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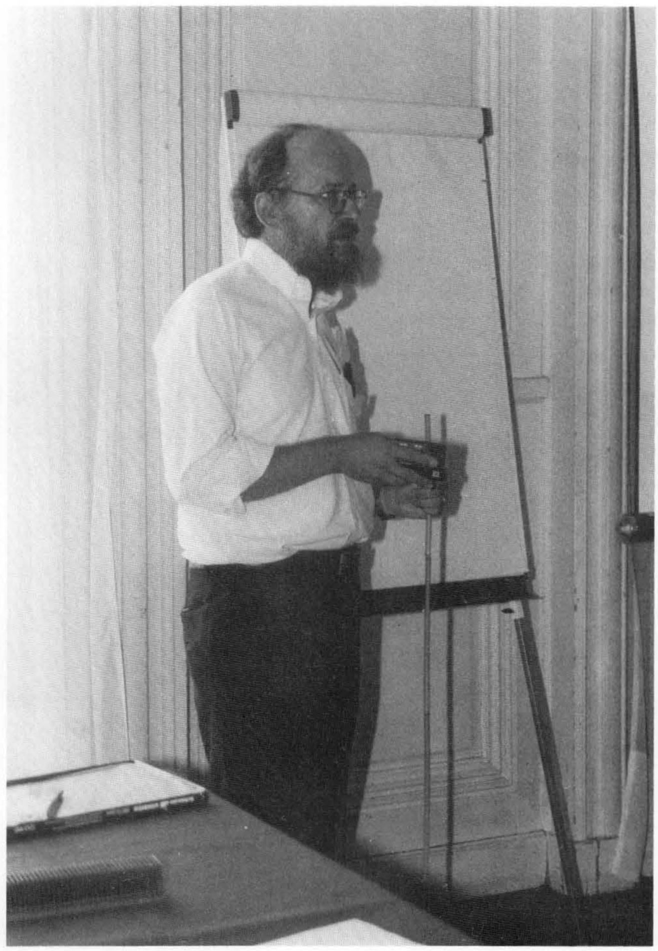

For many young people, the choice of a career is a trial-and-error process that lasts for years. But not for Phil Wankat. His father suggested that he become a chemical engineer, Phil said "OK" . . . and that was that. His father, an analytical chemist, was actually making an informed suggestion, knowing as he did the engineering world and Phil's penchant for science and math.

Phil's other major decision—to become a professor—also came early and easily. However, Phil chose a roundabout way of achieving his goals by deciding to take advantage of the opportunity for getting an education in one of the military academies. His first and second choices, the naval and air force academies, were unavailable to him, so he went to West Point. It didn't take long for him to realize that military life wasn't for him (roughly one month, to be exact!) but he felt he had to give it a fair shake and he stayed two years. To those of us who have never seen him without his beard, the image of "General Phil" is intriguing, to say the least.

He has no regrets, however, and claims that three valuable lessons came out of his Academy experience. First, he learned that you could want something very badly, work very hard for it—and still not attain it. This proved to be equally true for his expectations of the military and for his hopes for fluency in French. Second, he learned discipline (a valuable but difficult lesson for many college students to learn), and he became accustomed to "being yelled at." And third, he decided in his second year that he wanted to earn a PhD and become a professor; through some informal tutoring he was doing in math, chemistry and physics, he had discovered he greatly enjoyed working with people and explaining things to them.

Phil transferred to Purdue after two years at West Point, and eventually graduated first in his class (in 1966). His interest in separations was kindled by Lowell Koppel's lectures on distillation. He also continued tutoring, nurturing his interest in teaching. When he applied for graduate school he made note of his interest in teaching, which (it turned out) qualified him for a National Defense Education Act Scholarship. Princeton offered him one and he accepted.

At Princeton his interest in separations was sidetracked for a while since the only person doing research in separations was Dick Wilhelm (who was doing parametric pumping). Unfortunately, Phil "couldn't understand the research at all, the way it was presented," so he went to work with someone else, in the area of Monte Carlo simulation in thermodynamics. But when his advisor was denied tenure, Phil had to switch again! This time he decided to talk only to full professors, and he eventually went to work for Bill Schowalter, who not only taught him how to do research but also served as Phil's model of how to guide grad students. His research was on hydrodynamic stability analysis, specifically on the Bernard problem. Although it was a far cry from separations, his experience taught him something he still strongly believes today: that the area of one's PhD is not all that important since the real purpose of grad school is to train one *how* to do research and *how* to formulate problems.

