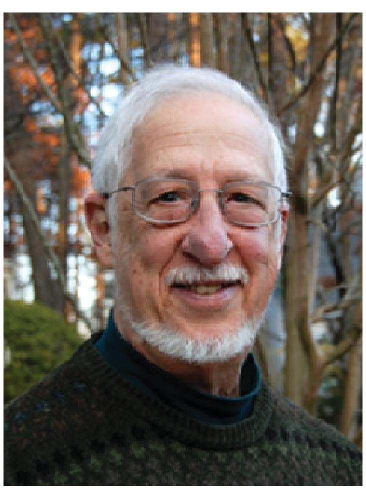
Richard M Felder – an Author, an Educator… a Legend

SHOEB AHMED & NAFISA ISLAM

RICHARD M. FELDER is Hoechst Celanese Professor Emeritus of Chemical Engineering at North Carolina State University, Raleigh, North Carolina. He is a coauthor of the famous book *Elementary Principles of Chemical Processes,* which has been used as the introductory chemical engineering text by roughly 90% of American universities and a number of universities abroad. He has authored or coauthored over 300 papers on chemical process engineering and engineering education and writes "Random Thoughts," a column on educational methods and issues for the quarterly journal *Chemical Engineering Education.* He has presented hundreds of seminars, workshops, and short courses to industrial and research institutions and universities in the United States, Europe, and South America. Since 1991 he has codirected the National Effective Teaching Institute under the auspices of the American Society for Engineering Education.



Nafisa Islam and **Shoeb Ahmed** are graduate students at North Carolina State University. Nafisa, has completed her BSc in Chemical Engineering from BUET in 2006. Currently she is working on nanoscale protein-ligand interaction on various substrates for develeopement of efficient bioassays. Shoeb has completed his BSc and MSc in Chemical Engineering from BUET in 2004 and 2007 respectively. Currently he is working on intracellular signalling during mammalian cell migration on different bio materials that leads to better understanding of cancer cell movement.

Dr. Felder has won many awards for excellence in teaching, research, and contribution in engineering education, including the R.J. Reynolds Industries Award for Excellence in Teaching, Research, and Extension (1982), the ASEE Chester Carlson Award for Innovation in Engineering Education (1998), and the AIChE Warren K. Lewis Award for Contributions to Chemical Engineering Education (2002). He is also the inaugural recipient of the Global Award for Excellence in Engineering Education presented by the International Federation of Engineering Education Societies (2010). He was selected as one of five Outstanding Engineering Educators of the Century by the Southeastern Section of the American Society for Engineering Education in 1993. Dr. Felder's papers and columns can be found at his web site: *www.ncsu.edu/effective_teaching*

Many people know Dr. Felder as a professional. However, very few know about his personal life. "CHE Thoughts" had a great opportunity to talk to him about his life, work and plans. Here is an excerpt from his interview conducted by *Shoeb Ahmed* and *Nafisa Islam.*

It is our pleasure to have you with us for this interview. Let's start with a brief biography of you.

Okay. I was born in New York City in 1939. I lived there for the first 6 years of my life and then moved to Buffalo, New York and lived there for 7 years. Then I went to high school in North Miami, Florida. I came back to New York City and did my undergraduate work at City College of New York in Chemical Engineering. I went to Princeton University for my PhD and then spent a year at the Atomic Energy Research Establishment in Harwell, England, followed by two years as a research engineer at Brookhaven National Laboratory. Then I started looking for academic positions and came to North Carolina State University (NCSU) in 1969. As a New Yorker, I was afraid that when I moved to the South I'd be leaving civilization completely and thought I'd try it for a year, and if I didn't like it I'd go somewhere else. That was 41 years ago and I've never seen any reason to go anywhere else—I really like it here.

> *"Choosing chemical engineering turned out to be an extremely lucky choice, because what I had no clue about then but subsequently learnt was that if you graduate in chemical engineering you can pretty much do anything you want."*

Talking about your childhood a little bit more; what was your childhood aim?

