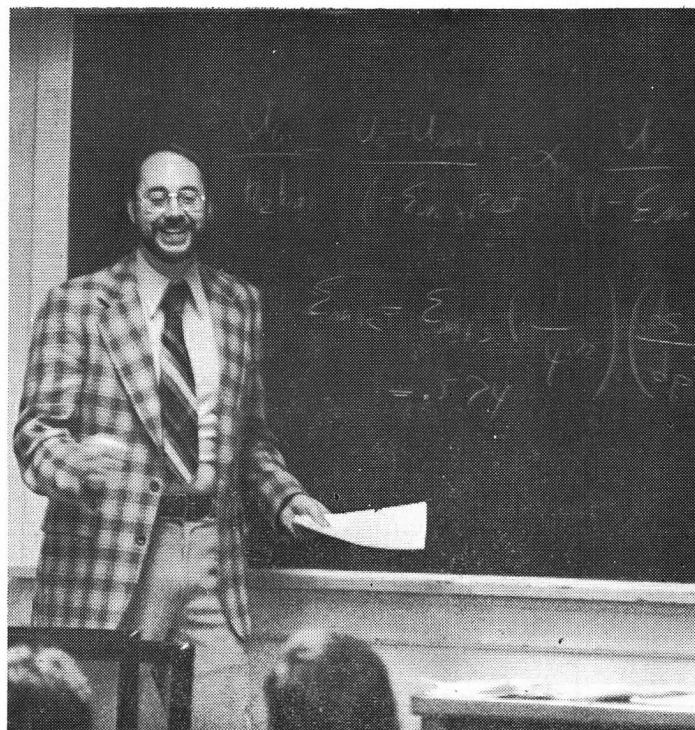


Scott Fogler

A Teacher Of Learning



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SCOTT FOGLER ENJOYS teaching, enjoys students, enjoys the challenge of arousing interest in his classes, enjoys the fulfillment of accomplishment in his students. In short, he comes as close to a Teacher of Learning as one is apt to find as this typical statement from one of his students shows: "I believe he really cares about each and everyone of his students; how they are doing in his courses, in other courses; and in particular the problems that students have in understanding course material. He is a top man. I would like to see more dedicated men in the teaching profession like him."

Scott remembers his first class as a teacher. It was during his first summer as a graduate student at Colorado, and he was asked to fill in

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for a month, teaching a rate operations course for juniors. Beginning teachers usually experience a combination of exhilaration and fear: Scott felt both. He loved the teaching, and the experience was a major reason why he decided to teach. But he also had fears.

"What if I teach all my life . . . and do it ineffectively?" Scott has paid attention to not doing it ineffectively. His sensitivity to students' interests, mastery of teaching techniques and communicable enthusiasm produce classes which challenge—and entertain—his students. He moves about the room, gesturing, poking at formulas on the board. He pauses for effect. He calls students by their first name, asking questions, and throwing in one-liners that keep the class alert and entertained. As one student says: "He's got to be good to keep a class this awake at 8:00 in the morning!"

An intensity and deep involvement pervades most of Scott's activities. He is always a man in motion striving for perfection—in class, in research conferences, in faculty meetings—his intense persistence on goals and achievements sometimes exhausts the efforts of others to keep up his pace.

INFLUENCE OF TEACHERS

SCOTT'S ENTHUSIASM for teaching is explainable. His father was a professor of chemistry at Illinois State Normal University, in Bloomington, Illinois. His father's example and Scott's own intellectual curiosity proved a decisive combination: he gave up his interest in competitive swimming after graduating from Morgan Park High School in Chicago to devote more time to his studies. At the University of Illinois, where he received a BS (in 1962) he studied with Max Peters, one of the influential teachers in Scott's life. He was so impressed with Peters that he followed him to Colorado in 1962 when Peters accepted the Deanship there.

At Colorado, Scott had the fortune of working with Klaus Timmerhaus, another master teacher. From Timmerhaus, Scott learned the significance of maintaining an open, permissive atmosphere for students. He learned how to let students confront problems in their own way, and to learn from mistakes as well as successes. In this stimulating environment, Scott was encouraged to start his own seminar in interfacial phenomena as a graduate student.