It was in graduate school that Phil learned how to ask questions. In his own research and in his relationships with his grad students, he still regards questioning to be one of the main purposes of grad school. A student at the Master's level may need to be given a problem, but he or she should have the freedom to work out the solution, with the advisor acting only as a coach along the way. At the PhD level, a student should be exposed to a broad area and then guided toward framing important questions.

RESEARCH

During Phil's first semester as an assistant professor at Purdue, Robert Greenkorn (department head at the time) suggested that he go to Puerto Rico for an AIChE meeting. Although Phil wasn't very interested in attending, money was available—so he went. At a conference session on separations, he talked at length with Norm Sweed, who suggested that since Phil was interested in separations he should do some parametric pumping. The result: he did just that . . . for the next ten years.

One of Phil's major research interests has been in developing new operating cycles for adsorption and chromatography. Early work in this area focused on parametric pumping and cycling zone adsorption. However, since industry saw little advantage in operating in this mode, Phil later switched to Pressure Swing Adsorption (PSA) and chromatography, where there is considerable industrial interest.

Industrial research is usually driven by the need to solve a specific separation problem, and this need often results in interesting and novel ideas. Working in a university atmosphere, Phil has been able to define his problems in more abstract and general terms, without having to tie the research to a specific problem. Although this approach can lead to sterile solutions, it can also lead to solutions that are different from (but every bit as useful as) industrial solutions. In PSA, Phil's research led the way to multicomponent separations and showed the importance of pressure drop in ordinary operations. Both of these advances have since been adopted by industry.

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An early (1965, Phil's junior year) experiment in tensile strength?

In chromatography, Phil has been interested in developing generic operational methods, treating chromatography as a unit operation. One example is moving withdrawal chromatography which can increase throughput by one or two orders of magnitude and which is generally applicable to migration chromatographic systems. This approach is easy to scale up and easy to generalize, contrasting with the biotechnological approach that looks at each separation problem as chemically unique. The combination of these approaches will eventually make chromatography a standard separation method.

Phil has always mixed independent and collaborative research. He is currently working with a cross-disciplinary team of chromatographers in an NSF-sponsored mini-center. This group includes George Tsao and Linda Wang (chemical engineering), Mike Ladisch (agricultural engineering), and Fred Regnier (chemistry). In addition, he has a long-term collaboration with Martin Okos (agricultural engineering) on combined fermentation and separation, which has resulted in a patent. He has also worked with Alden Emery and Dave Kessler (chemical engineering) on separations, and with Fritz Friedlander (electrical engineering) on high gradient magnetic separation. Even further afield, he has coauthored papers with Bud Homsy of Stanford (an outgrowth of a sabbatical at Berkeley), with Rich Noble of the University of Colorado, with Daniel Tondeur of ENSIC in Nancy, France (from another sabbatical), and with Renato Rota of the University of Milan.

Research, scholarship, and teaching are inextricably linked for Phil. His research in separations led to the development of his course on advanced separations; this course fed into his work on adsorption and chromatography, ion exchange, and membrane separation; this work in turn led to modifications in the course, out of which came his book on rate-controlled separations. Clearly, this book has a solid background in research. Among his projects, Phil considers his intensification work on adsorption and chromatography, as well as his chromatographic research on developing large-scale systems, to be the most significant.

Neal Houze, Phil, and Ron Barile making a philosophical statement. (1976)

TEACHING

His first experiences in teaching taught him that he didn't know what he was doing. He wanted to give the students in a sophomore distillation class a strong, abstract, theoretical base of separations, using a deductive, top-down approach. The result was a disaster. The material was entirely over their heads. Although his years of study had enabled him to distill the knowledge for himself, his students didn't have that preliminary study to build upon. After that experience, he "became more concrete in his teaching"—he talked about equipment and took students to the unit ops lab so they could see the equipment, enabling them to visualize it in the future.

Another experience occurred later, during his research. When he was a grad student, he studied the Thomas method for adsorption, but the material was covered only in lectures and he had never solved any problems with it. Later, while doing research, Phil came across the Thomas method again, but he had no memory of the earlier encounter. He studied it and figured it out—but it wasn't until two years later that he came across some old notes and realized that he had studied the method during his grad-student days! Apart from making conclusions on the quality of Phil's short- and long-term memory, we can appreciate the import of his realization that "the incident convinced me that you have to make students do things. Lecturing isn't enough. They have to do problems and derivations, and make connections."

