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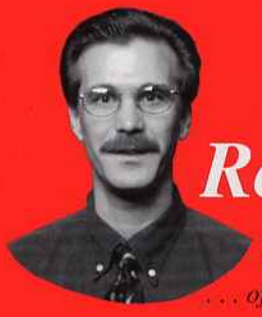

Robert Hesketh

. . . of Rowan University

MEMBRANES IN ChE EDUCATION

Also ...

and ChE at . . .

Vanderbilt University

Robert Hesketh

of Rowan University

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I first met Robert Hesketh at the 1992 Chemical Engineering Summer School in Bozeman, Montana. Phil Wankat and I led a workshop that he attended, and I immediately noticed his enthusiasm for engineering education. As a result of that meeting, he and I later coauthored an article on separations for *CEE*.[1] Little did I know that I would eventually have the opportunity to hire him as one of the founding members of the Rowan Chemical Engineering Department!

During Robert's faculty interview at Rowan we were impressed with his enthusiasm and his ideas for the freshman engineering program. We knew that his ideas on the use of a coffee machine would work as a basis for our hands-on approach to engineering education at Rowan. We felt he was a perfect fit for the new engineering education program at Rowan, and his dedication to teaching has since been rewarded by several educational awards from ASEE, including the 2002 Robert G. Quinn Award, the 1999 Ray W. Fahien Award, the 1998 Dow Outstanding New Faculty Award, the 2001, 1999, and 1998 Joseph J. Martin Awards, and four other teaching awards. To date he has obtained over $2 million in external funding from federal, state and industrial sources.

As one of the founding faculty members of the College of Engineering and Chemical Engineering Department at Rowan University, Robert has spearheaded an effort to develop the industrial component of the four-year sequence of the multidisciplinary engineering clinic. In addition, he has created several courses that integrate experiments and lectures in an inductive framework within chemical engineering. He has made many major contributions in laboratory methods that demonstrate chemical engineering practice and principles, the most notable of which uses the coffee maker. He has helped advance the state-of-the-art in laboratory-based education nationally through his many publications, presentations, and seminars at ASEE and workshops supported by NSF.

Hesketh in front of the distillation column he helped to design for Rowan University's Chemical Engineering Department.

ROBERT'S EARLY YEARS

What were the major influences in Robert's early years? His mother, Joyce, claims it was the time she spent with him in his crucial developmental years. "He was always happy and singing," she says. Robert

was born into a family with music and engineering skills on September 28, 1960, near Philadelphia, Pennsylvania. His mother is an accomplished musician with specialties in French horn, piano, organ and harp. His father, Howard, received three degrees in chemical engineering from Pennsylvania State University—State College and is also an accomplished violinist. After earning his Master's degree, Howard served in the army and later returned to DuPont, where he became a senior chemical engineer. He returned to college for his PhD in chemical engineering after working for Beryllium Corporation and Bell Laboratories of Western Electric. In 1970 he accepted a faculty position at Southern Illinois University. During his years at SIU he wrote 18 books in the areas of air pollution and hazardous waste management. Based on his industrial experience, Robert's dad always had a special appreciation for the practical side of engineering.

Robert's enthusiastic personality is reflected by the activities of his early childhood: playing the cello, Boy Scouts, running, and academics. He started playing cello in fourth grade and joined the family ensemble, together with brothers Howard and Ryan and sisters Joy and Melody. There are many theories on the effect of classical music on improving math skills[2] and it appears that Robert benefited, as evidenced by his receiving the O. K. Bowen Award for Mathematics upon graduation from Carbondale Community High School. He believes that playing a musical instrument also develops a philosophy of practice-makes-perfect. He feels that while it is often impossible to solve a complex problem right at the beginning, just as it is impossible to master a new orchestral piece of music on first reading, through music he learned at an early age how to break the music or a problem into smaller, more manageable, pieces to work on. Music was one of the aspects of Robert's life that gave him confidence in who he is today.

Robert was a nontraditional sports enthusiast. His dad believed that physical activities are an essential part of life, so he began running with his father at the SIU playing fields and eventually set his high school's record in the mile with a time of 4:29 minutes. He also led his cross-country team for the last two years in high school. Again, these early experiences helped Robert develop his work ethic. By practicing (in this case running) every day he was able to drop his half-mile, mile, and two-mile times a few seconds each race. His dad also had plenty of work around the house for Robert to attend to, including installing a swimming pool, building several new houses, mowing the multi-acre lawn, etc. Robert was raised with the philosophy that one needs to work hard to become excellent.

