ChE educator

Bob Sparks*

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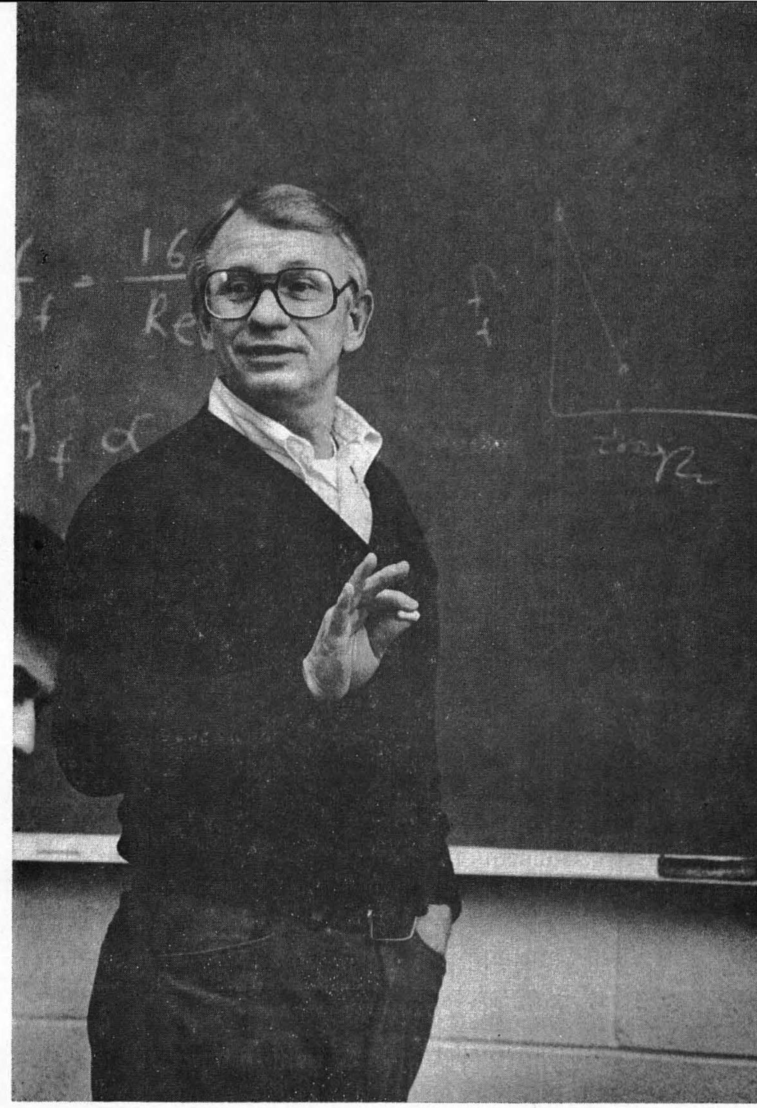

THIS IS A MAN WHO gets excited over nine dots on a piece of paper and different ways to connect them. He offers the puzzle, a common brain twister, to fourth-grade students and academic colleagues alike—anyone willing to engage in a little unorthodox problem-solving.

This is a man, three times chosen Professor of the Year by Washington University engineering students, who was recently the recipient of a national award for excellence in college teaching. The same man, still, has written more than fifty scientific papers in areas ranging from artificial kidney technology to contraceptives.

The man is Robert E. Sparks, professor of chemical engineering, chairman of the biomedical engineering program, and director of the Biological Transport Laboratory at Washington University. If forced to wear a single label, though, he prefers "inventor."

The nine-dot problem is one he sometimes assigns to his classes to make a point about creativity. It consists of three rows of three dots which must be connected by four straight lines. The answer usually given involves extending those lines outside the tic-tac-toe-style grid, a move not immediately considered by most.

But for Sparks, "going outside the grid" has become an approach toward everything he sees and does. He takes special delight in twisting and turning the nine-dot and other problems until they yield not one, but whole handfuls of solutions.

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"It's the hidden assumptions that always bite. The first question I ask is, How else? For instance, what if the dots are really on the surface of a sphere? Or, imagine instead that they are really magnets, or perhaps different sizes. What then?"

