

A Survival Guide to Chemical Engineering

Dr. Lisa G. Bullard
Department of Chemical and Biomolecular Engineering
North Carolina State University

As you prepare to take your first chemical engineering course, you may be feeling a bit smug, or perhaps a bit nervous, or both. You managed to navigate your one-person kayak through the relatively smooth waters of the freshman year, easily maneuvering around the rocks of calculus, chemistry, and physics by spending about 30–45 minutes (usually 30) on any given homework assignment and studying the night before a test, usually for an hour and a half at the most. The terrain was familiar based on your strong high school preparation. Group work was not necessary (hence your one-person kayak); you may have noticed your fellow kayakers paddling along, some falling by the wayside, but most keeping pace with the group.

Now you and some others have made your way to what looks to be a large, remote island. As you climb out and gaze at the island, you see in the distance that there are spectacular, steep cliffs. Some have beautiful waterfalls cascading down. You can see beautiful flowers and exotic plants before you. All of a sudden some natives emerge from the forest to greet you and your fellow travelers. They look a little strange and they are speaking a language that you don't understand. They hold out some sort of tools in an effort to be friendly (you hope), but you have no idea what they are or how to use them. You realize that you've developed strong paddling skills in order to get here, but you have no idea what lies ahead of you and how to reach those spectacular cliffs.

Welcome to Chemical Engineering.

Taking the first course in your major—any major—is an exciting but scary step into the unknown. There's the excitement of feeling like you're **FINALLY** getting into your chosen field, accompanied by the nagging feeling that you're not sure what it really is or what you'll end up doing with it. After teaching the first course in Chemical Engineering—CHE 205—several times, I've observed that the course is a big shock for many students. They spend several weeks or perhaps the whole semester discovering ways in which CHE 205 is different from courses they've taken before, and trying to figure out how to be successful. Some students quickly get “the lay of the land” and adapt their study habits to achieve success. Other students fight it kicking and screaming all semester, and either give up or barely limp through, feeling battered and betrayed at the end of the semester.

In an effort to equip and inform you from Day 1, I asked some current and former undergraduate and graduate students to share advice and observations that might help you avoid the mistakes they made when they took the course. I hope that you'll take their advice to heart, since they have successfully scaled the high cliffs and stand looking back on the journey with valuable perspective on the potential pitfalls along the way. Comments in italics come directly from students—they say it best.

- **Develop a strong work ethic.** This theme was echoed in almost every student response.

There is no such thing as a lazy (successful) chemical engineer.

You do not have to be brilliant to be a CHE, but you do have to have the dedication, persistence, and downright stubbornness to keep working at it until you get it. Along the way you will doubt yourself. Those who really want it will succeed.

Most importantly, CHE 205 requires time, lots of time. Time spent reading the text, reviewing notes, speaking to the professor, working on the problem sets solely, working on the problem sets collectively, speaking to the TA, and going to problem session. One is also required to quickly develop a work ethic that has never been required before, because in high school they never studied and did well and freshmen year was hard but they still managed to do well with simply doing the homework and studying right before the test. This approach will not prove successful in chemical engineering.

- **Get used to working in groups.**

I recommend that everybody taking these classes should have a group of people that they can study with. Everyone approaches complex problems differently so working with a team may allow someone to see an aspect of the problem that they would otherwise not consider.

At the beginning of CHE 205, you may think you have it all under control. Don't learn the hard way that a study group is a great source for understanding CHE material. In addition, you may be the resource someone else needs to understand a topic. Working in groups has mutual benefits. Remember, the group members need and value your input as much as you need and value theirs.

I did everything short of going to the bathroom with my group.

- **...but don't rely on group work to carry you through.**

My instructors always emphasized working in groups, but being able to do the problems independently. Unfortunately, I didn't fully appreciate that advice until later on. The problems never look that difficult when you see the solutions your group members or instructors develop. The solutions are usually straightforward and relatively short. However, the amount of trial and error and flipping through notes and books that it takes to develop those answers seems endless if you actually complete all the problems on your own. So when you sit down and take your first exam, you need to be able come up with these "short" answers on your own from all the information you have been taught up until that point. This can be difficult or impossible if you have relied on your group to carry you along.