Robert and his brothers developed a love for the outdoors in Boy Scouts. His father was the Scout Master and led a monthly expedition into the forests of Southern Illinois. Many adventures were had by Robert and his family such as 20-mile hikes, camping in below freezing weather, and backpacking on extended weekends. Robert later became an Eagle Scout, the highest rank obtainable in Scouting. One of his merit badges was in orienteering, where he was able to combine his passion for running through the woods with his problem-solving abilities. He tells me that he still enjoys standing alone in the woods with a map and a compass asking himself, "Where am I now?"! Robert became very successful at orienteering and traveled around the country on weekends to compete in national competitions. The highlight of his orienteering was competing on the U.S. Team at the 1984 University World Championships in Jönköping, Sweden.

Robert has spearheaded an effort to develop the industrial component of the four-year sequence of the multidisciplinary engineering clinic [and]has created several courses that integrate experiments and lectures in an inductive framework. . .

Robert started working on environmental projects as a result of his father's work in air pollution control. In the 1970s, Robert's dad started a pilot plant project at the SIU power plant to show that sulfur dioxide emissions from coal could be controlled using venturi scrubbers. Robert and his brothers became a team and assisted their dad on stack tests. In many cases these tests were done either in freezing conditions on the top of a building or in the middle of summer at elevated rooftop temperatures.

UNIVERSITY LIFE

Robert had two requisites in selecting a college: running and chemical engineering. He was good at math, chemistry, and physics and was a natural for chemical engineering. Robert's dad said that he could go to any university in the country, but agreed only to pay an amount of tuition equal to SIU's! The result was that Robert went to SIU for two years and then transferred to the University of Illinois at Champaign-Urbana. While at SIU, Robert continued working with his father by conducting developmental work to support a patent on the catenary grid scrubber. This work resulted in Robert's first publication as an undergraduate and gave him practical experience in designing experiments—he learned that duct tape was excellent for temporary seals on large clear plastic sections of piping! In addition, Robert's father wrote his first textbook in 1972 titled, *Understanding & Controlling Air Pollution*.[3] It would eventually be used in over fifty universities as a text in air-pollution control and would be updated several times.[4] Robert was extremely fortunate to watch how his father produced a text, and he worked as an office assistant, typing portions of the copy that were sent to the publisher.

▲ *Running in the Philadelphia Half-Marathon in 1983.*

◄ *Robert, far right holding the dog, at the start of a 1974 backpacking trip (brother Ryan at other end).*

► *Hands-on house construction of parent's house in Carbondale, 1978.*

Robert and Fiona Cutting their cello wedding cake, 1990. ▼

◄ *Hiking with Alexander, Natasha, and Fiona in Rocky Mountain National Park. Longs Peak in background, 2002.*

Robert continued his work on environmental engineering problems through two summers of employment in Orlando, Florida, for an environmental engineering consulting firm, Cross-Tessitore and Associates. During this time Robert experienced not only the rigors of environmental audits and assessments, but also the Florida life style of Frank Cross. He felt fortunate to be able to live with the Cross family, who introduced him to white-water kayaking!

In 1982 Robert graduated with a BS with Distinction in Chemical Engineering from the University of Illinois and started graduate school at the University of Delaware. At the University of Delaware, Robert had a special opportunity to work with T. W. Fraser Russell[5] and Arthur W. Etchells, who is now a DuPont Fellow distinguished by his work in mixing. Working with both Fraser Russell and Art Etchells furthered Robert's appreciation for the practical side of engineering. In this work, Robert developed a correlation for bubble size in turbulent fluid flow that has been cited in over 25 journal articles and is currently being used in the chemical industry for the design of multiphase reactors and piping networks. Both Fraser and Art have helped Robert immensely throughout his career, from shaping and guiding his research to giving him advice on career moves. He recalls one incidence when he was struggling with a bubble breakage function for a population balance model; he had found numerous complicated models and was trying to figure out which was the best. Fraser, with the wisdom of experience, looked at him and asked, "Have you tried a first-order rate?" Fraser's ability to look for the simple solution to problems remains a cornerstone in Robert's teaching philosophy.