Well, once I got past the point where I wanted to be a cowboy or world famous baseball player, I didn't have anything particular in mind. I finished high school in 1957, and at that time almost everybody who was good in science and math was going into engineering because there were lots of stories about engineers getting high starting salaries and companies rolling out red carpets for them. I was good in science and math and I didn't have any other burning ambitions; so I said, ok, I will go into engineering too.

Why did you pick chemical engineering?

I had no reason in the world for choosing chemical engineering except that I had a chemistry set when I was a kid and liked the idea of combining two colorless liquids and having them turn green. So I said "All right, chemical engineering...."—a dumb reason to select a curriculum and a life career. But I really didn't have anything else that called my name—I no longer wanted to be a cowboy and I didn't have enough talent to be a professional baseball player. It turned out to be an extremely lucky choice, because what I had no clue about then but subsequently learnt was that if you graduate in chemical engineering you can pretty much do anything you want. That gave me infinite flexibility to go in any direction I wanted to.

Did you have anybody in your family who was an engineer or chemical engineer? Or was there any role model for you back then?

My parents were not even close. My father got a law degree but he never practiced law. He sold insurance and later worked for the Internal Revenue Service. My mother never worked outside the home after she got married. I had a cousin who was an electrical engineer but I saw him maybe 2–3 times in my life before I made the decision to go into engineering. So I really didn't have any role model. It was simply that engineering was a popular destination for those who were good at and enjoyed math and science, and I just went along with the crowd.

How about now? Is there anyone from the family now in chemical engineering?

Nobody is in engineering but two are in teaching. I have three children. My oldest boy graduated with a dual major in physics and English. He eventually started his own software firm with one of his friends. They were successful and Microsoft bought them. He worked there for 3 years and now is teaching math and physics in high school. My daughter is a psychotherapist who never came anywhere near engineering or science. My youngest son got his doctorate in physics and now teaching physics at Smith College. And if you ask me what I do for living, I'm also not an engineer—I never practiced engineering except for a few summer jobs. My career has been as a research scientist and an engineering educator, both of which are much different from engineering.

Can you please share with us any memorable experience while you were studying?

Studying chemical engineering is hard—always was and always will be. Long hours of studying and difficulties of some of the subjects really help you bond with your classmates. It is like, "we all are in this together, we will do what we can to help each other to get through" and that was a really good experience. The friendships we developed during that extremely difficult stage are really

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memorable. I also had memorable experiences with some spectacularly bad teachers—my former class-mates and I laugh about them whenever we get together.

Is there any memorable experience during your teaching life that you would like to share with us?

Probably the most interesting experiences during teaching involve interactions with the students. I've had many memorable students. Some of them were brilliant, way smarter than me. If I did anything wrong on the board or if there was any mistake in the textbook, they immediately pointed it out. I love getting students like that—I can learn as much from them as they can from me. I also enjoyed having students who were not just fixated on engineering but who had other interests. I can remember one student who triple majored in chemical engineering, chemistry, and political science! He was also a ballroom dancing champion. He will probably take over the world someday. Other students went into medicine and law, and one ended up with a PhD in science and society.

One particularly brilliant former student is Russ O'Dell, who is now working on the department staff at NCSU after a very successful career in industry. When he was an undergraduate student, I was preparing the solution manual for the textbook Ron Rousseau and I wrote. I decided I would work out all the problems by myself and get somebody else to work them out independently and then compare the solutions. I chose Russ, who was in a couple of my classes and I don't think he ever made a mistake. He got 100% on every test and homework assignments...just unbelievable! So we worked out all the problems separately. If the solutions agreed then I was fairly confident that they were correct; if they disagreed then I would just go back to my solution and find out what I did wrong.

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"Students have different learning styles. Some students learn more from verbal information such as written and spoken explanations while some prefer visual information such as pictures, diagrams and flow charts. "

What differences do you see in the Chemical Engineering education compared to your student life?

I can answer that in two contexts: students and teaching. I think students are of the same intellectual quality as they were then, but there are some differences. Students have different learning styles. For example, some students learn more from verbal information such as written and spoken explanations while some prefer visual information such as pictures, diagrams and flow charts. In my teaching career I have found more visual learners than verbal learners and I think things have been accelerating in that direction. Students don't read now as much as they used to 25 years ago—reading for fun has almost disappeared. This generation of students has grown up on television, video games, and iPods, and they have more difficulty getting meaning from written words than students in previous generations had. They may read a complex passage of text but it really does not register with many of them. That might be one of the biggest differences I see. I also don't think textbooks help students much because most of them are not written for students—they were written to impress professors into adopting them.

