatial skill that has the strongest gender difference is the ability to mentally rotate something, she says, "and that's the one most closely linked to success in engineering." The extra course, however, can narrow that gap. At Michigan Tech, the retention rate for women in engineering who take the extra course is 77 percent, versus 48 percent for those who do not. At the University of Texas-Austin, an optional class based on the first five modules of Sorby's one-credit course was administered within the Women in Engineering program last fall. Despite the shorter version, scores on the spatial visualization test climbed by three points on average, with one student's score zooming from 13 to 21.

Less quantifiable, though no less significant in retaining engineering undergraduates, is student-faculty interaction. While such strategies as learning students' names and saying hello outside of class may seem basic, they've been shown to positively influence retention rates, notes Carol Muller, Stanford University's electrical engineering department manager and founder and former CEO of the nonprofit MentorNet, a national electronic mentoring network for women in engineering and science. Muller, whose research underlies ENGAGE's third strategy, explains that encouraging more short-term interaction between faculty and students can have some of the same effects as mentoring without the large, often impractical, investment. "Small pieces of encouragement, and conveying that students can succeed in this field even if they have to work really hard," she says, "can really help" increase engagement and enthusiasm for engineering. Based on her own studies and other research, Muller developed guidelines to help ENGAGE participants foster such daily exchanges. "These are classes where people learn a lot, fast, and often with a lot of peers," observes Muller. "A lot of times, your energy is focused on 'how can I convey all this information in 45 minutes?' without thinking about things like interaction."

Frying up sausages until their casings burst gives a vivid example of Mohr's circle for stress.

ISTOCK

A Cookie Break

BEYOND CONTENT, such informal exchanges can communicate a sense of engineering as a discipline and profession. UT-Austin ENGAGE leader Tricia Berry, for instance, is adding an occasional 15-minute cookie break in first- and second-year engineering classes for professors to talk about themselves and their work. "We hope that the students can feel more comfortable with the faculty and see them more as a real person than someone who's just standing up there lecturing," she says. Robert Gustafson, director of Ohio State University's Engineering Education Innovation Center and leader of the school's faculty-student interaction effort, asked his graduate teaching fellows to review the ENGAGE guidelines with other faculty. The exercise raised awareness of the approach's merits while sparking conversation around teaching and learning. "A simple cue like putting some positive feedback on a paper may be obvious, but you may not think about it in the heat of grading papers," says Gustafson. "The things we're talking about are not rocket science, but they are good things to talk about." Some, especially cookie breaks and sizzling sausages, also make good eating.

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