Random Thoughts . . .

MEET YOUR STUDENTS

2. Susan and Glenda

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Susan and Glenda are seniors in chemical engineering at a private northeastern university. They are both bright and personable. They like to study with friends and enjoy the lengthy bull sessions that the study sessions sometimes turn into. They both have a hard time saying no to requests for help with classwork, even if they don't have the time for it. Neither one cares for laboratory courses. They have almost identical grade point averages–about 3.2/4.0.

The resemblance ends there, however. Susan was an outstanding student in junior high and high school, and in college she has gotten B's in almost all of her courses, with an occasional A. Her instructors have an easy time grading her homework and test papers: the solutions are neatly laid out, with each step clearly following the preceding one, and she gets a great deal of credit even when her answers are incorrect.

Glenda is another story. Her transcript is a mixture of A's and C's. She usually starts out in a class by doing poorly on the homework and failing the first quiz, and she may spend the rest of the semester trying to catch up. Her problem solutions are jumbles of apparently unrelated numbers and equations with the answer magically appearing at the end; she rarely gets much partial credit, and if anyone asks her to explain what she did, she has an extremely difficult time doing so.

Sometimes, however, Glenda seems to undergo a transformation. She begins to solve homework and test problems with ease, occasionally using methods that were not taught in class. She may then go on to get an easy A in the course, or, if the class moves on to completely new material, she may revert to her previous performance level and struggle until either another breakthrough is achieved or the semester ends. Even after she makes a breakthrough, her problem solutions are frequently incomprehensible to anyone else; the difference is that the answer that suddenly appears at the end is correct. She has been hurt on several occasions by instructors who implied that she had cheated, although no one ever had any proof. (In fact, she never cheated.)

Susan is a *sequential learner,* Glenda is a *global learner* [1]. Sequential learners tend to gain understanding in a linear fashion, with each new piece of information building logically from previous pieces. They tend to solve problems the way they learn–in a linear, stepwise fashion–and their solutions make sense to others. They generally have little trouble in school because of their sequential way of learning and solving problems: their courses, books, and teachers are all geared to their style.

Global learners function in a much more all-or-nothing fashion. They absorb information almost randomly, in no apparent logical sequence. In consequence, when they are first learning a subject nothing may make sense to them, and they may be incapable of solving trivially simple problems. But then at some point a key piece of data is taken in, a critical connection is made, the light bulb goes on, and they "get it." They may be fuzzy about details after that, but they see the big picture in a way that most sequential learners never achieve. Thereafter, when presented with new material that they can fit into this picture, they may appear to assimilate it instantly, and when solving problems they may leap directly to the solution without seeming to go through the required intermediate steps. They may also see surprising connections between newly-learned material and material from other subjects and disciplines.

Strongly global learners often have difficulty in school. Before they make their mental breakthrough in a given subject, their struggle to solve problems that their sequential counterparts handle with ease makes them feel stupid. Even after they make breakthroughs, their inability to explain their problem-solving processes can get them into trouble, as when Glenda was suspected of cheating. These difficulties–which most of them experience from the first grade on–are truly unfortunate, since global learners collectively constitute one of society's most valuable and underutilized resources. If they are allowed to progress in their seemingly disjointed manner, some of them will go on to become our most creative researchers, our systems analysts–our global thinkers.

Felder and Silverman [1] suggest ways that engineering instructors can accommodate the learning styles of global learners. Most of these suggestions involve providing a broad perspective on the course material, relating it to material in other courses and disciplines and to the students' prior experience. Perhaps the best thing we can do for these individuals, however,

Continued on page 11.

sian. It has been a regular "citation classic" for being referenced in the literature with a frequency comparable to such classics as Abramowitz and Stegun (Handbook of Mathematical Functions) and Carslaw and Jeager (Conduction of Heat in Solids). It is recognized as the most important textbook in the profession in the last quarter century.

In 1974 Ed published the pioneering text *Transport Phenomena and Living Systems* which showed how to use the art and science of chemical engineering to solve important bioengineering problems by including details of the physiological and pharmacological phenomena.

Recently he has devoted his efforts to the development of modern biotechnology, with special emphasis on the engineering of metabolic pathways and materials separations. He was the driving force in the organization of the Bioprocess and Metabolic Engineering Consortium at the University of Wisconsin. With the support of Abbott Labs, Agracetus, APV Crepaco Inc., Becton Dickson, Bio-Technical Resources, DuPont, Kraft, New Brunswick Scientific Co., Procter and Gamble, Promega Biotech, Universal Foods and Xylan, the consortium promotes the use of biological organisms and biochemical processes to produce specialty chemical products.

Just this year Ed led a University/Industry/State-of-Wisconsin team in the development and design of an industrial process to produce high purity lactic acid from waste cheese whey. This industry seeks to produce valuable chemicals and jobs from a particularly troublesome waste product of one of the state's largest industries. This service to industry and state follows Ed's successful approach to research in combining the science and practice of engineering. □

RANDOM THOUGHTS

Continued from page 7.

is to watch for them, and when we find them (which we will), explain and affirm their learning process to them. They probably already know all about the drawbacks of their style, but it usually comes as a revelation to them that they also have advantages–that their creativity and breadth of vision can be exceptionally valuable to future employers and to society. Any encouragement we provide could substantially increase the likelihood that they will succeed in school and go on to apply their unique abilities after they graduate.

Postscript: 10 years later

Susan graduated and went on to get a masters degree in chemical engineering, got a number of good job offers, and went to work in the process design division of a large petrochemical company. She did extremely well and is now making rapid progress up the technical management ladder. Glenda went through a lengthy job search when she graduated–all those C's on her transcript worried prospective employers–and finally found a position with a small firm of design consultants. Her first project involved designing and installing process simulation software for a pharmaceuticals manufacturer. She did almost nothing on the project for months, despite increasing pressure from her supervisor. Then she came up with a package that not only did the required simulation but also used it to schedule production, manage inventory, and determine production bottlenecks and the best methods of eliminating them. The company estimated that the program led to savings of two million dollars in its first year of use. Glenda now gets the problems too difficult for anyone else in the firm to solve. Sometimes long periods go by without any apparent results, but no one pressures her any more. □

[1] R.M. Felder and L.K. Silverman, "Learning and Teaching Styles in Engineering Education," *Engineering Education*, **78**(7), p.674 (1988). Susan is a representative sequential learner and Glenda is a representative global learner, but not all sequentials are just like Susan and not all globals are just like Glenda. These labels simply denote tendencies that may be strong or weak in any given individual, and everyone exhibits characteristics of both types to different degrees.

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