

Chuck Eckert

of
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Many people refer to Chuck Eckert as the “father of modern supercritical processing technology.” His work over three decades ago on solvation and reaction fundamentals under supercritical conditions helped reawaken chemical engineers to the opportunities within the supercritical state. This reawakening has blossomed into a rich subdiscipline that now encompasses much more than reaction and partitioning processes. Indeed, many of the most exciting topics now involve tailoring control of morphology of complex solids such as pharmaceuticals and polymers—items not initially envisioned even by Chuck.

Because he has had such a professional impact in chemical engineering, I was surprised by Chuck’s answer to my question, “What do you consider your most important contribution?” With a twinkle and wink of his eye, he pointed to a chart on his office wall. It comprised a “family tree” of individuals he has worked with through the years and who he felt he had positively affected. He said that the list symbolized his *real* life contribution—much better than any article or discovery could. He noted that most practical developments in the supercritical area were due to his students and their students and post docs long after they had left his direct supervision. The “family tree” that Chuck pointed to was prepared on the occasion of his selection as winner of the 1995 ACS Murphree Award. The award dinner, where the family



tree was presented to him, brought together many of Chuck’s former students, post docs, and colleagues who celebrated a career that had focused on coupled technical and personal mentorship for many individuals. This coupled contribution is truly his “signature” characteristic.

OVERVIEW

Chuck’s 39 years in academia include 24 years at the Uni-

versity of Illinois and 15 at Georgia Tech. During this period of time, he supervised an impressive 76 PhD dissertations and 65 additional MS theses. This pace continues, with another 10 PhD's still in progress. The names of his students are shown in Table 1.

While numbers don't tell the full story, they underline the truth in Chuck's perception that "people have been his proudest product." Ken Cox, a senior researcher at Shell Oil, has said, "There is no individual, outside my family, who has had such a major impact on my life. Strange thing is . . . he really is family! Many of the alumni from his research groups at Illinois and Georgia Tech form a close family for . . . Pappa Chuck!"

Another dimension of this picture is revealed by understanding the academic branches in the "family tree." Eighteen current or retired academics have worked with Chuck as either graduate students or post docs. Moreover, a probably incomplete list shows six "academic grandchildren" who have been educated by Chuck's direct academic descendents and who should also be added to the list to bring this academic branch up to at least 24.

Keith Johnston (UT Austin) says that "Chuck is totally dedi-

cated to the careers of his students." Similar sentiments come from Barbara Knutson (U. Kentucky): "Chuck develops both intellectual skills and people skills in his graduate students. He has acted as my coach, my mentor, and a cheerleader long after graduation, but most importantly, he is my friend. Chuck has succeeded in creating a close academic family." Joan Brennecke (Notre Dame), who won the 2001 ACS Ipatieff



Chuck accepts his "Family Tree" at the 1995 Murphree award dinner.

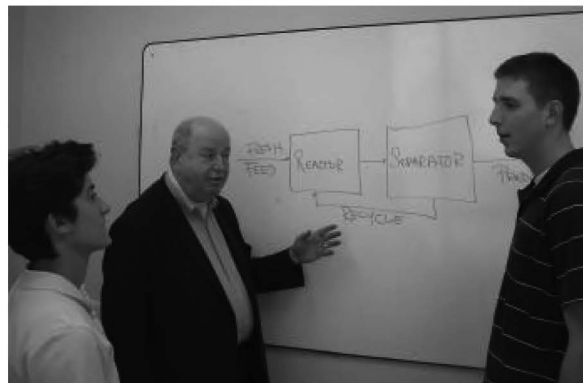
TABLE 1
Chuck Eckert's Graduate Advisees