CAMBRIDGE UNIVERSITY

After completing graduate school, Robert had both a job offer with a major pharmaceutical company and an offer of postdoctoral work at Cambridge University in England. Robert was destined for academics, however, and chose to work with Professor and Department Head, John F. Davidson, at Cambridge University. There, he added very fast chemical kinetics to multiphase fluid flow by working on combustion problems in fluidized beds. This work continued his environmental theme of working with coal combustion that results in lower emissions of pollutants than conventional burners.

Robert enjoyed his stay in England from 1987 to 1990, and while there he also decided to improve his musical abilities by taking cello lessons. Attending a concert in 1987, he compared a list of cello teachers with the concert program and found a match; not only for cello lessons, but for the person who later became the love of his life—Fiona L. Stafford! Rob-

ert became one of Fiona's biggest fans. Their wedding in 1990 was notable in that the cello section of the Cambridge Philharmonic Society played before the wedding and their cake was in the shape of a cello! As a special treat for Robert's relatives, he held the wedding rehearsal dinner at Trinity College, where they got a real taste of Cambridge University life.

Robert's passion for engineering education had its genesis at Cambridge. The English love tea, which is served twice a day to all the faculty, staff and students, but Robert wanted real coffee (not the jars of instant had by all other postgrads) and formed a coffee club. It was highly successful until the coffee machine plugged up. So, Robert and his future best man, A. B. Pandit, took the coffee machine apart and cleaned out the tubular heat exchanger. He learned two things: that Cambridge has very hard water and that coffee machines are fascinating.

TULSA UNIVERSITY

Robert's next decision was whether to accept a job offer from a British university or one from Tulsa University in Oklahoma. He had introduced Fiona to San Francisco at the 1989 AIChE annual meeting and apparently convinced her that the rest of the United States was just like San Francisco, so Tulsa won out.

At Tulsa Robert was profoundly influenced in engineering education by his colleagues Richard Thompson, Ramon Cerro, and Martin Abraham. As Department Chair, Rich Thompson introduced Robert to the American Society of Engineering Education by sending him to his first Chemical Engineering Summer School in Montana. The friendships he formed at this first summer school helped guide him as an engineering educator. Rich Felder and Rebecca Brent are still major influences on his teaching style. He has attended at least four effective-teaching workshops and has avidly tried new teaching strategies from each workshop. Based on these workshops, he has employed cooperative learning and an inductive teaching style in his classes. He has also gained important aspects of teaching from educational leaders such as Jim Stice (instructional objectives) and Don Woods (problem-based learning).

Robert also developed a successful teaching and research program at Tulsa and ultimately received three teaching awards, including Professor of the Year in the College of Engineering and Applied Sciences. By the end of his tenure in Tulsa, he had obtained $670,000 in external funding, including NSF Research Initiation and DuPont Young Professor awards. An outlet for Robert's teaching enthusiasm was found in a series of three NSF Young Scholars Programs at Tulsa, where he worked with Martin Abraham, John Henshaw (ME), and Keith Wisecarver. In these programs Robert expanded his coffee-machine experience into a series of young scholars experiments and as an outreach tool for student recruitment. At Tulsa Robert also was influenced by the work of Ramon Cerro in both his hands-on laboratory experiments as well as his love of theory.

He is one of the founding professors of the new and innovative engineering clinic. His forward-looking ideas on measurement, design, and course content were incorporated into the engineering clinic starting from the time of his first interview at Rowan University.

A NEW STYLE OF ENGINEERING EDUCATION: ROWAN

Robert is a leader in teaching innovations at Rowan. He is one of the founding professors of the new and innovative engineering clinic. His forward-looking ideas on measurement, design, and course content were incorporated into the engineering clinic starting from the time of his first interview at Rowan University. After observing Robert's excellent leadership skills, Dean James Tracey chose him to be the Freshman Engineering Clinic Coordinator. The engineering clinic at Rowan is unique to engineering education in that engineers are actively engaged in hands-on engineering science and practice through the interdisciplinary clinic for eight semesters.

