ChE educator

CAROL McCONICA

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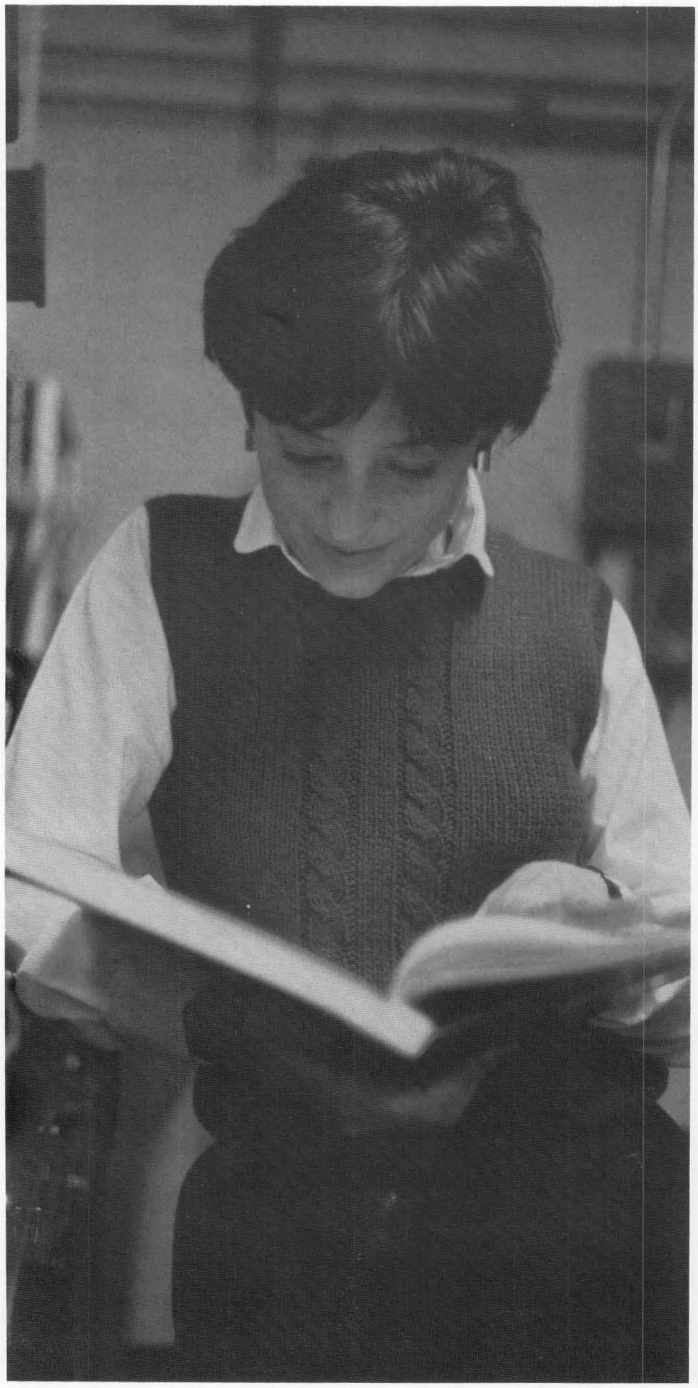

THE VIRTUES of solitude have not been lost on Carol McConica. In many ways, her life has been shaped by them. In solitude, she has been free to speculate, to experiment, to innovate—and to buck traditional constraints.

At an early age, this Colorado State University chemical engineer grew to love the feeling of being alone, of forging a kinship with nature. The daughter of Colorado geologists, Carol and her sister spent many summers living out of a tent in rural settings throughout the West, isolated from the constraints and expectations of civilization.

"We had no TV, no media, no *Seventeen* magazine. We had no running water, no electricity. We had nothing. We had a natural environment for a playground. We grew up being in touch with nature, and my parents couldn't have cared less about societal roles," McConica remembers.

"That was wonderful. I think what happened was that I was molded by nature rather than by man. You become very creative, very independent and resilient."

Today, at 37, McConica has replaced the tent in the wilderness with a research lab, but the isolation from traditional limitations still allows her to search for knowledge in unconventional areas.