Asking questions that are not normally asked is a gift, he concedes, whether the subject is a simple puzzle or a highly technical innovation. But it is also a skill that can be developed. Can it be taught? He swears it can, if only in the beginning by osmosis.

This positive, flexible attitude, this unmistakable enthusiasm of a mind leading other minds. Sparks brings to his classes, whether conducting a special workshop for gifted grade school children or teaching a college class in fluid mechanics.

"What I want more than anything else is to get students thinking," he declares. "Long after they've forgotten the homework, the formulas, the professor, I want them to remember the excitement of having their own ideas."

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Other projects are the investigation of a new form of birth control using targeted drug release, a synthetic material resistant to clotting for use in artificial blood vessels, and a chambered device through which pancreatic cells from an animal might be transplanted to diabetic patients.

"Number-crunching," student lingo for the mechanical process of plugging figures into formulas and grinding out answers, is the alternative that too often passes for education. Many have grown to expect this—professors say that students even complain when examinations ask them to use concepts imaginatively in situations they have not seen before. Concluded one after such a test experience, "I thought that was going too far." Unfortunately, Sparks believes, some professors don't go far enough.

"We get so tied up in teaching great gobs of technical material that we sometimes act as if it were not possible to think until all the facts and figures have been mastered," he observes. "We sometimes forget that lecturing is not necessarily teaching, and listening is not necessarily learning. More important, learning is not necessarily thinking."

He expounded these ideas in June 1980 at the annual meeting of the Chemical Manufacturers Association. The meeting included the 1980 Catalyst Awards ceremony, which honored outstanding teachers of chemistry and chemical engineering at the high school, college and university levels. Sparks was one of six to receive the association's award—a $1,500 prize, a medal, and a citation. In the address, he described the problems associated with the traditional college lecture course and, naturally, proposed a solution.

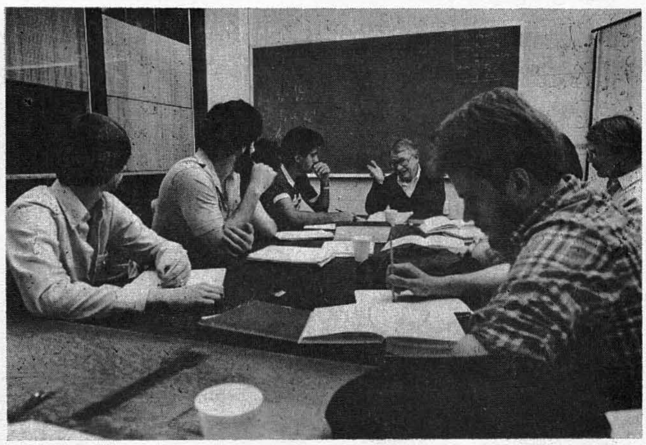
"Students can't think during a lecture. They are so busy taking notes that they don't have time," he contends. "And yet, in most technical classes much factual information and many analytical techniques are conveyed."

After tumbling this dilemma around in his mind, looking for a way to approach it from another direction, Sparks decided to apply a new formula to his content-loaded junior-level course, Heat, Mass and Momentum Transfer. He decided to hold two lectures a week and give the third meeting over to discussion groups that would meet separately with him on Friday. This "sacrifice" of one formal session proved to be one of the most successful practices around.

"It's the best thing since peanut butter," announced one student to his adviser. Others have remarked, "It's one of the few classes I feel I really get my money's worth out of," or simply, "Friday sessions are the best part of this course."

"The focus of these small sessions is always on the meaning behind the facts and calculations. We continually ask Why? or What can we do with this information?" says Sparks. "My guiding axiom is, 'Lead, don't tell.' They are," he adds, "the most awake and alive classes I have ever taught."

The spirit of the Friday sessions is taken farther in Inventive Reasoning, an optional freshman course designed by Sparks and offered every other year. The two-hour course, which evolved from a series of informal, voluntary, noncredit seminars, aims specifically at developing the student's ability to generate his own ideas. It has now expanded to industrial lectures and workshops on inventive thinking for researchers.



