Chem. Engr. Education, *40*(2), 96–97 (2006)

A WHOLE NEW MIND FOR A FLAT WORLD

Richard M. Felder
North Carolina State University

Interviewer: *"Good morning, Mr. Allen. I'm Angela Macher—project engineering and human services at Consolidated Industries "*

Senior: *"Good morning, Ms. Macher—nice to meet you."*

I: *"So, I understand you're getting ready to graduate in May and you're looking for a position with Consolidated...and I also see you've got a 3.75 GPA coming into this semester—very impressive. What kind of position did you have in mind?"*

S: "*Well, I liked most of my engineering courses but especially the ones with lots of math and computer applications—I've gotten pretty good at Excel and Matlab and I also know some Visual Basic. I was thinking about control systems or design."*

I: "*I see. To be honest, we have very few openings in those areas—we've moved most of our manufacturing and design work to China and Romania and most of our programming to India. Got any foreign languages?"*

S: *"Um, a couple of years of Spanish in high school but I couldn't take any more in college—no room in the curriculum."*

I: "*How would you feel about taking an intensive language course for a few months and moving to one of our overseas facilities? If you do well you could be on a fast track to management.*"

S: *"Uh...I was really hoping I could stay in the States. Aren't* any *positions left over here?"*

I: *"Sure, but not like ten years ago, and you need different skills to get them. Let me ask you a couple of questions to see if we can find a fit. First, what do you think your strengths are outside of math and computers?"*

S: "*Well, I've always been good in physics."*

I: *"How about social sciences and humanities?"*

S: *"I did all right in those courses—mostly A's—but I can't honestly say I enjoy that stuff."*

I: "*Right. And would you describe yourself as a people person?"*

S: *"Um...I get along with most people, but I guess I'm kind of introverted."*

I: *"I see...."* (Stands up.) *OK, Mr. Allen—thanks. I'll forward your application to our central headquarters, and if we find any slots that might work we'll be in touch. Have a nice day."*

* * *

This hypothetical interview is not all that hypothetical. The American job market is changing, and to get and keep jobs future graduates will need skills beyond those that used to be sufficient. This message is brought home by two recent books—Thomas Friedman's *The World is Flat*[1] and Daniel Pink's *A Whole New Mind*[2]—that I believe should be required reading for every engineering professor and administrator. The books come from different perspectives—the

[1] T.A. Friedman, *The World is Flat*, New York: Farrar, Straus, & Giroux, 2005.
[2] D.H. Pink, *A Whole New Mind*, New York, Riverhead Books, 2005.

first economic, the second cognitive—but make almost identical points about current global trends that have profound implications for education.

An implication for engineering education is that we're teaching the wrong stuff. Since the 1960s, we have concentrated almost exclusively on equipping students with analytical (left-brain) problem-solving skills. Both Friedman and Pink argue convincingly that most jobs calling for those skills can now be done better and/or cheaper by either computers or skilled foreign workers—and if they can be, they will be.[3] They also predict that American workers with certain different (right-brain) skills will continue to find jobs in the new economy:

- creative researchers, developers, and entrepreneurs who can help their companies stay ahead of the technology development curve;
- designers capable of creating products that are attractive as well as functional;
- holistic, multidisciplinary thinkers who can recognize complex patterns and opportunities in the global economy and formulate strategies to capitalize on them;
- people with strong interpersonal skills that equip them to establish and maintain good relationships with current and potential customers and commercial partners;
- people with the language skills and cultural awareness needed to build bridges between companies and workers in developing nations (where many manufacturing facilities and jobs are migrating) and developed nations (where many customers and consumers will continue to be located);
- self-directed learners, who can keep acquiring the new knowledge and skills they need to stay abreast of rapidly changing technological and economic conditions.

Those are the attributes our students will need to be employable in the coming American engineering job market. The question is, are we helping them to develop those attributes? With isolated exceptions, the answer is no. We still spend most of our time and effort teaching them to "Derive an equation relating *A* to *B*" and "Calculate *Z* from specified values of *X* and *Y*." We also offer them one or two lab courses that call on them to apply well-defined procedures to well-designed experiments, and we give them a capstone design course that may require a little creativity but mostly calls for the same calculations that occupy the rest of the curriculum. Nowhere in most engineering curricula do we provide systematic training in the abilities that most graduates will need to get jobs—the skills to think innovatively and holistically and entrepreneurially, design for aesthetics as well as function, communicate persuasively, bridge cultural gaps, and periodically re-engineer themselves to adjust to changing market conditions.

Why don't we? It's because people as a rule don't want to leave their comfort zones, and engineering professors are as subject to that rule as anyone else. We are all comfortable deriving and solving equations for well-structured single-discipline systems, but most of us are not so sure about our ability to handle ill-defined open-ended multidisciplinary problems or to teach creative thinking or entrepreneurship. So, despite a crescendo of headlines and best-sellers about the growing exodus of traditional skilled jobs to developing countries (including high-level research and development jobs, which are increasingly moving to India and China[4]), many engineering faculty members vigorously resist suggestions to make room in the curriculum for

[3] If you don't think this is already happening in engineering, check out a 2005 NAE Report called "Offshoring and the Future of U.S. Engineering: An Overview," <*www.nae.edu/NAE/bridgecom.nsf/weblinks/MKEZ-6G6R4D?OpenDocument*>.

