A PROFESSOR'S PERSPECTIVE

Let's Teach Engineering Like We Teach Baseball

by Dr. Richard Miller, University of Cincinnati

If we taught baseball the way we teach engineering, no one would play. Before taking to the playing field, potential players would have to take separate classes on the rules, and how to throw, catch, hit, and run the bases, and they would initially have no idea why they were learning some of these things. They would have to spend years learning the basics in the classroom before they were allowed to play their first game. By that time, they would most likely have forgotten how to throw or catch because it had been so long since they had worked on those skills. If they managed to hit the ball and run to first base, they might have no idea why or what to do next. This scenario assumes players would not get completely bored with the whole thing and quit long before they ever played an actual game.

What I've just described is how most colleges and universities currently teach engineering. In their freshman year, students take math and science classes, which mostly repeat high school coursework. Next, students take engineering science. They analyze beams and columns that aren't connected to anything, and loads are given in the problem with little or no explanation of how they were calculated. Students learn disparate theories with little reference to actual practice. Design classes are usually about component design, first covering beams and then columns, but rarely entire structures. In the senior year, students take a "capstone class" where we expect them to pull it all together and design something. When this method of teaching is used, many engineering students struggle—just as you would struggle to learn baseball if you didn't actually play the game.

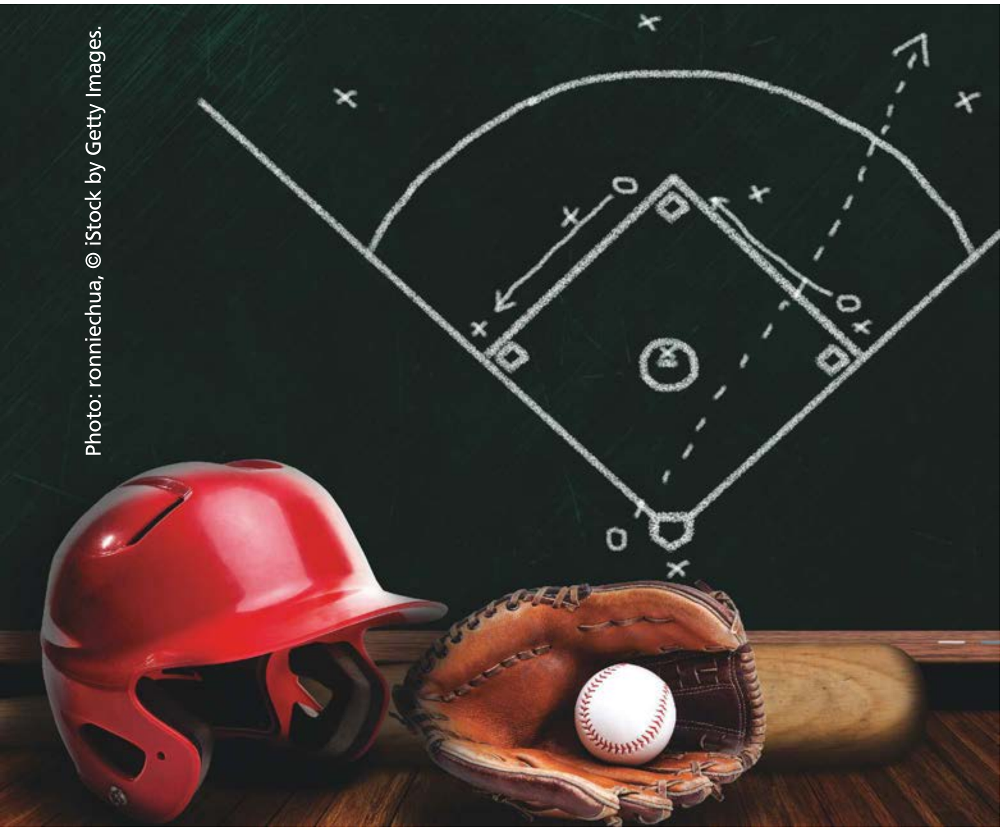

Photo: ronniechua, © iStock by Getty Images.

Historically, engineering education was originally an apprenticeship program. In the United States, college degree programs in engineering started in the 1860s, when Congress wanted to establish land-grant universities to teach the practical aspects of disciplines like engineering. Engineering remained a hands-on type of education until the 1930s when European professors such as Westergaard, Timoshenko, and von Karman shifted American engineering education toward more theory, making it similar to the European model.

In the 1950s and 1960s, the U.S. government began to fund millions of dollars of research to develop technologies, mostly for military purposes and the "space race." Universities responded by tilting engineering curricula further toward theory and science to meet the demand for research. At this point, some of the original proponents of the more theory-based education felt that the balance had tipped too far toward theory and that the practice of engineering was being lost.

For modern students, the situation is complicated by the lack of opportunities to work on practical, hands-on problems. Before they entered college, past generations of would-be engineers had repaired their own cars, built amateur radios from kits, played with chemistry sets, and fixed household items. Today's students do not always have the same opportunities to fix or build things, and many arrive at the university with little practical, mechanical knowledge.

So, perhaps we should teach engineering the way we teach baseball. In baseball, we start by teaching a simple version of the game—the ball is hit off a tee, players can only advance one base at time, there is no stealing, an inning is 5 runs or 3 outs, and so on. After T-ball, the game grows more complex and challenging until eventually the players are playing the actual game of baseball. From the start, what is important is that players are learning the fundamentals and can immediately apply what they learn to real situations. They also have fun.

For years, some have argued that we need to teach engineering in a more holistic way. Some small colleges have tried this, but most large universities stick to the status quo model. The basic idea in the holistic approach is to introduce civil engineering elements—like a building, a bridge, and a roadway—in the freshman year, and then build students' engineering knowledge incrementally through application.

The first step would be to explain how the elemental items actually work. How does a snow load get from the roof to the foundation? How do wheel loads act on a bridge? What are some of the basics of laying out a road? This initial class would be conceptual, aimed at getting students to understand how things fit together.

Subsequent courses would use these elements. We could use different loading patterns on the bridge as example problems in statics or strength of materials. Frames within the building could be homework problems in structural analysis. The road could be the project in surveying. All elements could be used in design classes and perhaps in the senior design project. We could also work with professors teaching general education classes to integrate the elements from the engineering curriculum into courses exploring relevant nontechnical issues, such as economics, public concerns, and sustainability.

So why don't we do this? Accreditation is one barrier. About 20 years ago, the Accreditation Board for Engineering and Technology (ABET) made a change to accreditation. Consequently, schools now have a set of learning outcomes they must assess. This was a good change because it is a performance-based specification—tell us what you want us to do and then see if we do it. Unfortunately, some of the old, prescriptive-based accreditation rules (such as engineering majors are required to take 32 credits of math and science) remained. If the ABET requirements were strictly an assessment of outcomes, we could innovate more in the engineering curricula.

Another factor that deters programs from adopting the holistic method is that it requires coordination among faculty across many classes. I can tell you that coordinating faculty for a few sections of single class is a challenge. Trying to coordinate across an entire curriculum will be even more difficult, but it can be done.

The final barrier is that many people are just resistant to change. For 50 years, engineering curricula have basically remained unmodified. Change always takes a lot of work and involves risk.

However, if we are willing to take a more holistic look at curricula instead of the piecemeal approach we use today, we might better educate engineers who can see the big picture and are better able to create innovative designs to meet an ever-growing public need.