ENGINEERING CLINIC SEQUENCE

As a founding faculty member of the College of Engineering, Robert has taken a leading role in developing the engineering clinic program—one of the most innovative vehicles for educating engineers. Starting from the novel hands-on freshman semesters in measurement and reverse engineering, he has influenced each subsequent engineering clinic. In the sophomore clinic, he started the detailed planning of the original linkage between the writing faculty and the engineering projects. This planning was further developed by Drs. Anthony Marchese and Jim Newell. The junior and senior clinics have been developed into industrially related engineering projects. Robert brought the first industrially funded project and helped formulate the Clinic Affiliates program where industry is asked to sponsor engineering clinic projects for the junior and senior years. The upper-level engineering clinic has been vertically integrated by having juniors, seniors, and graduate students work on projects funded by industry and the government. He has also worked on integrating the Rowan hallmarks into the syllabus of the clinic. None of these achievements would have been possible without the energetic, innovative, idea-generating faculty of the engineering college.

Robert works with every member of the chemical engineering faculty on industrial and classroom projects. He serves as a mentor for faculty to bring in these projects and has

worked with our chemical engineering faculty on almost every industrial project. As a result, his industrial involvement has included relationships with companies such as Johnson Matthey, Sony Music, Givaudan-Roure, Campbell Soup Co., Pepperidge Farm, Value Recovery, General Mills, and DuPont. Because of this industrial involvement, Robert has had the opportunity to work in fields such as supercritical fluid extraction, microfiltration, liquid-liquid extraction, electrochemical separations such as plating and electrodialysis, adsorption, and ion exchange. He says that the clinic experience is one of the greatest joys of his work at Rowan University.

FRESHMAN ENGINEERING CLINIC

In the Freshman year of the clinic, Robert uses a common consumer product, the coffee machine, as a vehicle for illustrating engineering science and practice. It contains examples of engineering principles from many disciplines. For example, chemical and mechanical engineers are required to design heaters, condensers, and systems for multiphase transport of fluids, and to fabricate plastic and glass components. The process of leaching the organic compounds from the coffee beans uses principles from mass transfer, which is unique to chemical engineering. Automation of processes requires concepts from electrical, mechanical, and chemical engineering. Finally, engineering decisions are required to select the components of a system and place them within an affordable, compact unit that can be easily used by the consumer. This innovative example has been adopted for use at many other institutions. Robert has continued his development of the freshman clinic with Dr. Stephanie Farrell in grants from the National Science Foundation on reaction engineering and drug delivery.

Robert examining the internals of a coffee machine.

The first year the coffee machine was used, the students not only reverse engineered the unit, but also designed a new system. This is the only project I am aware of where the students actually used what they were making so that they could do an "all-nighter" to ready their final presentations in freshman clinic!

Another innovation Robert incorporated into the freshman clinic is a module on process measurements using the university's cogeneration facility. He worked with the plant's director to set up tours for each of the five sections (115 students). On the tour, students took readings of pressure, temperature, and flow from gauges, thermometers, and the plant's data-acquisition system. They used these measurements to calculate material and energy balances on two heat exchangers. First, the students used their readings as input for a chemical process simulation, using HYSYS, to determine the heat duty for each heat exchanger. Then for homework they manually calculated the heat duty using all of the engineering equations used by the simulator. This experience was a simulation of the day in the life of a chemical process engineer–truly a unique experience for freshmen.

COOPERATIVE LEARNING

Robert uses the technique of cooperative learning in his courses. He creatively employs cooperative learning in lectures and in homework and semester design projects. In the classroom, students form small groups and within a short period of time solve engineering problems. Robert creatively works with these groups to help them focus on the problem during this session. Using cooperative learning in the classroom creates an active learning experience for students and improves their retention of the material over a pure lecture format. In group homework and design problems he has employed a variety of assessment tools to make each person in the group accountable for achieving all the objectives. This technique is at the forefront of engineering education methods and Robert's use of it shows that he is at the leading edge of teaching pedagogy.

INDUCTIVE LEARNING

Robert has been transforming his courses so that both the content and the lecture format are in an inductive order. With the inductive order of presentation the professor starts with an experiment, demonstration, or the results of an experiment and finishes the lecture with the derivation and solution of equations describing these results. The second concept is placing the course content in an inductive order. For example, heat transfer could be taught starting with heat exchangers and overall heat transfer coefficients followed by sections on the factors that contribute to the overall heat transfer coefficient, such as conduction and convection. Finally this area of transport could end with coverage of unsteady-state heat transfer. Each of the lectures presented in this novel topical order can be done in an inductive manner, starting from experimental observations and ending with a derivation and solution of the governing equation. Robert has been working with Stephanie Farrell on converting lectures, courses, and labs to an inductive order for fluid

mechanics, heat transfer, and transport.