Another difference, I think, is that this generation of students is more socially conscious than previous generations. Previous generations of engineers went into engineering to solve technical problems and earn a lot of money—it didn't really matter what type of problem they were dealing with. But today's students are more concerned about the purpose of the work they are going to do, and whether it will do anybody any good besides increasing the company's profit. I think that is why many students are going into biosciences and environmental sciences. Women are particularly concerned with the social importance of their work, which I think is an extremely positive viewpoint that will help the engineering profession. While hiring engineers, now companies have to emphasize the social good that engineers can do, not just profits.

So in a way teachers have had to evolve as students have evolved.....

They will in the future, but I think the evolution of teachers has lagged behind the evolution of the students. Most engineering teachers are still teaching in the way engineering teachers taught 50 years ago. They go to class and lecture for the whole period without seriously considering whether anyone is learning anything. When students do poorly, the default assumption is that there is something wrong with the students. As students have evolved, changing their learning styles and becoming more concerned about the importance of what they are doing, I think it becomes increasingly necessary for teachers to change how they teach to be as effective as they can be. Also, globalization has changed the pattern of engineering jobs. The jobs for which engineering education was designed to prepare students 20-30 years ago are now increasingly done by technicians with computers or by people in developing countries where wages are low. Tomorrow's chemical engineers will not spend a lot of time substituting numbers into formulas or calculating the number of stages in a distillation column. Computers do that very well now. Now it is crucial to learn such things as **1) thinking outside the box, critically and creatively**, **2) keeping up with developments in technology, which is advancing at an exponential rate**, **3) learning how to deal with people from other cultures who speak other languages**, **4) thinking entrepreneurially**. Those skills were never part of the engineering curriculum. They need to be incorporated in place of some technical content which no longer serves its original purpose.

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You mentioned "active learning" several times in your columns and interviews. Can you please tell us about this a little bit?

Active learning means getting students to do course-related things in other than watching and listening to the professor lecturing. It can be answering questions or solving problems or troubleshooting or brainstorming or anything else that requires mental activity, and it is sometimes done individually and sometimes by students working in small groups. It has been researched and proven that people normally don't really ever learn anything meaningful by watching somebody telling them what they are supposed to know. The only way people learn any skill is by doing things. They usually get it wrong the first time, get feedback either from somebody else or learning from their own mistakes, try it again, and get better at it. "Active learning" provides some of the practice and feedback in the classroom, and if it is done well, then later the homework goes a lot smoother and the students get better grades in tests.

This seems easier to implement in a small class room. What about a large class room?

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The large class is where it is actually most important to implement. If I'm teaching 12 students I can get them actively involved without much trouble, but if I'm teaching a class of 150 students in a large auditorium, active learning is the only possible way I can get them engaged in what I'm teaching. In those large classrooms most students do not pay attention, and even if they pay attention, if it is just a straight lecture then they don't learn anything meaningful. Hard parts, easy parts, they all just fly by and nothing really penetrates. So, if you have a large class, the only way you are going to get some learning happening there is to use active learning. I've used it in classes, workshops, seminars and even in conferences. It might not work well with ten thousand people in a stadium but that is not the kind of setting most people teach in!

How do you normally handle a class of students with different styles of learning?

It is not possible to find out the learning style of each individual student and to teach them the way they prefer. If there are more than two students in the room, I cannot simultaneously adopt multiple teaching styles and implement them simultaneously. But even if you could do it, it is not what you should do. The key is "balance". Different skills are associated with different learning style categories. For instance, two opposite categories are *sensing* and *intuiting*. Compared to most intuitors, most sensing learners are concrete, practical; they do not want to be bothered with all the theories and math. They are more interested in real life applications. They are more careful, methodical, and painstaking; they check calculations over and over. Intuitive learners tend to be more oriented towards the theories, abstractions, and mathematical models. They tend to be more inclined to think outside the box and to be quick, not necessarily careful. They are not detailed oriented but they are very creative.

