Sometimes, everything old is new again. That certainly could be said about certain innovative teaching strategies that two University of Iowa College of Engineering professors are implementing in their classrooms. Sarah Vigmostad and Mona Garvin are employing 21st-century technologies to apply teaching strategies perfected by Socrates: frequent student/instructor interaction, challenging questions that build on one another, peer instruction, and frequent, low-stakes assessment.

Both assistant professors—Vigmostad in biomedical engineering with an affiliation in IIHR and Garvin in electrical and computer engineering and the Iowa City Veterans Affairs Health Care System—earned their BS, MS, and PhD degrees from Iowa and joined the UI faculty in 2008. Vigmostad researches the design and impact of biomedical devices related to blood flow dynamics and heart valve mechanics. Garvin is developing new methods for extracting quantitative data from 3-D ophthalmic images. In addition to conducting leading-edge research, both faculty members are accomplished, creative teachers whose classroom excellence recently earned them Collegiate Teaching Awards.

After teaching Statics for four semesters, Vigmostad decided to redesign the course around several “big questions” and transform class time into a more personal, active learning experience for her students.

“I realized that students often would get stuck on one or two little things that prevented them from progressing farther,” she says. “Traditional large-lecture courses make it difficult to work with students individually, and I was frustrated that these little bumps in the road were only being resolved for those who came to my office hours.”
Vigmostad says Iowa’s new Engineering Grand Challenge Scholars Program and several Center for Teaching workshops “opened my eyes to many different techniques that I could use to engage more personally with students during class and encourage them to actively think, not just passively listen.” She began transforming her teaching to incorporate challenging questions that inspire students to think deeply and across many different fields of study.

In certain past courses, Vigmostad would have devoted two lectures to marching through the FDA regulatory classifications for the approval of medical devices. The students were expected to memorize policies that were disconnected from any authentic context. Today, however, she begins the unit by asking students to examine questions such as, “Why does the FDA exist?” and “How does the regulation of medical device manufacturing differ from the oversight of that of tennis shoes?” In class, students work in teams to explore the FDA web site, delve into authentic, real-world problems, debate the pros and cons of policies, and apply what they have learned to the challenging scenarios Vigmostad poses.

“Once they have engaged with the material, they then can figure out the actual criteria the FDA has developed to categorize and regulate devices,” she says. “This makes them better able to answer questions about how and why the FDA makes its determinations and provides real context for the information they need to know.”

Students not only actively engage with course material, they also engage with each other through teamwork and peer instruction. By wrestling with questions together and trying to
Assistant professor of electrical and computer engineering Mona Garvin (above) poses a multiple-choice question, students respond with their electronic clickers. She then tells them to “turn to your neighbors and convince them of your answer.” After a brief small-group discussion, students again individually click in their answers. Research has shown that, fairly consistently, the number of correct answers increases the second time around.

Garvin says this peer instruction technique not only helps her students learn, but the clicker data also effectively and efficiently captures what students understand as well as where they are confused. She then can respond on-the-spot to clarify problems or move on without belaboring points most students understand.

In her quest to actively engage students in the learning process, Garvin also employs computers and small robots during class time in her Computers in Engineering course. Although not exactly as adroit as R2-D2, the robots are beguiling in their own way. They can play music, display text, move around the tables, and even follow a path. Garvin uses the robots to enhance students’ programming skills and provide a taste of the kinds of devices they may be working with in the future.

“Students work in teams to think through a series of challenge questions and tasks,” Garvin says. “So, for instance, I might ask them to figure out how one might password-protect a robot so it requires a ‘secret’ sequence of button pushes before it can do a particular task or find its way through a maze.”

Garvin sometimes programs the robots to play the Iowa Fight song and then asks students to examine the code and analyze how it works. They also figure out how to store a sequence of light sensor values obtained after each push of a button, and then display the median value.

Programming robots with teammates is intrinsically more motivating than simply writing code, which can be a tedious, solitary exercise.

“Instead of providing a stream of information in a lecture,” Garvin says, “I provide a brief presentation, and then ask students to grapple with some engaging questions. Their engagement goes far beyond a pat, ‘Oh, yeah, I understand and can regurgitate this,’” to ‘Oh yeah, I think I understand this, but now I also need to apply it, analyze it, defend it, and then question my peers about their answers.’”

While Garvin’s students can take their robots home to complete their assignments, for Vigmostad’s students, classroom technology is more firmly rooted in place. She teaches in one of the University’s new TILE (Transform Interact Learn Engage) classrooms—technology-enhanced rooms with round tables that seat nine students, extensive whiteboard space for student collaboration, and LCD screens where they can display their computer work for tablemates or the entire class. A three-day
TILE Institute sponsored by the Office of the Provost helped her begin redesigning Statics from a stand-and-deliver lecture to an interactive, team-based, inquiry-guided course. As student teams tackle questions during class time, Vigmostad moves around the room to provide guidance. Sometimes this means helping them get “unstuck” the way she used to do one-by-one during office hours. Often, it means pushing them to the next level of critical thinking after they have gained a good understanding of the material. In a 50-minute class, she easily can connect individually with all 81 students—an impossible task in an auditorium.

“They end up doing much more than regurgitating information,” Vigmostad says. “Even as undergrads, they actually start to generate information and ideas. You can see them having those ‘Ah-ha!’ moments. It’s very rewarding for them and for me.”

But do they learn the fundamental material?

“Absolutely!” she says. “In my four previous Statics classes, the average grade for the first exam was 40-50 per cent. The average in the TILE classroom was 78%. Even more important, the deeper questions I used to hear the day before an exam, the students now ask on the second day of class.”

Vigmostad has mentored a number of other UI faculty members in the team-based, inquiry-guided approach. In March, she also showcased the benefits of a TILE classroom to Iowa Governor Terry Branstad and Lieutenant Governor Kim Reynolds, who visited campus at the invitation of Student Government President Nic Pottebaum. A former president of the UI Graduate Student Senate, Vigmostad assigned “student” roles to the state leaders, who enthusiastically joined UI student leaders in tackling inquiry-guided questions about circulatory devices.

Vigmostad also has transformed her Senior Design Course by “flipping” basic course content into 15-minute podcasts that present new content or concepts. Created on Vigmostad’s tablet PC, each online presentation is followed by another brief podcast where she applies the new concepts to solve a simple problem. By watching the podcasts, students achieve a basic understanding of concepts before coming to class. They then build on that knowledge in class through teamwork and interaction with Vigmostad. Thus the classroom experience effectively models what engineers do in their professional lives.

Despite their recent collegiate kudos, neither Vigmostad nor Garvin are resting on their teaching laurels. Garvin hopes to develop an online course that will help students learn or review the programming languages and other knowledge and skills that are pre-requisite to her Computers in Engineering course. Vigmostad currently teaches an online course that employs WACOM Bamboo tablets which students use to communicate with her and each other via asynchronous podcasts and real-time discussion, problem-solving, and peer instruction. While most students are relatively local, one “beams in” from China.

The two teaching award winners continue to create fresh and effective approaches to actively engage engineering students in learning, while remaining ever mindful that the ultimate goal is to help students become successful engineers who can both identify and solve real-world problems.

“After all,” Vigmostad says, “engineers aren’t hired because they know the answers, but because they know how to discover answers.”