PhD Students			MS Students	
K. F. Wong (1969)	W. T. Chen (1986)	H. Lesutis (2000)*	K. F. Wong (1967)	S. P. Brinduse (1981)
R. A. Grieger (1970)	S. W. Gilbert (1986)	K. West (2000)*	R. A. Grieger (1968)	W. T. Chen (1982)
S.P. Sawin (1970)	B. S. Hess (1987)	C. Wheeler (2001)*	L. D. Clements (1968)	T. K. Ellison (1982)
B. E. Poling (1971)	M. M. McNeil (1987)	K. Griffith (2001)*	S. P. Sawin (1968)	P. C. Hansen (1983)
R. B. Snyder (1971)	H. H. Yang (1987)	V. Wyatt (2001)*	L. G. Schornack (1969)	S. P. Singh (1983)
F. G. Clark (1973)	W. J. Howell (1989)	T. Ngo (2001)*	J. R. McCabe (1969)	C. T. Lira (1983)
J. H. Byon (1973)	D. M. Trampe (1989)	S. Nolen (2001)*	F. G. Clark (1970)	J. G. Van Alsten (1984)
J. R. McCabe (1973)	J. F. Brennecke (1989)	J. Hallett (2002)*	J. H. Byon (1970)	S. W. Gilbert (1984)
C. R. Hsieh (1973)	A. R. Hansen (1990)	J. McCarney (2002)*	C. R. Hsieh (1971)	M. M. McNeil (1984)
J. S. Smith (1975)	A. M. Karachewski (1990)	X. Xie (2003)*	K. P. Slaby (1971)	R. L. Matuszak (1985)
M. E. Paulaitis (1976)	M. P. Ekart (1992)	T. Chamblee (in progress)*	J. S. Smith (1972)	M. J. Hait (1985)
B. A. Newman (1977)	D. L. Tomasko (1992)	M.Lazzeroni (in progress)*	D. W. Wood (1972)	H. H. Yang (1985)
G.L. Nicolides (1977)	M. J. Hait (1992)*	R. Jones (in progress)*	P. E. Walter (1972)	J. H. Cordray (1986)
P. G. Glugla (1977)	D. B. Trampe (1993)	N. Maxie (in progress)*	R. H. W. Powell (1973)	W. J. Howell (1986)
C. W. Graves (1977)	B. L. Knutson (1994)	C. Thomas (in progress)*	A. I. Ness (1974)	D. M. Trampe (1987)
R. R. Irwin (1978)	D. Suleiman (1994)	J. Aronson (in progress)*	P. G. Glugla (1975)	J. F. Brennecke (1987)
A. Huss, Jr. (1978)	D. L. Boatright (1994)*	M. Janakat (in progress)*	C. W. Graves (1975)	A. R. Hansen (1987)
K. R. Cox (1979)	F. L. L. Pouillot (1995)	R. Weikel (in progress)*	A. Huss, Jr. (1976)	A. Karachewski (1987)
T. C. Long (1979)	K. P. Hafner (1996)	C. Pondey (in progress)*	R. R. Irwin (1976)	S. R. Alferi (1989)
P. K. Lim (1979)	J. Berkner (1996)*	L. Drauker (in progress)*	B. A. Scott (1976)	M. P. Ekart (1989)
E. R. Thomas (1980)	F. Deng (1996)*	E. Giambra (in progress)*	T. C. Long (1977)	D. L. Tomasko (1989)
K. Kondo (1981)	A. Dillow (1996)	J. Grilly (in progress)*	K. R. Cox (1977)	P. Katsikopoulos (1990)
M. M. Alger (1981)	B. L. West (1997)	E. Newton (in progress)*	L. A. Halas (1977)	R. K. Denton (1990)
K. P. Johnston (1981)	D. M. Bush (1997)		P. K. Lim (1977)	K. J. Hay (1991)
T. Stoicos (1982)	M. Vincent (1997)*		D. P. Deschner (1979)	D. Suleiman (1992)
D. H. Ziger (1983)	K. Chandler (1997)*		E. R. Thomas (1979)	K. Chandler (1995)
P. C. Hansen (1984)	J. Jones (1998)*		T. T. Oberle (1979)	R. Thompson (1996)
T. K. Ellison (1985)	N. Brantley (1999)*		K. P. Johnston (1979)	B. Eason (2001)*
J. C. Van Alsten (1985)	Z. Liu (2000)*		M. R. Anderson (1980)	D. Kass (in progress)*
C. T. Lira (1986)	J. Brown (2000)*		T. Stoicos (1980)	D. Taylor (in progress)*
			D. H. Ziger (1980)	

* Joint with C. L. Liotta



▲
Chuck with one of his undergraduate researchers.