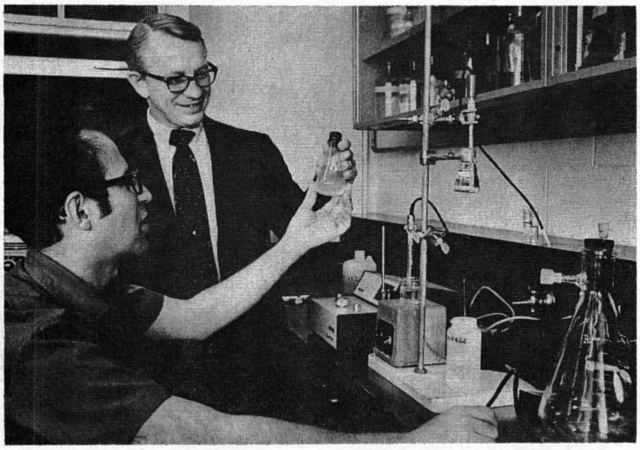
Sparks conducts the Friday sessions.

Many types of problems are presented from many points of view. Some stem from what Sparks calls reasoning from a phenomenon. How many uses can be found for a paper clip, he asks, or for microwave radiation, or liquid crystals? A second category is reasoning from an observation. Here, the class concentrates on the meaning of a process, from the act of stirring cold chocolate syrup into milk, to the nature of tarnish patterns on silver, or the characteristics of small sap droplets on a windshield. A third set of problems which he terms sensitivity to triggers are exercises to increase the awareness of input which might lead to new trains of thought.

Explains Sparks, "I contend that anyone exposed for very long to such an atmosphere soon becomes tenacious about inventing and will do something with any problem you give him, even if he has to change the nature of the problem. The change is okay, because the idea is more important than the problem which generated it. Problems are everywhere and anyone can ask questions. However, a good new idea is not easy to come by. It should be held onto, looked at, modified, and, if it is not immediately useful, it should be saved for future reference."

Norbert S. Mason, Sparks' collaborator and a senior research associate, attests, "He lives by that. It isn't just something he talks about in class. He's equally proud of his own ideas as of those of others."

Mason earned his Ph.D. in chemical engineering under Sparks at Case Western Reserve University in Cleveland, Ohio. When Sparks accepted



Sparks and senior research associate, Norbert Mason, appear to have discovered something.

an appointment at Washington University in 1972, Mason followed. Preferring the academic atmosphere to his former years in the chemical and rubber industry, Mason has worked with Sparks ever since.

"Sparks is an inventor, yes, but he is also a leader in getting diverse groups of people to work together," says Mason. "In our research, we have consulted veterinarians, gynecologists, dental-supply manufacturers, even felt-tip pen manufacturers. He's always well-organized, and that helps a lot."

Born in Marshall, Missouri, Sparks attended school in Independence and entered Kansas City University (now UMKC) as a prelaw student. After only six weeks, though, he grew so homesick

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for his favorite high school subject that he plunged into a chemistry course well after its beginning. He stayed with that decision, and in 1960, graduated with a doctorate in chemical engineering from Johns Hopkins University.

"I chose chemistry and engineering for the same reason I hope you would choose any profession—because it excites you. That nonlogical component, how it feels in the gut, is more important than the outlook in the job market or how much money you're going to make," he says.

Engineering, particularly in its biomedical applications, continues to be an exciting field for him. Elected president of the American Society for Artificial Organs last year, he is currently working on one industrial contract and three research projects funded by the National Institutes of Health. He also is negotiating research contracts with English and French biomedical companies and writing a joint research proposal with an Italian kidney specialist. In addition to Mason, his collaborators include Washington University surgeons Richard Clark and David Scharp, nephrologist Eduardo Slatopolsky, gynecologist David Keller, internist Robert Perrillo, virologist Sondra Schlesinger, and St. Louis University hematologist J. Heinrich Joist.

One project involves a process using membranes with skewed pore size distribution as a screen to filter blood into its components. If perfected, the process might someday be able to separate the hepatitus virus from bloodclotting fractions.