To be a successful engineer you have to have both of those sets of skills. You have to be careful, observant, pay attention like the *sensors* but you also need to learn to think more creatively like *intuitors*. If somehow I can manage to teach you exclusively in the way you like to learn, you may be happy and you would develop your skills in your preferences, but you would not get any practice or feedback in the opposite skills that you will also need to be successful in your career. The goal for teachers should be *balance*, being sure to address both sides of every learning style dimension, like sensing and intuiting. If you do that, part of the time you'll be teaching the way students prefer so that they are not too uncomfortable to learn, and part of the time in the opposite way so that the students will be forced to develop skills in areas they might prefer to avoid.

> *"The goal for teachers should be balanced, being sure to address both sides of every learning style dimension. "*

Another interesting topic you often talk about is "Cooperative learning". How do you ensure everyone is participating equally in cooperative learning?

Cooperative learning is different from active learning, as the latter one deals with the activities in class whereas the former one refers to students working in small teams outside class for longer assignments and projects. We form teams in engineering laboratory and design classes but what we do is usually not cooperative learning.

Cooperative learning means students working in teams under conditions that five criteria are satisfied. **The first** criterion of cooperative learning is *positive interdependence;* you have to set the exercise up such that students are forced to rely on their teammates, and if someone doesn't do their job, it hurts everyone. **The second**, and maybe the most important criterion, is *individual accountability*; every member of the team is held accountable in some way for what everyone did, not just for his or her part. There are varieties of ways you can ensure that. Individual tests covering the whole part of the project is the most obvious one. For projects, if students don't take tests but teams give oral reports, the teacher can arbitrarily assign individual students to report on different parts of the project just before the oral report is given. Since the students don't know the assignment in advance, they have to understand the whole project rather than just the parts for which they were mainly responsible. Part of each student's job is then to make sure that his/her teammates understand what he/she did, because everyone's grade is dependent on how well one of them reports on it. **The third** criterion is *face-to-face interaction;* students must sit together and discuss the entire assignment rather than just splitting it among themselves. **The fourth** is *development of teamwork skills.* There are lot of skills required to work in a team such as communication, time management, conflict resolution, leadership, etc. Part of cooperative learning is to make sure that students develop those skills. **The fifth** criterion is *regular self-assessment of team functioning.* The team periodically discusses what they have done well as a team, what they could do better, and what they will do differently in the future. This forces the students to bring problems out on the table to avoid serious disagreements and conflicts later. The degree to which these five criteria are in place is the degree to which an instructor is using cooperative learning. Cooperative learning is probably the most exhaustively researched instructional method in all of education, and there's a huge body of evidence showing that it equips students with many of the most important skills they will need for professional success.

You have written different satirical columns where you made fun of some of the characteristics of different professionals and also of engineering professors. (<http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Columns/Norespect.html> <http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Columns/Dayatoffice.html>) **Have you gotten any interesting responses to them?**

I haven't received any response from other professionals because they don't read *Chemical Engineering Education*. Most of my colleagues appreciated that the columns were intended to be humorous, but some of my colleagues were a little sensitive about the one where I portrayed an imaginary faculty meeting. They were afraid that everybody would think it was about the Chemical Engineering Department at NCSU, but that is really not the case. Part of my job in the past almost 20 years is going around to other campuses and giving teaching workshops. I've given over 300 of them. I also spent sabbatical semesters at other universities and attended many faculty meetings outside of my own department. So the pictures that I'm painting are really a composite of all of the places that I've been to.

I remember one particular column called "The View through the Door" (<http://www.ncsu.edu/felder-public/Columns/Viewdoors.html>) where I was walking through an imaginary corridor and looking into different classrooms and talked about what I saw. That was a humorous column about bad teaching. My colleagues may have been little unhappy about that. But the teachers I described there were not my colleagues at all, but were mostly based on teachers I had in college. As I told you earlier, some of my memorable undergraduate experiences involved some of my really awful teachers. That column was one way of kind of getting back at them a little bit! We have some really outstanding teachers in this department. There is an award for the best teaching department in the university, and a few years ago this department won that award. I think it's the only engineering department ever to win it.