Phil learned why that earlier class hadn't worked when, in 1972, he took a course entitled "Educational Psychology for College Teachers," taught by John Feldhusen at Purdue. The course opened up whole new ideas about teaching, and it became the seed out of which his Masters degree in counseling and his own course on teaching grew.

After his unhappy experience with the separations class, Phil converted his class to a self-paced format. Anyone who has ever been involved in instructional development knows what a risk it is for a young assistant professor to make this kind of class change. (The phrase "professional suicide" comes to mind.) Such conversions consume a great deal of time—time regarded by primary committees as better spent on research and becoming promotable. But Phil admits that he was immodest (or cocky?) in his belief that he could do it all. Events have validated that decision, of course, but that first semester required about thirty hours a week simply to develop test problems and study guides. His students had to meet an absolute standard, but if they didn't meet it, the only "penalty" was a retest. In this way students determined their own grades and did not finish until they showed evidence of mastery. The class was taught this way until 1982, when it ended after a curriculum revision.

Phil felt that new faculty members could be helped greatly in their first few years as professors if they had some prior knowledge of what being a teacher entailed. His idea was to teach a graduate course on educational methods, and the idea resulted in a course that has been taught biennially since 1983. In 1990-91, with an NSF curriculum development grant, the course was expanded to include all of engineering, and a workshop was conducted in July of 1991 for professors from ten major research universities. A book has been developed for this course, and it should be published in 1992.

Phil used the ideas first encountered in the teaching class and extended them to engineering, relying along the way on a number of noted educators in engineering as well as in science and education. In addition to those already mentioned: Rich Felder and Karl Smith, for getting away from lecturing and

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towards student learning; Jim Stice, for teaching methods; Rich Noble and Don Woods, for problem solving; Dick Hackney and Janine Bernard, who helped foster his early ideas on education; and Dendy Sloan, for combining caring and professionalism.

COUNSELOR

One thing which makes Phil unique (or odd, depending on your point of view) is that during a time when he was a full professor he also became a student again and earned a Masters in counseling. The incident that triggered this move occurred in 1975 when he had a student who was, by all accounts, very "strange." Exasperated and completely at a loss as to what to do with the student, Phil finally told him that his behavior was abnormal and bizarre and that he needed help—but Phil had no idea where to send him for such help. "It devastated me, having to tell that to a student. It left me in a state of shock."

Then, a friend of Phil's in Purdue's counseling program told him about a course that covered the basics of counseling. (Actually, it was quite an introduction: five credits with about twenty hours of work per week.) During that course, Phil discovered other interests in the area and wound up taking another course the following semester. Then, after a sabbatical, he applied for degree status in the program, but found himself confronting a bureaucracy that worried about conflicts of interests when faculty in one area wanted to study for a degree in another area. Phil argued that no conflict of interest existed since he was already a full professor and that he simply wanted to improve his teaching and counseling abilities. He finally got his wish, and he became only the second professor at Purdue who was allowed to enroll as a grad student. He finished the Masters in Education in Counseling in 1982.

Because of his interest in people and his desire to gain some practical counseling experience, he volunteered to work at the Crisis Center in Lafayette. Over the span of seven years he estimates that he gained at least a year's worth of valuable experience as a working counselor through this volunteer activity. An added dividend from this work was meeting a lady named Dot, who became his wife in 1980.

AUTHOR

It is not unusual for a professor to entertain thoughts of writing a book. The reasons, both pedagogical and personal, are many and varied. For Phil, it was simply a "huge desire to write a book." Ever since 1975 he had wanted to write a book, but there were already a number of good texts on equilibrium-staged separations in the marketplace. With his background, however, he felt he could write a book that was pedagogically sound, with an emphasis on what helps people to learn. For example, he would give specifics, be concrete, build up to a general argument, give detailed example problems, and follow a specific problem-solving strategy (based on the ideas of Don Woods). He would present the strategy in the first chapter and then use it in all of the example problems, giving the student a clear method to follow. He would also try to have at least one homework problem drawing on each and every section of the book, so that professors could have a choice. And he would list objectives for each chapter and provide numerous figures. The result, after ten years of intermittent labor, was *Equilibrium-Staged Separations.*

In addition to over one hundred and twenty publications, he is the author of four books: *Large Scale Adsorption and Chromatography* (CRC Press, 1986); *Equilibrium-Staged Separations* (Elsevier, 1988); *Rate-Controlled Separations* (Elsevier, 1990); and, with Frank Oreovicz, *Teaching Engineering* (McGraw-Hill, in press). He was a coeditor of *Adsorption and Ion Exchange: Fundamentals and Applications* (AIChE Symposium Series) and is Editor-in-Chief of the journal *Separations and Purification Methods.* His publications on education and teaching number more than thirty articles and include coauthors such as Ron Barile, Alden Emery, Neal Houze, and Frank Oreovicz.