▲
Chuck in class with some of his freshman students.



◀ **Charles Liotta and Chuck in one of their joint group meetings.**

Prize, said of her Ipatieff award symposium that “. . . it was the first time (and probably the only time) that the three most important men in my life were all in one room— my father, my husband, and Chuck! I think the continued care and mentoring is why the Eckert academic family has so many close ties.”

In addition to the mentor in Chuck, however, there is a major scholar who has produced well over two hundred archival journal articles, coauthored two books, and contributed twenty-one book chapters. One of his well-known coauthors, and his PhD research mentor, John Prausnitz (Berkeley) observed that, “Chuck communicates very well and encourages others by his enthusiasm and optimism. He thoroughly appreciates the importance of computers in research and education. In 1967, it was primarily *his* enthusiasm that convinced me to write with him (and two other graduate students) an early monograph on the use of computer calculations for multicomponent vapor-liquid equilibria—it was Chuck’s foresight and drive that accelerated the use of computers for applied thermodynamics in industry and education”.

Chuck’s contagious enthusiasm, tempered by a solid understanding of thermodynamics and thoughtful insights on

education, have made him attractive as an consultant and advisor. Moreover, strategically placed ex-students, knowing his catalytic capabilities have engaged him for services ranging from conventional analysis to the motivational aspects of education as well as research and its performance.

Chuck’s current research interests include

- *Molecular thermodynamics and solution theory*
- *Phase equilibria*
- *Supercritical fluid properties*
- *Applied chemical kinetics and catalysis*
- *Separation processes*
- *Environmentally friendly chemistry and processes*
- *Creation of novel materials*

Many of Chuck’s successes have resulted from his interest in “crossing the street” and collaborating with chemists. His work related to high-pressure reaction theory, the development of solvency models and development of new spectroscopic approaches typify this characteristic. In many respects, the chemistry aspects of problems are the greatest attractions for him.

Chuck’s approach involves a close coupling of experimental and theoretical attacks on problems. Prediction of limiting activity coefficients in water using a modified separation



Chuck with Aryn Teja and Ron Rousseau at a Georgia Tech reception in honor of Chuck's 1999 Walker Award.

of cohesive energy density coupled with actual measurement of these limiting coefficients illustrate the approach. The above work has provided important contributions to the understanding of “ordinary” liquids related to petrochemistry and even liquid metals. Another related, but still independent interest involves Chuck’s focus on spectroscopic techniques to study hydrogen-bonding systems—this initiative touches many areas in thermodynamics.

While the above work is well-known and highly note-worthy, probably Chuck’s best-known contributions relate to the gas-liquid critical region with particular reference to supercritical extraction and processing. With regard to the supercritical field, Pablo Debenedetti (Princeton University) notes that, “Since 1983, Chuck has, with unmatched regularity, made the key experimental observations and asked the truly important questions that other researchers in the field need to answer”. Indeed, in 1983, Chuck pioneered the measurement of solute partial molar volumes at infinite dilution in supercritical solvents. In addition to its practical importance, this ignited a large theoretical thrust across the field aimed at interpreting the provocative results he reported.

In 1988, Chuck introduced the use of spectroscopic techniques to study solvation in supercritical solvents. This pioneering work provided the first direct insights into the nature of solute-solvent interactions and the mechanisms of solvation under supercritical conditions. Focusing attention on short-range effects due to molecular asymmetry was a key advance. This theme has been developed by a huge number of subsequent researchers around the world

Still later, Chuck’s identification of the role of cosolvents in separations and supercritical processing marked another major contribution. The ability to design a solvent for a specific reaction or separation application through manipulation of process conditions or cosolvent type opened new possibilities and again stimulated many studies within the field.

