

Why not make THEM do the work? - Active learning in the engineering classroom

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Many students, especially engineering students, learn best by "doing" and not by "listening". Some would comment that today's students can't think, do not follow directions or read, and can not apply what they've been taught. Rather than becoming frustrated, however, we as faculty need to be reminded of Rich Felder's very simple admonition that there are three things affecting how well a student learns: Their background and native ability, their learning style or method of processing information, and the way they are taught, and the teacher can't do anything about the first two.² This essay describes my path to grapple with changing the way I teach to get students more involved in the classroom and to provide them opportunities to actively practice what is being taught.

The lecture/homework model works for some. But any teacher who has ever perused student notes of one's own lecture recognizes that those notes are usually a poor representation of the lecture. We expect them to grasp concepts and details we have pored over for hours to condense into 48 minutes and sometimes whip through as fast as we can because of some artificial pressure to "cover the material". Even if we make time for questions, students often do not have any because they've just seen a whirlwind of material for the very first time.

My claim is that it is better to get through a little less material with a much higher rate of retention and deeper understanding than to "cover the material" at the cost of much lower retention. So what techniques allow you to get students involved? One of the first is the easiest - leave something out of your notes and make the students fill in the answer. This has the advantage of forcing conversation in the class. Let students discuss among themselves and report out. You will learn very rapidly how they are processing the information you've been delivering.

Turn all your examples into in-class worksheets. If it's a really complex problem, ask the students just to outline the steps to save time. For

simpler problems, make the class pull out the calculators and get an answer. After all, the problem is only simple if everyone can arrive at the right answer using the right approach. It was 1984 in thermodynamics class at the University of Tulsa but I still hear my professor, Frank Manning's voice in my head "Engineers are paid not just to get answers but to get right answers". You will not know where students are struggling if you do not see first hand where their mistakes are. By doing this in class, you find those mistakes right away rather than waiting to identify them on homework or exams.

Discuss a little about metacognition and learning styles in class. Get students thinking actively about why material seems so difficult and how they process information. Use Bloom's taxonomy³ to classify old homework or exam problems and then let students design their own exam problem.

What will you give up? A little bit of control, a little bit of time, and a quiet classroom. These techniques result in the volume level going up and a certain amount of chaos. You have to be able to command the crowd and bring them back to you when needed. You need to be willing to admit that you do not know an answer because when students start off on problems they can take you in directions you never would have expected. You also need the patience to follow a student's process down a dead end path occasionally. You might initially think this is a waste of time but I believe these are sublime teaching moments. If one student makes an error in presenting a solution, ask other students if they agree. If they do not, ask a second student to explain the errors in the first. This immediately breaks down the fear of being wrong because it changes the nature of the conversation to a discussion between peers rather than a student answering a question from a professor. The second student benefits from getting to explain their answer and reinforces their own understanding. Does it take longer than if you explained the answer yourself? Sure! Do you have a better idea of what your students understand? Absolutely!

One of the most common complaints I hear about these methods is that it turns the teacher into a performer and I'll admit that this is partly true. However, I refuse to admit that you have to be an extrovert or entertainer to use these methods effectively. Getting students engaged in the subject matter is a matter of setting an example. We got into our disciplines because we are excited and enthusiastic about learning. Students will

pick up on that enthusiasm if you share it with them in the classroom. Take a few minutes in one of the first class periods and explain why you like teaching that particular class. If you do not like it - change the subject. Tell the students a little about your research or why you got into engineering or whatever you do. Get to class early and have a 5-minute office hour. If you show up late and run away immediately after class, don't expect the students to behave any differently.

My experience with these techniques is that the students connect concepts to application much more quickly and accurately because they get a chance to practice that connection immediately after being introduced to the concept. Students respond to these techniques in an overwhelmingly positive fashion because many of the worksheets we do in class are of a similar difficulty to the homework and exam problems and it establishes a work ethic in the classroom that carries over to homework. I have been able to more precisely state learning objectives and set clear expectations for each of my classes and have watched students rise to the occasion and meet those expectations.

Notes:

1 I want to acknowledge colleagues in the Department of Chemical and Biomolecular Engineering who have shared their ideas and notes with me over the years. I have bounced more ideas off of Professor Jim Rathman than I can count and have become a much better teacher with his help. Professor Barbara Wyslouzil has also provided very helpful tips and creative uses of powerpoint. Both demonstrate the value of community among scholars who share a desire for quality teaching at the university level.

2 This is a statement that Felder makes during his National Effective Teaching Institute offered in conjunction with the Annual Conference of the American Society of Engineering Education. Felder published one of the most widely cited learning styles inventories and his website is a treasure trove of advice, ideas, and humor for those who enjoy teaching - <http://www4.ncsu.edu/unity/lockers/users/f/felder/public/>

3 Bloom B. S. (1956). Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York: David McKay Co Inc.