W.J. YOUDEN MEMORIAL ADDRESS

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A Call to Action

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I thank Janice Shade and the FTC organizing committee for inviting me to give this address. It is the greatest honor of my career as a statistician. Before I actually start my talk, I need to acknowledge Rudy Kittlitz and John Cornell for their help in providing some background information about Jack Youden, and Bill Woodall for reading the written version.

The basic theme for my talk today is that Jack Youden is an appropriate role model for today's industrial statisticians. As a group, industrial statisticians face many exciting challenges and opportunities as we enter the 21st century. Jack Youden's life gives us a shining example to emulate as we face the great issues of today.

Jack Youden: A Model for Today

Jack Youden was originally trained as a chemical engineer, completing his B.S. in 1921. In 1924, he earned his Ph.D. in physical chemistry from Columbia University. He then worked at Boyce Thompson Institute for Plant Research. While there, he became very frustrated at the current practice of experimental design. His response was to do something about it. He went to England and worked with R.A. Fisher, the leading expert in experimental design of that time. Youden went on to do pivotal work in experimental design. People still discuss and use his Youden square designs. He became a strong missionary for good statistical practices. In 1948, Youden joined the National Bureau of Standards, where he did important work. Jack Youden was someone who appreciated the fundamental role statistics can play in industry, and again, even more importantly, he did something about it.

Brief History of Industrial Statistics

Tracing the basic origins of industrial statistics back to the 1950s, three papers stand out, for various reasons, from that time.

First is Box and Wilson (1951), which appeared with discussion in the Journal of the Royal Statistical Society, Series B. I love the fact that it is Mr. Box and Dr. Wilson. The paper which appeared before Prof. Box had earned his doctorate, outlines the basics of response surface methodology, which is fundamental to industrial experimentation. The paper is a classic and should be required reading for all industrial statisticians.

The second paper of interest is Duncan (1956), which outlines the basic economic model for Shewhart control charts. I readily grant the controversy over economic design. What I find remarkable about this paper goes back to a comment someone made at a dinner for the Journal of Quality Technology Editorial Review Board in 1998. This person pointed out that Duncan's paper was probably the last good paper on quality control to appear in the Journal of the American Statistical Association. No one at that dinner could come up with another.

The third paper is Box and Hunter (1957), which I understand is Stu Hunter's dissertation. This paper fills in much of the mathematical detail for response surface methodology. In some sense, it is a sequel to Box and Wilson (1951). What is most notable in my mind is that this paper appeared in the Annals of Statistics.

These three papers represent seminal work in industrial statistics. What is remarkable is that all three were published in very well respected, mainstream statistical journals. How often today do we, as industrial statisticians, find papers of abiding interest in the mainstream statistical journals?

From the early 1960s into the 1980s, we saw several trends in industrial statistics. First, there were a small number of companies with large, centralized statistics groups. The Applied Statistics Group at Du Pont under Don Marquardt certainly comes to mind. Many companies employed individual statisticians. Consequently, most industrial statisticians were extremely isolated. Such meetings as the Fall Technical Conference and the Gordon Research Conference were important forums and played an important role in developing appropriate networks among industrial statisticians. Industrial overhead allowed enough time for several people from industry to be very active researchers. Academic research seemed in sync, particularly with the arrival of Technometrics, which allowed both industrial and academic researchers to share insights and developments.

Starting in the 1980s and continuing throughout the 1990s, trends began to change. First, there was the impact of Deming and continuous quality improvement. Shewhart control charts became a widespread industrial tool.

Contined on page 15

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 14

Companies began to see the importance of statistics. The corporate response to Deming led directly to the rise of consultants. Very few companies had enough statistical expertise to lead the charge towards constant and continuous improvement. Many companies turned to a new class of consultants, who ranged from well qualified to hucksters. Many consulting firms had virtually no background in industrial statistics; however, they did have much experience in the "soft" interpersonal skills. These companies emphasized team building, interpersonal dynamics, and the "seven tools," of which the Shewhart control chart was the most complicated and most often mistaught. It is interesting to note the evolution of the American Society for Quality Control, which was a true technical society, to the American Society for Quality, which is more a management association.