Continuing to relish creativity, McConica is one of only a handful of chemical engineers on the cutting-edge of integrated circuit processing. After securing funding for the sophisticated, ultra-clean equipment and facilities necessary for her research, McConica built one of the nation's pioneering academic programs in the deposition of tungsten as the conducting interconnect on silicon computer chips. She believes that tungsten (which, ironically, was mined by her grandfather in the Colorado mountains) may be the key to denser, faster, more powerful microchips.

"In a lot of ways, I am leading my own solo ascent. It's like breaking a trail in a howling snowstorm, year after year. I am drawn to that, but it is overwhelming at times.

"You are out there breaking a new trail by yourself, raising money by yourself, being absolutely and totally isolated. On the other hand, without the constraints of a bureaucracy, I have a freedom of motion that no corporation can offer."

That freedom of motion allows McConica to travel between the academic world and the corporate environment, which she first entered in 1979 as a Hewlett-Packard Company engineer. A female manager with HP lured McConica to the computer company just as she was completing her graduate program at Stanford. McConica was the first American woman to receive a doctorate in chemical engineering from Stanford.

The integrated circuits industry, McConica soon discovered, was a good match for her curiosity and temperament. "I was attracted to it because it is such a high-paced industry, and I am a real driver-driver. I like to have an idea, test it out today, and see if it works tomorrow.

"In the oil industry it may take five years to design and test an experiment. But in the integrated circuits industry, processes last only one or two minutes, so you quickly get a lot of information about your basic ideas."

While it is rewarding to help advance integrated circuit technology in the United States, Carol says her chief goal is to help individual companies boost their profits. "I love nothing more than to go into a company and show them how my knowledge can help them. As long as I think that my contributions are going to help their bottom line, I feel victorious."

About a year and a half ago, she developed a theory that explained why companies couldn't get material into the holes of the chips the way they desired. "I developed a rough-cut model that utilizes basic chemical engineering principles. It showed the right trends, so the industry could get in the right mode of operation. It also allowed them to take a major leap forward in yield."

After demonstrating McConica's ideas, several companies incorporated them into chip production. "I captured the essence of the problem, and today it's helping someone's bottom line. To me, that is satisfying."

McConica's findings on integrated circuit processing are sought by large manufacturers like AT&T, small equipment suppliers, and now by a new industry/government consortium (known as Sematech) which is trying to counter the foreign semiconductor competition. Sandia National Laboratories, which has funded McConica's research for seven years, asked Carol to support the Sematech effort.

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Although it's still premature to gauge Sematech's impact, one of its best achievements so far has been to boost the recognition of equipment suppliers' importance to the integrated circuits industry, McConica points out. Many of those suppliers now ask Carol to help them become more successful as they improve their processes (often for the first time) with in-house scientists. At times, the advice she offers the suppliers about their equipment or facilities is met with disdain.

Becoming a successful company can be painful. "I reveal information about their equipment which they would rather not know. They really don't want to know that their reactor has many nonidealities. It's like raising children. They don't enjoy discipline, but you have to do it for their own good."

Whether promoting the integrated circuits industry through companies like IBM, AT&T, or through small start-up companies, Carol is fulfilling a dream she had when she left HP for Colorado State in 1982. "I had hoped that I would be able to have an influence on industry even after I left. I absolutely and totally love industry. . . . I love the pace of industry, I love the accomplishment of objectives. I thrive on the competition."