OK, now let's talk a little bit about the famous book *Elementary Principles of Chemical Processes*. How did that happen?

Ron Rousseau and I joined this department around the same time in 1969. In 1972, John Wiley & Sons invited Ron to write a stoichiometry book. He agreed and soon afterwards he asked me if I'd like to come in on it. I thought it might be fun and said "sure". Neither of us had a clue about writing textbooks. By the time we realized the magnitude of what we had agreed to do, we had invested far too much time and effort to back out. The first edition of *Elementary Principles of Chemical Processes* came out in spring of 1978. Its success is not something we could have anticipated when we were writing it.

Is there any specific part of this book you had a hard time writing?

I can't think of any particular part of the book that was harder than the others, but the whole thing was very, very hard. It took about 5 years to write the first edition of that book. In those days everything was handwritten. We wrote it by hand and gave it to a secretary to type. When we had enough material assembled, we used that in class and got feedback and corrections from students. We did that for 5 years and sent it off to the publisher in 1977 and the first edition came out in 1978.

What was the most significant response you got on this book?

When we wrote the draft of a couple of chapters we sent it to the publisher and they sent it out for review. It got mixed reviews so we revised and sent it to the publisher again. They sent it out for review again and some reviewers liked it and some still didn't.

> *"When the book actually came out, the response was overwhelming. The reviews were extremely good."*

But when the book actually came out, the response was overwhelming. The reviews were extremely good. At that time one book had almost the entire market, and schools started adopting ours almost the instant it came out. Within two years we captured almost 70% of the market and we have held it for decades. About 90% of schools in the United States have used it, and it's been translated into Spanish, Portuguese, Chinese, and Korean. All of this is far beyond anything we could have dreamed.

Why did you think about including the CD in the 3rd edition of this book?

Because "technology" happened between 2nd and 3rd edition. Instructional technology is a two-edged sword. There are lot of things you simply cannot do with chalk or marker in a classroom that you can do with technology. I can show what an industrial scale distillation column looks like and how it operates. I can simulate a control panel and show the responses of a system including blowing up, which is something you really don't want to do in laboratory. The CD for our text has interactive tutorials which every student can use, and it has an equation solver that can be used to solve problems that could take hours to solve manually. Technology can also have a negative impact on learning, as it does when an instructor just turns his or her class into a PowerPoint show, or students simply watch lectures on a computer monitor instead of in a live classroom.

Is there any new edition of this book coming?

Yes, as a matter of fact we have started one. Preparation of the 4th edition has been underway now for about a year. It is going to be Felder-Rousseau-Newell. In this edition we brought a new author to work with us because both Ron and I have moved on to other things. I developed an interest in teaching and giving teaching workshops to university instructors, and I'm also working on another book with my wife and colleague about teaching engineering and science. Ron Rousseau has been department head at Georgia Tech for many years, which is an extremely time-consuming job. So Dr. James Newell of Rowan University will be working with us on the 4th edition.

How different this edition will be compared to the current edition?

It is still going to be the same book. When you have something that has been successful for 32 years you don't mess around with it too much. The main change in this edition is that there will be lot of new problems. The old problems were there for a long time and the solutions are in widespread circulation. The new ones will cover a broader spectrum of the fields chemical engineers are now getting into. There will be more bio-, environment, materials, and so on. This time instead of a CD there will be a web-based resource that students can access. It will help us to avoid problems that we currently have with the CD, which is incompatible with some computers.

Now let's talk a little more about your life again. At this point of your life do you have any regrets? Anything you would have done differently? Or what would you have been if you would not have been a chemical engineer or teacher?