His broad and deep contributions to the chemical engineering literature were recognized in 1999 by the William Walker Award. *Chuck is shown in the photo above at an informal reception at Georgia Tech in his honor following his selection for the Walker Award.*

CONTRIBUTIONS TO THE COMMUNITY

Chuck’s contributions to his home institutions are discussed later, but his professional contributions to the broader community also deserve mention. In addition to

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membership in the American Institute of Chemical Engineers and The American Chemical Society, he is active in the International Association for the Advancement of High Pressure Science and Technology, the Association of Environmental Engineering Professors, and The International Society for Advancement of Supercritical Fluids. He has served on many National Science Foundation and National Research Council committees aimed at defining future directions in the thermodynamics area—especially for high pressure applications. Current and past service on the Editorial Boards of the *AIChE Journal*, *Industrial and Engineering Chemistry Research*, *Journal of Supercritical Fluids*, and *Fluid Phase Equilibria*, guarantees a steady flow of manuscripts to his desk

to review, which I sometimes find him pouring over when I visit his office.

In addition to presenting over 300 invited lectures, he has served in an almost-endless list of service capacities to our community. They range from the technical (Chairmanship of the International Symposium on Supercritical Fluids) to the time-consuming (AIChE, ABET Accreditation Committee), but all are aimed at enabling the functioning of our community.

A MIDWESTERNER EDUCATED ON BOTH COASTS

Chuck grew up in St. Louis and attended MIT for his bachelor's and master's degrees, which he received in 1960 and 1961, respectively. He then crossed the country and earned his PhD from the University of California at Berkeley in 1964. He also did a postdoctoral stint in France, which began a lifelong affinity for that country that still results in frequent visits.

A DYNAMIC CAREER AT ILLINOIS

Chuck joined the faculty at the University of Illinois, Champaign-Urbana, in 1965 as an Assistant Professor. Rising through the ranks with promotions to Associate Professor (1969) and full Professor (1973), he was recognized for both his research and teaching contributions.

Chuck was also one of the pioneers in using computers for interactive education. He developed a number of educational

programs on the "Plato" system focused on this interactive concept—well ahead of most of the chemical engineering community. In 1973, he received the Alan P. Colburn award and in 1977, the ACS Ipatieff Prize. In 1983, Chuck was elected to the National Academy of Engineering for his

"Outstanding contributions leading to the selection of liquid metals and supercritical fluids as solvents in chemical reactors, and to improved understanding of the extreme conditions in such reactors." He has also received awards for distinguished teaching and leadership reflecting his contributions to diverse curriculum and strategic planning.

Chuck served at the Head of the Department at Illinois from 1980-86. Moreover, service to the community on ABET and numerous Steering

Committees made the years in the middle and late 1980s extremely busy.

Chuck recognized that poor communication skills were at least as serious a handicap for a typical BS ChE as not being able to solve complex equations. Again ahead of much of the community, he developed a highly successful "Chemical Engineering Communications" course dealing with oral as well as written technical communications skills. He "crossed the street" once more, this time to the English Department where he was able to assemble a team to deal with the full range of communications needs. Such courses are now fairly common, but twenty years ago, this initiative was viewed as "unusual" at best. His selection for an Alumni Professorship in 1985 reflected recognition for his innovations to deal with the full range of student needs.

A HUGE IMPACT AT GEORGIA TECH

Chuck moved to Georgia in 1989 and began a new supercharged career. He holds the J. Erskine Love, Jr., Chair in the School of Chemical and Biomolecular Engineering. He also holds the title of "Institute Professor," which is reserved for individuals who have had significant impact beyond their individual School bounds. Chuck serves as the Director of the Specialty Separations Center, which has a cross-disciplinary vision and goals to connect activities across the Tech campus.

Clearly, in the move to Georgia Chuck brought with him his ideas regarding the importance of excellence in research



Son Ted and daughter Lynn (Gasey) with Chuck at 1995 Murphree Award Dinner.

and teaching, and he has found a receptive environment at Tech. He was attracted by the Institute's collegiality, its opportunities for multidisciplinary work and partnerships with industry, and the opportunity to help promote the rapidly emerging program at Tech. He notes that, "The reality has far exceeded my expectations" with regard to the above opportunities.