- **Get organized.**

Get organized and stay organized. I began each semester with everything in order and color-coded. As the semester progressed and the workload increased, before I realized what was happening, my organized notebooks and folders were in disarray. I soon learned the importance of setting aside just a few minutes one day a week to re-organize. It's much easier to maintain organization!

You should be able to pick up notes from classes a year ago and be able to read and understand them. You should also be able to look at a problem you worked and know what you were doing.

- **Embrace CHE as a new community.**

Learn to love the AIChE Lounge and to join AIChE as early as possible. There is always someone there to help you if you need help, or if you just want someone to talk with. I think that is one reason that I like being a CHE so much — we all stick together and work with each other and generally care about each other. I would recommend that students visit the lounge if they have a problem they can't solve, generally there will be someone from their class or a helpful upperclassman that has been through it and knows their pain.

The best friendships of my life were found in the ChE lounge.

CHE is more than a major, it is a lifestyle.

If you look around the room in your CHE 205 class, you'll see people that will become a significant part of life in the coming three years. You may not realize it now, but you will be spending a large amount of time with them. They will inevitably become your friends as you share pains and triumphs in the coming years. Take some time to get to know them. Go out to dinner together and talk about something other than CHE.

- **Recognize that you have to train your brain to think differently.**

Many students think the way to do well is to understand a little bit or memorize. In CHE, memorizing stuff is not important, but the way you THINK is. This retraining the brain to think like an engineer is trivial for some people, not hard for others, and nearly impossible for others that just don't understand how to apply concepts.

- **Get used to the idea that you will never see multiple choice tests again.**

Studying tips [From a former TA]:

- *Make a 'per exam' cheat sheet (cheat sheet for Exam 1, then 2, then 3) and figure out what you think will be most fruitful to put onto your "torpedo." Do not make the torpedo so confusing you cannot use it.*

- *Practice. In ALL of your further CHE courses, practice in doing various types of problems is the key to doing well. You will encounter problems in tests that make you go to the next level and expand on what you already know.*
- *Make your review problems that you do logical, neat and organized so you can always follow through what you did as a “summary” of the problem. You may get lucky and do a practice problem that the professor uses as an exam problem—it’s been known to happen!*
- *Do not get into the habit of plugging and chugging. It will not serve you well. Understand what is going on, make a reasonable analysis of the problem, and try to figure out what you should be getting. Doing this through the review problems will make them sink in and you will then remember what to do on the final.*

You have to invest the time before the test to know exactly how to find what you need in the book, and where it is. Putting tabs in your book might look geeky, but it will save you time in looking up commonly used tables and equations. And actually reading the book just might help, too.

- **Chemical engineering is not chemistry.**

Engineering is different from purely scientific fields. Where chemists and physicists futilely search for truth, engineers realize and accept limitations and concentrate on what is practical. Upcoming students should be ready to be trained in this way of solving problems. An engineering education seems to be more of a way of looking at the world and putting it to use than looking at the world and trying to explain it.

- **You can’t get away with procrastination.**

I think that time management is the biggest thing that a student must learn when coming into the CHE curriculum. In other classes, it is often easy to wait until the last day to do an assignment, and still end up with a good grade. In CHE, it is a necessity to start the work early. There are too many concepts that will escape your grasp if you don’t start early because the problems take a large amount of time, and you will never finish them in one sitting. Scheduling time to ask questions (with a teacher or TA) is also a must. It is inevitable that there will be a time when you get stuck on a problem, and none of your classmates are able to figure it out either. Basically, I believe it is impossible to procrastinate and be successful in the CHE curriculum.