Maybe a psychologist. The trajectory of my career is very unusual. There may only be 2 or 3 other people I know who did something similar in their careers. When I began my academic career I was very conventional, doing whatever everyone else around me was doing: writing proposals, getting grants, dealing with graduate students, preparing lectures and so forth. It took me about 15 years before I realized that to me students were much more interesting than distillation columns. I started to think about such things as "How do they learn? Why aren't they learning? Why aren't they doing well in class although they clearly have the intellectual capability of doing it?" and so on. The challenge of figuring out answers to those questions was much more exciting to me than modeling

"Students are much more interesting than distillation columns"

stochastic chemical processes and other research I was working on. I was reasonably good at traditional research but it just didn't excite me all that much. Once I realized that I could really make a career out of education—not just teaching but studying how people learn and how instructors can help people learn—I really found my life's work! I started paying more and more attention to those issues. After a certain point I stopped regular research and made my career education: teaching, writing, and giving workshops; and I've been doing that ever since.

"Listen to your heart. Figure out what you are good at and love to do, and do it."

I can't really think of any regrets. I love my life and the way things have worked out. If I have to state a regret, it is that I didn't make the decision to focus on education sooner. I kept on doing traditional engineering research long after I had really lost interest in it. I might have been happier sooner if I listened to myself earlier. The academic profession is not set up to encourage this particular choice—prestige and status are based on research performance. I have some colleagues who still think I might have made something of myself if I'd stayed in traditional research. But you shouldn't let what other people think bother you. For your own internal satisfaction, you should try to do what you love doing as much as you can.

What do you do when you have leisure?

I always liked playing chess since I was a kid. I also like other games such as Scrabble, Trivial Pursuit.....things that require some thought. I have a permanent chess match going with each of my two sons on Facebook. As soon as one game is over, we start another one. We also have a three-way Scrabble game going on. I love all kinds of music, especially classical music. When I was a little kid my father introduced me to classical music and I've loved it all my life. I also listen to jazz, folk, rock, almost all kinds of music. I play classical guitar though I don't play much now.

How about movies and sports?

I don't watch lots of movies except on airplanes. I enjoy spo-rts. I watch basketball, American football, and I enjoyed the World Cup. I used to run track in high school and played tennis and racquetball when I was younger. But at this point most of my physical activities are on the elliptical trainer.

What is your favourite piece of technology right now?

I have an iPod which I enjoy. I have a Blackberry which is useful but I cannot say I derive a great deal of enjoyment from it. I would say the computer is my favourite. I spend a lot of time on the computer checking mails, browsing, and listening to online radio stations when I'm not working. I'm interested in languages and speak Portuguese and Italian. So, once in a while I turn on a Brazilian or Italian radio station just to stay in practice.

Can you please give us a snapshot of a typical day of Dr. Richard Felder?

When I'm home I sleep late, which may be the principal benefit of retirement! Then I go to my computer, check my emails and reply to them. I'm normally involved in three or four writing projects at a time and work on some of them. I take frequent breaks. I exercise about an hour if I'm home. We (my wife and I) sometimes get together with friends in the evening. We have seven grandchildren and four of them live just half an hour away, so we spend private times with each of them. My wife and I each like to cook and we sometimes cook together. Those are the things we typically do when we're home. On average we travel 90 days a year for workshops and conferences, and those days are of course much different.

Before we end, would you like to say something to the "CHE Thoughts" readers?

For students, I would go back to what I've said before. Do your best to identify what you enjoy doing, what gives you the most satisfaction, and try to figure out how to make a living doing it. It could be within chemical engineering, because there is an enormous range of fields you can go into with a degree in chemical engineering. It can also be totally out of chemical engineering as it might be if you have a real talent for music or you feel a calling to be a physician or a minister. You should not be moved much by which job pays the higher starting salary. If you are doing something that you really don't enjoy, it will feel like an obligation. You don't want to do that five days a week for the next 40 years. Listen to your heart. Figure out what you are good at and love to do, and do it.

> *"To the students: Do your best to identify what you enjoy doing, what gives you the most satisfaction and try to figure out how to make a living doing it."*

To the faculty, I would say that not all students learn the same way. Probably, relatively few of your students would learn the way you learnt. You completed your undergraduate degree, went for graduate study, and joined a faculty, but most of your students aren't going to do anything like that and they have no *desire* to do anything like that. So, teaching them as if they were you is a mistake. Find out how they learn and the conditions that lead to the greatest learning, and try to incorporate those conditions in your teaching as much as possible.

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