Other projects are the investigation of a new form of birth control using targeted drug release, a synthetic material resistant to clotting for use in artificial blood vessels, and a chambered device through which pancreatic cells from an animal might be transplanted to diabetic patients.

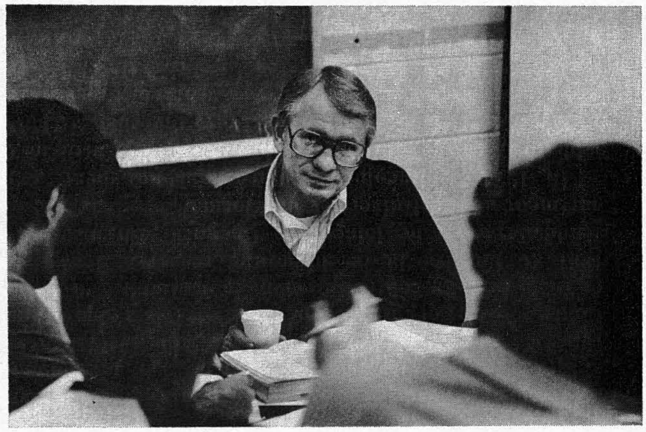
Closest to becoming a commercial product is a substitute for a chalky slurry that many patients with kidney disease must drink daily to remove phosphate impurities from the blood. Sparks and Mason formulated a new antacid gel potent enough to be taken in much smaller quantities. Animal and preliminary human testing has been completed, and they are now awaiting production in large enough quantities for wider testing prior to approval from the Food and Drug Administration. The unlikely source for this idea was literature from the Atomic Energy Commission, which used thin layers of similar gels to remove radioactive impurities from contaminated water.

"For me, thinking inventively is an exciting experience and a lot of fun," Sparks says. "By excitement, I mean that peculiar absorbing interest that makes one forget the clock or his stomach or how tired his eyes are. Excitement and motivation are the most precious gifts of all those I would like to give my students."

Not that Sparks disdains the basics. He has no special affinity for the short-lived educational trend in which many traditional school subjects were declared irrelevant. "Facts, procedures, and skills—oh, these are gold! They shouldn't be boring," he emphasizes. "But you only see it that way once you realize that the facts are the raw material for thinking."

These are strong sentiments, and one offshoot is a book he is in the midst of writing for the adolescent audience, tentatively titled *Think Loose!* It is based on the ideas he developed in his Inventive Reasoning course. A liberal salting of cartoons is one of its special features. "Cartoonists are extraordinarily inventive," notes Sparks. "If their comics only portrayed the obvious and straightforward, you wouldn't laugh."

In addition to a good-sized cartoon collection, Sparks also claims as his hobbies squash, jogging, and backpacking in the Rockies. His favorite non-academic pastime, though, is music. He sang in church as a child and in high school and college he performed in operrettas, barbershop quartets, choruses, and as a soloist. He once sang first tenor in the New Jersey Novice Champion Barbershop Quartet, and while teaching at Case Western Reserve University, he sang with the Cleveland Orchestra Chorus and Chamber Chorus under Robert Shaw and George Szell. For the last two years he has been a member of the St. Louis Symphony Orchestra Chorus, and with both these choruses has performed four times at Carnegie Hall.



Sparks "in session" with students.

Two of his sons are serious music students. Mark is studying the flute at the Oberlin Conservatory in Ohio, and David, a senior at Kirkwood High School, plays the clarinet. A third son, Chris, is majoring in philosophy at Webster College in St. Louis. His wife, Adna, a doctoral student in educational counseling at St. Louis University, is, as well, a source of inspiration for new teaching methods.

From time to time, Sparks enjoys a change of pace from university-level curriculum, and he dips into primary and secondary school teaching, holding sessions on creativity by presenting such favorites as the nine-dot problem or devising new endings to fairy tales. "I like to get in and stir things up a little," he admits. "Once they catch on, the kids are great. They fill up the whole chalkboard with ideas."