- **Follow instructions.**

The syllabus will probably say something like: “Use green engineering paper (available in the Student Supply Store), one side of each page; begin each problem on a new page, and box the final answers. Each completed assignment should be in one person’s handwriting. Staple the pages and fold them vertically when you hand them in, putting the names and roles of the participating group members and the problem set number and date on the outside.” Follow these instructions—to the letter. You can believe that the TA’s will take off points for not stapling, writing on the back, etc. You may think these

things are silly but if that's what the prof asks for, do it. One day your client will ask for something just so—and that's what they expect, too.

If the homework is due at the beginning of class, then it had better be there. Set two alarms, get your roommate to wake you up, whatever, but don't be late or the rest of your group will hate you forever (deservedly). If in doubt, put it under the instructor's door the night before (or at 3AM when you finish it).

Writing legibly is a must. You can't get partial credit if no one can decipher your scribbles.

- **Ask for help.**

Get help when you need it. If you are unsure or completely lost, get help from other students in the class, the TA or the professor. Engineering classes are built upon information from your previous classes and previous lectures. If you get lost at one point, it is likely that you will be lost for the rest of the class and possibly longer. Don't make it harder on yourself; there is no shame in getting help. Don't be embarrassed to go to the Engineering Tutorial Center and get a personal or group tutor—that's why they are there!

- **Choose a major for the right reasons.**

[From a former CHE 205 TA]: There was one commonality with the students who REALLY struggled in the class. During an informal talk with some of these students, I asked them why they chose chemical engineering. And all of them (these are the ones who get D's and F's in CHE 205) told me that they chose chemical engineering because of the money or job opportunities. In contrast to that, the ones who did well tended to respond that they chose chemical engineering because they liked math and science. The students who were really struggling were hating every moment of the science, math and engineering courses.

- **Become comfortable making assumptions.**

Now I have learned to list all the assumptions I am making when solving a problem. It is difficult to learn when you can make certain assumptions and when you can't. Making an assumption when describing a system might make my life easier while solving the problem, but it might not provide an accurate enough picture for the process, depending on the accuracy required. The more problems I work through, the more I know when it is okay to simplify a component/idea to get a solution.

In all the other classes I'd had, there were definite right and wrong answers to a given question; however, in CHE, there may be a number of different ways to arrive at an answer that might be considered correct. This took some getting used to.

- **Don't be devastated if you aren't at the top of the class.**

The majority of people in CHE were at the top of the class at some point during their academic career. Whether it was high school or freshmen courses, chances are you were too. You are now among the best, the competition is a little tougher, and the course material is going to be more difficult. You may not be at the top of the class, but always put forth your best effort. You may not always be satisfied with the result, but you'll know you did everything you could do.

School and grades had been one of the most important things to me in my life up to this point, perhaps, sadly, the most important thing to me. (I say sadly because many parts of life are more important than grades, which are, after all, subjective and superficial. I now believe my spiritual state, my relationships with other people, actually learning, which is different from making good grades, and my health are more important).

I finished my freshman year with a 4.0 GPA. I had thoughts creeping in telling me that I may be the smartest person in the world. Then I took CHE 205. I spent a LOT of time on the homework, and I made a ~70 on the first test. Since I thought I may be the smartest person in the world, I had figured my grades in my major should be even better than what I had been making. This idea was supported by the fact that I did not think I had tried really hard to do well before, even in the classes that I did do well. Actually, I was somewhat of a slacker and a procrastinator. I began to realize that I had this attitude: I had to achieve perfection in order to have joy. I thought such a frame of mind was necessary to keep me motivated and doing well. Instead, not being content with anything less than perfection almost destroyed me. Having successfully completed the curriculum and obtained my degree, I now encourage you to study CHE for the sake of learning, not for the sake of being the best.

- **Keep your eye on the goal.**

Listening to people talk about "real" chemical engineering and learning more about different industries and the application of chemical engineering principles can be quite helpful. Because chemical engineers go into such a broad array of fields, I think that it is all the more important that students begin considering where they might like to go early on by learning about what's out there (through attending lectures, conversations with professors/advisors, etc). When I was a junior in college, I felt a certain sense of shame because I could not name 10 chemical engineering-related companies, when in fact there are hundreds of companies which hire ChemE's.