From my own observations, and the comments of colleagues here at Tech, it is fair to say that the same sentiment is shared with regard to the payoff on expectations.

Arnie Stancell, a faculty colleague at Tech says, "I have had the pleasure of working with Chuck for ten years, and his enthusiasm for educating students is infectious. He is always working on ways to engage students in learning. He personally took on presenting a seminar course for freshman to introduce them to chemical engineering. He developed interesting problem sets illustrating applications of chemical engineering. He brought in speakers to discuss current societal problems that the chemical engineer can help solve. Chuck did not have to do this—he has won many honors and is highly respected. He did it because of a genuine passion for educating students and seeing them grow in their knowledge and understanding."

Indeed, Chuck's enthusiasm is infectious. His latest initiative is to promote research opportunities for undergraduates. Besides his full complement of graduate students, Chuck has opened his lab and made time to meet with undergraduates. Although always a part of his vision, the significantly expanded activity to involve undergraduates has caught the attention of faculty and administrators alike. The President's office at Tech has encouraged a broader participation by undergraduates and cited Chuck's "ahead-of-the-curve" leadership as exemplary. In his own words, Chuck notes, "Research is perhaps the best instructional tool that professors have at their disposal – the one-on-one creative interaction of real, unsolved problems is the best method of teaching and learning." The motivations for such a program are many, and include

- *Teaching fundamentals in ways that are more meaningful than contrived textbook problems, or sanitized cookbook laboratory experiments.*
- *Providing motivation, as the students are able to see the impact of their efforts on the real world. Students gain enthusiasm and self-confidence.*
- *Putting the students in close contact with PhD students, postdoctorals, and other high-level professionals; it demonstrates teamwork and motivates students to seek leadership roles in their professions.*
- *Providing a framework that permits students to gain more from their coursework.*
- *Providing a focus for students' understanding of the*

I left with the feeling that this duo could cook up more than enough ideas to keep a full industrial research center actively engaged if they were aimed at any particular problem.

profession, and helps them formulate meaningful plans for their futures – practice of the profession or graduate study.

- *Fostering creativity, where traditional courses tend to discourage it.*

In 2000, Chuck received a *State of Georgia Regent's Award* for his leadership in this regard.

THE ECKERT-LIOTTA TEAM

In addition to the institutional issues that helped attract Chuck to Georgia Tech, an important personal connection also encouraged the move. Charlie Liotta, an internationally well-known organic chemist in the Tech School of Chemistry, jokes that they built the School of Chemistry around him, since he has been there for 39 years. Chuck and Charlie became personally acquainted during numerous interactions as consultants for DuPont. Their hosts at DuPont would often team them together during consulting visits, and Chuck and Charlie eventually realized that there must be a message there. Indeed, their mutual technical interests and strengths were extremely complementary, and possibilities for collaboration were often discussed but never acted upon—until the opportunity for Chuck to move to Georgia Tech materialized. Ron Rousseau, Chairman of Chemical and Biomolecular Engineering at Tech, enlisted Charlie's active participation in recruiting Chuck in 1989, and the "dynamic duo" has been inseparable ever since. Together, they have published over fifty papers in the past fourteen years. Moreover, all of the most recent and current PhD and MS students that Chuck and Charlie supervise in both chemical engineering and chemistry are done jointly.

I have been lucky enough to participate in one of their weekly high-energy group meetings, and the intellectual intensity there was impressive. I left with the feeling that this duo could cook up more than enough ideas to keep a full industrial research center actively engaged if they were aimed at any particular problem.

Chuck indicates that much of the focus of their current research is on sustainable development and environmentally benign processing. This includes a variety of phase transfer catalysis-related projects, under supercritical and near-critical conditions. These topics integrate three long-time favorite subjects of Chuck's: phase equilibrium, high-pressure reactions, and supercritical partitioning. Based on the past experience, this will be a good area to expect future developments! □