Sparks wishes he could get to his pupils even earlier. "Developing a child's attitude toward education and society in those beginning years is as important as teaching information," he affirms.

It is no surprise then, that an idea Sparks is proudest of is not a new biomedical invention, but a new way to group children for instruction. His proposal, called cycled ability grouping, replaces the common high-average-low tracking system by overlapping students so that each group has an ability range spanning approximately 50 percent of the total. A student with medium ability, therefore, might be at the bottom of a fast-moving class one year, in a middle group the following year,

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and at the top of a slower-moving class the next. Several schools in the Cleveland Heights school system have been using this grouping system for several years.

The system seems complicated at first glance, but Sparks insists that its benefits overwhelm any initial confusion. He condemns the normal track system as a disaster, noting, "If a child stays in the same group for more than a year, he begins to feel irrevocably locked into the system, and sees no hope for a change. This can have a stifling effect on his aspirations." He believes teachers, too, would find the change stimulating, particularly those who instruct the bottom-level classes.

Perhaps the key to Sparks' overall success as an inventor and teacher is that he cultivates flexible and creative thought without abandoning the framework of reality. He readily acknowledges the "test-taking attitude" all students must have to survive, but he makes clear to his classes that the ability to distinguish right and wrong quiz answers will not suffice forever. "Once you get out of school," he warns, "people will expect you to think."

"For me, education is the growing of minds, including attitudes. I have begun to think of teaching now as leading people to see and helping them learn how to lead themselves to see. An internal response which has been growing with some surprise and disbelief is the feeling, 'I am a teacher.' It is an exhilarating feeling." □

ChE letters

COMMENTS ON FAHIDY PAPER

Sir:

Concerning Professor Fahidy's article in the Spring 1981 issue. He has his biases, ably expressed, and I have mine, well over toward the numerical end of the applied-math spectrum. Both of us, however, should be careful of over-kill.

I doubt seriously his statement that a Legendre expansion

> **"would be typically introduced by discussing in a class lecture the steady-state temperature distribution in a homogeneous hemisphere whose surface is maintained at a constant temperature and whose base (equatorial plane) is insulated."**

The solution to such a problem is, of course, $T(r,\theta) = T_o$ or, in dimensionless form, $u = 1$. Lest anyone imagine that the author had in mind an axisymmetric pattern of constant surface temperature, the boundary condition $u(R,\theta) = 1$ is explicitly stated. Perhaps Professor Fahidy is merely using this problem as a novel way of demonstrating that certain infinite sums of weighted Legendre polynomials must add up to unity or that, if you get lucky, certain infinite series will degenerate to one term. His purported "solution" describes some very different problem with a mysterious zero at the center. Curiously, the problem is well posed in verbal form, with Dirichlet or Neumann conditions at every point on the surface of the hemisphere, but the mathematical equivalent has too few boundary conditions.

If he's not more careful, Professor Fahidy will give special functions a bad name.

DAVID B. MARSLAND
N.C. State at Raleigh

FAHIDY RESPONDS

Dear Editor:

The following is my response to Professor Marsland's comments:

Professor Marsland would be happier, I presume, if the hemisphere problem were treated using the more general boundary condition $u(R,\theta) = f(\theta)$. When the simple $f(\theta) = 1$ condition is posed, his intuitive solution is correct; however, algebraic manipulations are simpler in this case without much manipulative encumbrance. This specific problem is a standard exercise, (see e.g. Kersten: Engineering Differential Systems, McGraw-Hill 1969, No. 5, 33, p. 106). The fact that certain infinite series possess unity as their sum is a rather useful piece of information and, contrary to Professor Marsland's statement, degeneration to a single term is a matter of structure, not luck. Zeros, by no means mysterious, in potential theory do not hinder a fairly wide application of the theory and Professor Marsland would find several books (e.g. Dettman: Mathematical Methods in Physics and Engineering. McGraw Hill 1962, 1969) a delightful counterproof to his belief. As for my ability to "give special functions a bad name," there is little fear: much more brilliant mathematicians than I ever can hope to be have already established their good name.

T. Z. FAHIDY
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