[From an alumnus]: Encourage the students to view the course as representative of things that real chemical engineers do. Because of this, the hard work is very worthwhile, far beyond the value of getting a good grade. Some graduates (like those who go to medical school) will not use the material very much, but for many others it will be the very core of the value they present to their future employers. Particularly for people in process engineering, in research and development, or for others in the process industries, they will return to the content of this course over and over again. My group essentially applies

all the classical chemical engineering approach using the latest advances, but all our work has CHE 205 as a foundation. We use these ideas continuously to the point of them being second nature to us

[From an alumnus]: *Embrace ChE with all its good and bad. We all love the title and the smugness we get from telling people "I'm an engineer, a CHEMICAL engineer." Kind of like "Bond, James Bond.." I feel good about it because I survived it, because I sacrificed to get it, and because I wanted it more than anything else - other than my family.*

At this point, you may be thinking one of two things: (1) "This isn't so bad, I think I can probably handle it if I just discipline myself to follow some of these common sense tips;" or (2) "Why would anyone want to survive such a hellish major...and where do I submit my drop form?" If you're inclined to (2), let me offer some words of advice before you run screaming to Registration and Records.

First, chemical engineering is an exciting career field and is worth investing your time and effort. You will be able to work in a number of different industries including pharmaceuticals, petrochemicals, electronic materials, paper, textiles, consumer products, and more. You will have the skills to perform many different job functions, including research and development, process engineering, project management, sales, marketing, environmental assessment, quality assurance, technical support, information technology, and management. Many companies specifically target chemical engineers as new hires because they have found them to have a broad skill set and a strong work ethic. The fact that chemical engineers traditionally have the highest starting salaries of all engineering disciplines and the job market is always more stable for them than for most other branches of engineering reflects the value that employers assign to a chemical engineering degree.

Second, others no smarter than you—and many not as smart—have trod this path before and lived to tell about it. Chemical Engineering alumni frequently cite the importance of problem-solving and teamwork skills that were developed during the chemical engineering curriculum and in CHE 205 in particular.¹ And all those horror stories about 50% of the class getting F's are not true—just look at recent grade distributions. In my Fall 2002 section of CHE 205, 70% of the class—those who stuck it out—got A's or B's.

Lastly, if you think you're the only one with doubts, think again. The quotation that follows is from an article about the "Impostor Phenomenon," which is like a tape that people play inside their heads.

If you're an engineering student looking around at your classmates, the tape goes something like this: "These people are good—they understand all this stuff. They really belong here...but I don't. Over the years I've somehow managed to fool them all—my family, my friends, my teachers. They all think I'm smart enough to be here, but I know better...and the very next hard test or hard question I get in class will finally reveal me as

¹ R.M. Felder, "The Alumni Speak," *Chem. Engr. Education*, 34(3), 238–239 (2000).
<<http://www.ncsu.edu/felder-public/Columns/alumni.html>>.

the impostor I am." And what would happen next is too horrible to contemplate, so at that point you just rewind and replay the tape. What you don't know is that almost everyone else in the class is playing the same tape, and the student in the front row with the straight A average is playing it louder than anyone else. Furthermore, the tape is usually wrong. If you survived your first year of engineering school, you almost certainly have what it takes to be an engineer. Just remember all your predecessors who had the same self-doubts you have now and did just fine. You do belong here, and you'll get through it just like they did. Try to relax and enjoy the trip.²

So anchor your kayak, strap on your backpack, and let's begin. Contrary to rumors you might hear, the natives are not hostile, and some of your fellow travelers actually look somewhat friendly. There may be some spine-tingling adventures ahead, some precarious positions to get through, and a few death-defying moments, but I assure you that the view from the heights is worth the climb.

Acknowledgments

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² R.M. Felder, "Impostors Everywhere," *Chem. Engr. Education*, 22(4), 168-169 (Fall 1988).
<<http://www.ncsu.edu/felder-public/Columns/Impostor.html>>.