After receiving his PhD in 1965, Scott joined the Faculty of The University of Michigan. Beginning the following year, he fulfilled his ROTC obligation, spending two years at the Jet



The Fogler Tribe.

Propulsion Laboratories. There, he also taught evening courses in mass transfer through UCLA's evening extension program.

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ing. Always a hard-driving perfectionist, Scott first dug into the literature of learning theory and developed a comfortable ease with the concepts and language for the analysis of educational approaches. "Open-ended, programmed learning, guided design, computer gaming, simulation, information dissemination, Keller plan, synthesis, motor skills," etc. were only some of the concepts that Scott brought to the Chemical Engineering Faculty over the next few years. At first, these were but abstractions to the rest of the faculty, but Scott made them real by applying them to his classroom activities. The results are remarkable, as students and colleagues attest. Scott has confronted the problem of individualized instruction in large classes with success. At least,

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Scott Fogler's teaching techniques are aimed at a double goal: to convey basic information, and also to teach the process of creative problem solving. His classroom approach reflects this philosophy. Scott spends class time telling his students about analysis and synthesis; how he thinks when he tries to solve a problem. He constantly asks himself "What intellectual ability am I teaching?" What he strives for is not just the factual basis for problem solving, but the creative ability to choose the best way of finding solutions. He feels that lab sessions are a time when the student should use his own intellectual arsenal for problem solving. Learning factual material, deriving equations and other "book work" is for the students' own time, out of class.

CHALLENGING STUDENTS

SCOTT CALLS TEXTBOOK exercises "... convergent: if you work the formulas long

enough, you'll come up with the right answer. The world isn't like that. In industry, you may not know even if there is a problem. And if there is a problem, it may not have an answer or it may have many answers."

Scott reaches for "divergent" exercises, ones which challenge the student to use all his abilities for analysis and the synthesis of a solution. One of his favorite projects in an open-ended laboratory course he developed is a microplant. This is

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a continuing effort, begun several semesters ago, which is continued by succeeding classes. The project is a miniature plant for manufacturing polystyrene. It has progressed through the design to the hardware stage. Presently, after three years of student efforts, it produces small quantities of polystyrene. Continuing student efforts are directed to improving the product and increasing plant efficiency.

A student may be called on for abilities completely outside chemical engineering to solve problems in Scott's classes. Another project is to dramatize some classic material in ChE in a 10-minute videotape. The effort injects creative problem solving into the perfunctory experiments every chemical engineer has to know.

Scott uses audio-visual materials in other ways, such as in computer graphics. He currently has six interactive computer programs, two of which are played like games. One game is a murder mystery and uses a knowledge of rate reactions to find the body and determine the murderer. It must be in the processing vat because its conversion shifted dramatically at about the time of the murder. Each time the student signs on the computer, there will be a new randomly selected murderer and victim. The other computer game is more immediate: the student is told he has just been infected by a lethal bacteria. He has only a few minutes to perform a limited number of experiments. The first problem: which experiments

must he choose? The student who becomes too engrossed in experimentation will be told abruptly that he has taken too long, and has just died. As this game demonstrates, Scott feels that experimentation must be taught as a method of creative problem solving, and not as an end in itself. He cautions students to experiment economically, to try to reach the best solution with the fewest possible tests.

Another interactive computer graphics program simulates a microplant which has randomly-selected faults. With this program, each student is confronted with a unique diagnostic problem. For example, one of the components, such as a reactor, may be malfunctioning. Through a series of interactive diagnostics the student must find the faulty unit and suggest corrective measures. This sophisticated simulation took about three years to complete.

Scott is very concerned that the student be allowed to develop at his own speed whenever possible. He has tried the Keller plan of teaching, which allows individual rates of progress, but found that the need for proctors made the plan difficult.