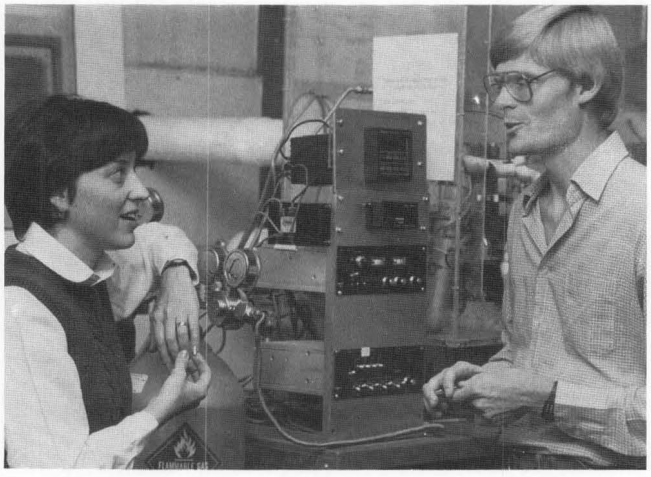
And, much like her early enjoyment of the geological adventures with her family, Carol thrives on being free to explore new terrain on her own. Fortunately, her life as a researcher and a teacher allows her to try out new research ideas away from the commercial constraints of manufacturing.

She explains that in academia she can push the boundaries of current integrated circuits technology because she isn't limited to research on equipment and processes that lead only to production. "I am allowed to build my own equipment, which is totally unrelated to someone else's goals. I can try out new ideas and make contributions that people in industry cannot make because they are tied to production."

McConica has long known the thrill of testing new ideas and limits. Her early interest in biology and math was fueled by the fact that nearly every math

and science teacher she had in the ninth through twelfth grades was a woman. The idea that a woman could be a scientist was both acceptable and conventional.

She first discovered the irresistable lure of a research lab while growing up in Boulder—home of the University of Colorado—in the unconventional 60s. At the time, Boulder was a counterculture cocoon that sheltered free thinkers and innovators. Wrapped in a culture that encouraged individual self-realization, Carol found it natural to spend much of her time in CU labs, helping neighbors and family friends with



Carol feels that hands-on experience is invaluable, and many of her classes focus on experiments.

their research. While in high school, she was chosen to conduct research with CU researchers under a National Science Foundation program. "I was able at 17 to do the kind of work that PhD students get to do. If I hadn't had that hands-on research experience, I never would have known how much fun it can be."

Later, as an undergraduate at the University of Denver, Carol's love of learning was further channeled by professors whose primary goal was teaching. She now feels a strong kinship with her own students, remembering the guidance offered by her DU professors, and says, "I felt cared for, I felt nurtured, I felt mentored, I felt accepted, I felt challenged—everything an undergraduate should feel."

Now, as a Colorado State faculty member, McConica is determined to provide the same quality of instruction and commitment to her students. She feels that excellence in engineering instruction comes from hands-on knowledge; therefore, many of her classes focus on experiments.

For instance, if her graduate students are studying reactor design, she will instruct them to build a simplified version of a reactor and then study flow and diffusion theories. Her students have built plexiglass reactors filled with beads and water in order to study the flow rates of dye and other substances. She believes that a hands-on, senses-oriented approach to teaching is the only way students can really experience the joy of science—and understand its fundamentals.

"I have seen many students who are capable of deriving differential equations in the dark without a pencil. They are brilliant. But they have no concept of engineering. You ask them how they would design some very simple experiments, and they have no idea. I think we are bringing up and importing a whole generation of students who have never been in a hardware store. As educators, we need to remember that profits come from products, not theories."

To counter this lack of practical experience, McConica challenges her students to do things such as disassembling a bicycle down to its last nut and bolt and then putting it back together again. And she is adamant that they also learn how to ask for help if they need it. "By the time I am through with my graduate students, they should have good hands-on ability and interpersonal skills. They should be able to say, 'I don't know,' and to admit their mistakes. Otherwise, they will be impossible to work with in industry."

To better position her students for career success, Carol teaches seminars on issues encountered in the workplace. She addresses, for instance, corporate politics and risk-taking, time management, personality styles, negotiation and listening skills, and quality control. Most of all, she views herself as a conduit through which well-educated and mature students can enter the corporate world. "I see myself as trying to train the best people for industry."

But Carol's loyalty to the corporate arena doesn't blind her to its faults. She is a staunch critic of the corporate world that encourages and rewards achievements at the expense of family stability. She feels that in the drive for success and materialistic glory, some workers and employers have forgotten that families are the ultimate foundation upon which society (and corporations and universities) rests.