ADMINISTRATOR

At one time, Phil swore he would never be an administrator, but his Dean looked at Phil's resume (after being prodded by Nick Peppas) and thought Phil would be a perfect match for Head of Freshman Engineering. The more Phil thought about heading up the freshman engineering program at Purdue, the more intrigued he became. For one thing, he had been a professor for seventeen years and felt he could benefit from a new challenge (while still maintaining his research and teaching). For another, the new program was clearly focused on students, with a

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the two impellers is essentially equal. The data of Figure 4 indicates that the interphase mass transfer coefficient increases with the power input to the one-fourth power, which is consistent with the data discussed by Nienow.[3]

CONCLUSIONS

We have found that the study of sourball candy dissolution can spice up an agitation experiment. The technique is safe, inexpensive, rapid, and is capable of yielding meaningful results. The interpretation of the experiment requires the students to develop a mathematical model of the dissolution process which adds to the instructional appeal of the experiment. Although the experimental technique was developed as an unstructured research experiment, it is also possible to supply the students with the technique and instruct them to use it to solve other problems, such as making a sugar solution (make up a good assignment story), comparing the performance of various impellers, determining the effect of vigorous agitation on liquid-solid mass transfer, and comparing the data with reported values in the literature.

ACKNOWLEDGMENTS

The assistance of Bonnie Struble and Russ Logue in developing this experimental technique is gratefully acknowledged.

NOMENCLATURE

- A total liquid-solid interfacial area at any time (m^2)
- C_L liquid-phase concentration of the solute (kg/m^3)
- C_{SAT} equilibrium liquid-phase concentration of the solute (kg/m^3)
- k_{LS} liquid-solid interphase mass transfer coefficient (m/s)
- M total mass of solute remaining in the solid phase at any time (kg)
- $\dot{m}$ rate of interphase mass transfer of the solute from the solid phase to the liquid phase (kg/s)
- n number of solid particles used in an experiment (-)
- r radius of the solid particles at any time (m)
- t time (s)
- V_L liquid volume (m^3)
- ρ_s solid density (kg/m^3)
- o subscript indicating initial conditions

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EDUCATOR: Wankat

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strong emphasis on counseling. He felt he could put his counseling experience to good use by dealing with students who were at a critical stage in their careers. He feels that the vast majority of students who enter the freshman engineering program have the ability to graduate and become successful engineers, but that the lack of motivation is a problem for some of them. Phil rejects the "sink or swim" idea—that the best students will rise to the top while the others sink. Rejecting the notion of teaching only the intellectually elite, he believes that the "purpose of a university is to nurture students' learning and to help them get past barriers." That is the goal of the freshman engineering program.

PERSONAL

Phil has won numerous awards, among them ASEE's Western Electric Award (1984), George Westinghouse Award (1984), and Chester F. Carlson Award (1990). In 1991 he was named a Fellow of ASEE. He has also held several divisional offices, including Chairman of the ChE Division of ASEE.

Phil and Dot have two children: Charles (7) and Jennifer (4)—both of whom, alone or in tandem, provide him with all of the exercise he needs. When he feels contemplative, or simply in need of quiet moments, he likes to head to a favorite fishing spot; fishing is his Zen meditation. When it is possible, he likes to go canoe camping (especially in the Quetico-Superior area) and (hopefully) catch fish every day.

A Chicago-area native, Phil has never outgrown his addiction for the Bulls, the Bears, and the Cubs. For him, 1991 was "Bull Heaven." And finally, what surely labels him as an eternal optimist, he still believes the Cubs will win it all next year.

Phil Wankat is a busy man: teacher, researcher, counselor, author, editor, administrator. "Just do it . . . but care!" would be a good slogan for him. His career exemplifies what many others strive for—a blend of excellence in both research and teaching. ❐