One of Scott's techniques for large classes is straight out of Education School: the Buzz Group. Scott gives a brief lecture, and the students then break up into small groups to solve a class problem. As they work, Scott goes from group to group, encouraging, answering questions, probing. With this method, he can, in fact, provide a personal touch even in classes of 80 students.

Scott's greatest success to date with individualized learning is his *Programmed Text in Chemical Reaction Engineering (PTCRC)*. In this text, the student learns incrementally, frame by frame, pretty much at his own pace. One of the first texts of its kind in ChE, it is in its second printing in just three years.

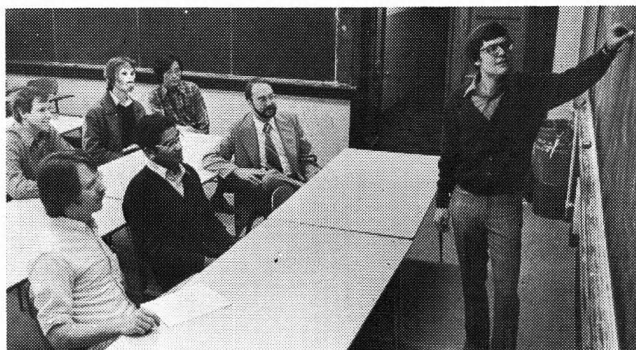
RESEARCH PROGRAM

S COTT REALIZES THAT masterful teaching techniques are not enough to keep a Professor

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going: "To have any impact on teaching, you need to have a sound research program before anyone will listen to you. I had some early ideas about guided design, but my research program really wasn't where it is now." Now, there are six PhD students doing research with Scott, and he has a bibliography of over 35 publications and over \$125,000 per year in research funding. In the beginning, Scott's own research interests came before his interest in teaching. He decided to pursue a PhD because he found he liked research after a summer project with John Quinn at the University of Illinois. It was that summer class in rate operations at Colorado that convinced him to teach. Scott started his research career with Klaus Timmerhaus in the area of ultrasonics. His interest in ultrasonics expanded at The University of Michigan to include some pioneering work on ultrasonic emulsification, and he recently achieved a breakthrough in predicting liquid-liquid droplet breakup dynamics in an ultrasonic field based on fluid mechanical and interfacial considerations.

Scott has become deeply involved in the kinetics and mechanism of heterogeneous interfacial dissolution of minerals, especially as applied



Scott's graduate research group holds a weekly seminar.

to improving oil and gas recovery (acidization) in porous rock formations. Scott is especially excited about his recent development of a mathematical model that predicts the movement of reaction and permeability fronts in porous media.

In related work, he has applied a fundamental kinetic approach to obtain some very strong leads on the interrelationship of acid attack on minerals, based on the crystal structure of the mineral and the behavior of interfacial reaction systems. One colleague commented that Scott was the first person to study the fundamental reaction of minerals in contact with acids, and his work will

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be of lasting importance to investigators in that field.

In addition to his research interests, Scott spends time consulting for Chevron Oil. He agrees that constant industrial contact is necessary for one who is training future chemical engineers. He brings as much non-proprietary data as he can to his classes.

Scott's enthusiasm for teaching—and doing it right—has won him recognition as an outstanding educator. He is perhaps most proud of being a Fulbright Scholar to Norway in 1974-75, at the Physical Chemical Institute of Bergen. While there, he studied flow and reaction in porous media, specifically the North Sea Oil wells. He is also proud of the Dow Award he received in 1972, a recognition given to outstanding young faculty in the mid-west. Scott has been honored by the University of Michigan Class of '38E as an outstanding young faculty member, and has also received the U-M Junior Faculty Award. Scott also remembers with pleasure the Annual Canoe Trip Seminar at the University of Pennsylvania: the invited guest gives an informal seminar after a scenic canoe trip.

OUTSIDE THE CLASSROOM

SCOTT'S ENTHUSIASM and intensity pervades most of his activities, both inside and outside the University. He is very much involved in the activities of his family, and through his children, has become very active in Little League and Indian Guides.