She argues that men and women in their 20*s* to 40*s*, for instance, should focus on raising and instilling values in their children, but they are instead pressured to become corporate superstars or research wizards. Carol points out that a solution to these skewed values may lie in the philosophy of Confucius, who taught that no community could respect a man who could not lead his own family.

"It would be good for us to study the teachings of Confucius. Somehow our society has forgotten that a prestigious career and a weak family are as useful to society as a house with no foundation. In Indian philosophy, life stages (known as ashrama) are acknowledged. A man is responsible first for learning, and then, in his later years, he must lead his family as a "householder." As he grows older, he leads his community and ultimately prepares for death. It is much more sensible to make our older and wiser workers the vital essence of our institutions while letting the younger members build solid homes in their early years."

The workplace needs to accommodate the multiple roles of men and women and not to penalize those workers who choose to have children and continue their careers," says McConica, the mother of 11-year-old Anna and 14-year-old Ian, who were born while she worked on her degrees. "The national labs, the top five companies, and the top education institutions fail to recognize any existence other than one which is experienced by a single male with no obligations beyond the classroom. They hire based upon graduate GPAs and years elapsed between degrees."

Because of these inequities, McConica sees many young women choosing not to have children, fearing that the workplace will not allow them to have both children and a career. "In the corporate board rooms of America, there are three taboo subjects: childbearing, childrearing, and death—events certain to happen to most of us. It is comical to me that the very engineers who pretend to understand boundary conditions and initial conditions so well seem to be completely ignorant of the fact that tomorrow's students and employees come from women who have agreed to supply their wombs for the creation of those lives. In today's society, with dual careers, there is little incentive for a woman to make this sacrifice."

Corporations and society must support women and men who choose to balance children and careers, McConica says. She adds that practical solutions could be found in government-mandated parental leaves (including job security), the encouragement of part-time employment and flexible hours, and significant tax credits for the work accomplished by homemakers.

As exciting as corporate achievements, travel, and consulting can be, society must judge itself through its elderly and its children, she says. "I will consider myself a success if my children freely understand that they have choices in their lives and if my students understand that the human side of engineering is just as important as the technical side. It is the balanced, whole person who ultimately builds a strong society." □

ChE letters

HEALTH AND SAFETY TEACHING AIDS

To the Editor:

Mr. J.P. Gupta's article in the summer 1989 issue of *Chemical Engineering Education* outlines one way to teach chemical process safety and health for those undergraduate engineering students who elect this course. The Center for Chemical Process Safety of the American Institute of Chemical Engineers has chosen a different means – teaching health and safety to virtually all students within the framework of required, traditional engineering courses. Teaching health and safety concepts in several courses is an important step toward satisfying "minimum" ABET *Criteria.*

The teaching material, available for the 1990-91 academic year, consists of 90 problems which illustrate safety, health, and loss prevention concepts, such as vapor releases, explosions, and toxic exposure, *and which supplement the teaching of traditional engineering courses,* including thermodynamics, heat transfer, kinetics, process design. They require mathematical solutions using engineering principles as well as consideration of safety, health, and loss prevention safety issues.

The problems were conceived and developed by chemical engineering faculty of several universities, government officials, and industry professionals working under the auspices of the Undergraduate Education Committee of CCPS. To assure realism and ease of use, the material has been reviewed by engineers in industry for accuracy and applicability and has been tested and critiqued by chemical engineering faculty of 40 colleges and universities.

To encourage widespread use of these problems, the Instructor's Guide, with problems, student and instructor notes, and solutions, is available free of charge to faculty who wish to use the problems with the student's book. The Student Problem book, good for all years of study and later reference, will be sold through bookstores at $18. The U.S. Environmental Protection Agency and National Institute for Occupational Safety and Health which consider this a high priority program are, along with CCPS sponsors, subsidizing project costs.

Information about the Instructor's Guide and Student Problems book is being mailed in February to all chemical engineering faculty in the U.S. and Canada. Faculty members who do not receive this information are urged to contact the Center for Chemical Process Safety at AIChE's offices, 345 East 47th Street, New York, NY 10017, or by calling (212) 705-7319.

F. Owen Kubias
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CCPS/AIChE