[4] S. Lohr, "Outsourcing is Climbing Skills Ladder," *New York Times*, February 16, 2006. This article reports that of 200 multinational corporations surveyed, 38% said they planned to "change substantially" the worldwide distribution of their R&D work in the next three years...and this particular trend is still in its infancy.

multidisciplinary courses and projects or anything that might be labeled "soft." Even though most of our alumni in industry—95%? 99%?—assure us (as they have done for decades) that they haven't seen a derivative or integral since they graduated, the traditionalists still insist that we can only produce competent engineers by devoting almost every course in the curriculum to deriving and solving equations, analytically and with Matlab. The same professors are no less resistant to efforts to move them away from the traditional "I talk, you listen" pedagogy toward the active, cooperative, problem-based approaches that have been repeatedly shown to equip students with the skills Friedman and Pink are talking about. (See bibliography below.)

So far we've gotten away with it, although sharply declining engineering enrollments in recent years should be a red flag. We can't count on getting away with it much longer, however. The relentless movement of industry to computer-based design and operation and offshoring of skilled functions and entire manufacturing operations is not about to go away. On the contrary, as computer chips get faster and developing countries acquire greater expertise and better infrastructure, the movement will inevitably accelerate. The American engineering schools that respond by shifting toward more multidisciplinary problem- and project-based instruction—the way Olin, Rowan, Rose-Hulman, the Colorado School of Mines, and a number of others have already started to do—will survive. The schools that try to stick with business as usual may not.

Bibliography

Effective Teaching Methods and the Research that Supports Them

Bransford, J.D., A.L. Brown, and R.R. Cocking, eds., *How People Learn: Brain, Mind, Experience, and School*, Washington, DC: National Academy Press, 2000. On-line at <*http://www.nap.edu/html/howpeople1/*>.

Felder, R.M., D.R. Woods, J.E. Stice, and A. Rugarcia, "The Future of Engineering Education: 2. Teaching Methods that Work," *Chem. Engr. Education, 34*(1), 26–39 (2000). On-line at <*http://www.ncsu.edu/felder-public/Papers/Quartet2.pdf*>.

Woods, D.R., R.M. Felder, A. Rugarcia, and J.E. Stice, "The Future of Engineering Education: 3. Developing Critical Skills," *Chem. Engr. Education, 34*(2), 108–117 (2000). On-line at <*http://www.ncsu.edu/felder-public/Papers/Quartet3.pdf*>.

Active Learning

Felder, R.M., "Random Thoughts" columns in *Chemical Engineering Education*:
(a) "Learning by Doing," <*http://www.ncsu.edu/felder-public/Columns/Active.pdf*>.
(b) "How About a Quick One?" < *http://www.ncsu.edu/felder-public/Columns/Quickone.html*>.
(c) "It Goes Without Saying," <*http://www.ncsu.edu/felder-public/Columns/WithoutSaying.pdf*>.

See also <*http://www.ncsu.edu/felder-public/Cooperative_Learning.html*>.

Prince, M., "Does Active Learning Work? A Review of the Research," *J. Engr. Education 93*(3), 223–231 (2004).

Cooperative Learning

Felder, R.M., and R. Brent, *Cooperative Learning in Technical Courses: Procedures, Pitfalls, and Payoffs*, <*http://www.ncsu.edu/felder-public/Papers/Coopreport.html*>. See also <*http://www.ncsu.edu/felder-public/Cooperative_Learning.html*>.

Two meta-analyses of research on cooperative learning vs. traditional instruction can be found at <*http://www.co-operation.org/*> (University of Minnesota) and <*http://www.wcer.wisc.edu/nise/cl1/CL/resource/R2.htm*> (University of Wisconsin)

A Web site with links to CL-related papers and to what must be every cooperative learning site in existence is Ted Panitz's site, <*http://home.capecod.net/~tpanitz*/>.

Problem-Based Learning

Prince, M.J., and R.M. Felder, "Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases," *J. Engr. Ed., 95*(2), 123–138 (2006). On-line at <*http://www.ncsu.edu/felder-public/Papers/InductiveTeaching.pdf*>

Duch, B.J., S.E. Groh, and D.E. Allen, *The Power of Problem-Based Learning,* Sterling, VA: Stylus, 2001.

University of Delaware Problem-Based Learning Clearinghouse, <*https://chico.nss.udel.edu/Pbl*/>.

Ted Panitz's site (<*http://home.capecod.net/~tpanitz*/>) and *Deliberations*, a site managed by London Metropolitan University (<*http://www.londonmet.ac.uk/deliberations/problem-based-learning*/>) are good sources of both information about PBL and links to other PBL-related sites.