Indian Guides teaches the virtues of self-reliance, honesty, and concern for others through bi-weekly meetings, and other activities such as camping and canoeing. It emphasizes participation by the father-son team; in this case, Scott and his sons Pete, age 11 and Robby, age 9. Robby also shares his dad's affinity for scary movies, and periodically they share an evening of pleasurable fright.

Continued on page 36.

or that K in equation (2) is less than 1. Were we to use this reaction to produce B , the equilibrium mixture leaving the reactor would contain less B than A , and consequently would need to be separated into its components, with the unreacted A being recycled to the reactor. Notice that the free energy change in moving pure reactant to the *equilibrium state* is *negative* even when the overall ΔG°_r is positive. Therefore *the reaction always goes to its equilibrium state*. If ΔG°_r is positive the concentration of product in the equilibrium reaction mixture is low and insufficient to make $K > 1$. Of course if $K \ll 1$ this concentration may be so low as to be insignificant, as for example in the decomposition of water to hydrogen and oxygen at room temperature. On the other hand as $K \rightarrow 1$, for valuable or easily isolated products, the product concentration may be large enough to make cleaning up the equilibrium mixture worthwhile.

HERESY III

" $dU = TdS - PdV$ For A Reversible Process (in a simple system)"

The statement is indisputable but only because it is a tautology. You can say with equal validity:

$dU = TdS - PdV$, in Paris in the Spring;

or, on Tuesdays or Fridays;

or, for an *irreversible* process

I consider it heresy because it implies to too many students that dU , a differential of a property, is dependent on process or path, and is otherwise defined for an irreversible process.

Statement III should never stand alone, though it does all too frequently in many respected texts. Better still to avoid it completely or replace it with the following:

For *any* process, reversible or irreversible, that moves a simple system from one equilibrium state to another, the internal energy change may be evaluated by integrating:

$$dU = TdS - PdV$$

along any reversible path that interconnects the terminal states of the process.

I have discoursed briefly on some old, treasured and well rooted thermodynamic prejudices. Should there be some among the multitudinous readership who feel that stronger remedies of a more metaphysical nature, are needed to dispel the doctrines here condemned, I have in my files a copy of the exorcism formula, pronounced prior to hanging, against the murderers of the Arch-

bishop of Dublin, in 1534, and adapted for use on thermoheretics. This I will be glad to send to the initiated in unmarked brown envelopes upon request. □

ChE EDUCATOR: Scott Fogler

Continued from page 7.

Scott's daughter, Kristin, age 6, was quick to feel left out from the Indian Guides activities. Scott realized that there wasn't a similar activity for young girls in Ann Arbor. At Kristin's urging, he organized a council of "Indian Princesses" in Ann Arbor. Scott was the first Nation Chief of the Indian Princesses. He's been a successful Chief: In the first year there were five tribes with a total of about 50 fathers and daughters.

Peter, age 11, got Scott involved in another after-hours effort: Little League. When Peter's 5th grade class couldn't find a willing coach, Scott stepped in to lead the team to a 1 and 9 record for the season, which doesn't speak too well for the ability of the team (or coach?). But, imagine keeping eighteen 10-year-olds interested enough to keep playing ball even though they were losing all the time! That takes real dedication and understanding.

Jan, Scott's wife, is also involved in teaching as she has 25 piano students and currently serves as president of the Ann Arbor Area Teachers' Guild.

In his few leisure moments, Scott spends some time gardening. He finds Michigan a frustrating place to raise plants because of its hard clay soil. He plants three trees for each one that lives.

The whole Fogler family shares an enthusiasm for travel, and Scott has lectured in Scandanavia, Italy, South America, and Mexico City. Whenever he travels, he takes along his programmed-learning text. He has a file of slides which show him reading the text in front of landmarks such as the Tower of Pisa. He uses the slides as visual one-liners during his lectures.

Scott Fogler loves teaching, loves research and approaches them both with unbounded energy. He is perhaps his own best example of creative synthesis. He has developed his teaching skills and mixed them with humor to produce memorable classes for his students. He has used some bit of educational theory and his own creativity to gain recognition as an outstanding educator. As he says: "A little theory is very practical!" □