GREEN ENGINEERING

Robert came full circle with respect to his dad's textbooks. After helping with the production of an earlier version, he finally taught a course in air pollution control using his father's 1996 textbook.[6] In addition to this course, Robert is currently conducting research on methods to reduce the emissions from diesel engines in school buses, with funding from the New Jersey Department of Transportation. The chief problem in this area is particulate emissions, and his dad's text, *Fine Particulates in Gaseous Media*,[7] has been very useful.

Robert is currently leading an effort to integrate green engineering into the undergraduate curriculum. Green engineering is the design, commercialization, and use of processes and products that are feasible and economical, while minimizing generation of pollution at the source and risk to human health and the environment. This way of thinking embraces the concept that decisions to protect human health and the environment can have the greatest impact and cost effectiveness when applied early to the design and development phase of a process or product. With the help of Kathryn Hollar, Robert just received a three-year grant from the EPA to oversee the development of course-specific modules in green engineering and is looking for faculty who will help him with this endeavor.

WORKSHOP LEADER

Using hands-on experiments, Robert has presented his ideas on education at national meetings and workshops. At the 1997 ASEE Chemical Engineering Summer School for university faculty, he co-led a one-day workshop on Undergraduate Laboratories. At this workshop he led participants through heat transfer, pressure measurement, and coffee strength experiments. He also gave a presentation on innovative teaching techniques in the laboratory. In the summers of 1998 and 1999, Robert and I led a series of workshops based on a grant we wrote together titled, "A Multidisciplinary Workshop on Novel Process Science and Engineering Principles for College Faculty." For this workshop Robert developed new experiments in batch processing (a breadmaker), reaction engineering (catalytic oxidation of VOCs), and polymers (fluidized bed coating), and continued to develop experiments using the coffeemaker. These experiments were conducted by participating faculty from around the country through support from the NSF Undergraduate Faculty Enhancement Program. At the 1998 AIChE annual meeting Robert helped Phil Wankat and myself direct a workshop on teaching effectiveness where he presented a session on active learning techniques in lecture courses and had faculty perform an experiment with the instrumented coffee machine. Most recently Robert co-led a workshop on Innovative Laboratory Experiments with Stephanie Farrell and myself at the 2002 ASEE Chemical Engineering Summer School in Boulder, Colorado.

PROFESSIONAL SOCIETY SERVICE

Robert is highly active in both ASEE and AIChE. He has published and presented his work in ASEE's *Chemical Engineering Education*, the proceedings of the Annual Conference, and at ASEE zone and regional meetings. He has chaired sessions in education for both ASEE and AIChE. Most notably, he organized the first ever Topical Conference on Education at an AIChE annual meeting titled, "Chemical Engineering Education in the New Millennium." Currently he is the chair of Group 4—Education in AIChE and was previously Vice-Chair of 4 and Chair of 4a—Undergraduate Education. In addition to this service work, Robert has helped formulate the Chem-E-Car competition and has served as the competition's emcee since the races began.

THE MOUNTAINS

Robert retains his passion for music and the outdoors. His family has grown from two cellos to four with the addition of Alexander (5 years old) and Natasha (9 years old). They also love to travel as a family to the Rocky Mountain National Park on hiking expeditions. They have gone to the mountains nearly every summer since getting the "mountain bug" in 1992 at the Bozeman Chemical Engineering Summer School. Robert enjoys hikes with his family, and last summer their longest hike was by Odessa Lake (with an elevation of 10,020 ft and total distance of 9.5 miles) and the most thrilling was climbing up a waterfall to Sky Pond (for a total distance of 9.2 miles).

Robert is destined to climb higher mountains not only in Colorado, but also in his professional life. Throughout his life he has uniquely mixed chemical engineering with his love of music and the outdoors. His educational innovations have touched the lives of numerous students, not only at Rowan and Tulsa, but also at many schools throughout the country that have adopted these methods. He is a trusted friend and a key member of the Rowan chemical engineering team.

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