During the 1980s, traditional industrial statistics topics began to lose favor in most academic statistics departments. Programs long known for developing solid, productive industrial and applied statisticians began to concentrate on more mathematical topics within statistics. At the same time, companies began to tighten overhead. As a result, fewer people in industry could find the time to publish. How many Ph.D. statisticians went to industry with an understanding that they could spend 5 or 10% of their time on research projects, only to find out that reductions in overhead precluded them from working on anything except a paying project?

Current State of Industrial Statistics

Probably the most important program, for at least the near future, to come out of the 1990s is Six Sigma. Six Sigma, which originated at Motorola in the 1980s, was the basic quality improvement strategy that led to Motorola winning one of the first Baldridge Awards. Many people at Motorola were instrumental in developing Six Sigma. Certainly, Mikel Harry was one of these people; however, there were many more, most of who have not sought the limelight. There are several stories on how Six Sigma and Mikel Harry were introduced to General Electric. The key point is that General Electric represents one of Six Sigma's greatest success stories and is one of the greatest proponents for the spread of Six Sigma. It would be very wrong to give all, or even most of the credit to Mikel Harry. I submit that the real heroes of Six Sigma at General Electric were Gerry Hahn, Bill Tucker, Fred Faltin, and Roger Hoerl, all well-known and well-respected industrial statisticians. These are the people who brought the real technical foundation to the General Electric Six Sigma program, and it is this technical foundation that led to General Electric's success.

My point is not to trivialize Mikel Harry's contribution; rather, it is to put it into perspective. I must admit that seeing Mikel Harry on the cover of Quality Progress did disturb me. I feel he gets far more credit than he deserves. However, in all fairness, he did make two fundamental contributions. First, he did get the attention of upper management. We, as industrial statisticians, must understand the vital importance of access to the true decision makers. Without this access, industrial statisticians are marginal players. We are simply technical support and not key to the business. Second, Harry tied the results of quality improvement to the bottom line: to how much money is saved or generated. The fundamental purpose of business is to make money. We are nothing more than technical support unless we can justify our efforts in terms of actual profit.

We are now beginning to see the passing of the generation that founded and nurtured industrial statistics. Who do we currently have to replace such people as Lloyd Nelson, Don Marquardt, Gerry Hahn, Ron Snee, Bill Hill, and Jim Lucas?

Lloyd was the statistician at the Nashua Corporation when Deming became popular. No person, other than Deming is cited more often in Deming's Out of the Crisis. Lloyd was Deming's model for an industrial statistician. Lloyd was the last editor of Industrial Quality Control prior to its split into Quality Progress and the Journal of Quality Technology (JQT). He was the founding editor of JQT, and he continues to remain active in JQT's operation. Don Marquardt headed the Applied Statistics Group at Du Pont for many years and has served as President of the American Statistical Association. Gerry Hahn has worked for years at General Electric, leading General Electric's statistical activities. Ron Snee started his career with the Applied Statistics Group at Du Pont and later became a vice-president for NYNEX before it merged with Bell Atlantic. He is now a Six Sigma consultant. Bill Hill has worked as a leading industrial statistician for years at Allied-Signal, now Honeywell. Jim Lucas retired from the Applied Statistics Group at Du Pont.

These are all people who

- Worked in industry
- Published in industrial statistics journals
- Won the Brumbaugh Award, (goes to the paper in an ASQ journal that makes the greatest contribution to the development of industrial applications of quality control)
- Won the Shewhart Medal, (ASQ's highest yearly award)

These people have provided significant leadership to the industrial statistics community. They were all cut from the same mold as Jack Youden.

It is important to consider the current state of academia today. Most statistics departments aspire to emulate Stanford and Berkeley. Thus, most statistics departments put greater emphasis on publishing in the more theoretical statistics journals. The application is more an excuse for the mathematics rather than the mathematics serving as a basis for the solution of a real problem. Academic statisticians working on basic industrial problems often do not

Contined on page 16

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 15

get the same rewards and recognition within their departments as those who work either in mathematical statistics or computationally intensive statistics. The Department of Statistics at the University of Florida is a prime example. I spent eleven years in that department and have many friends there. Recent retirements and the hiring of a new department chair have begun a series of changes to this department. Historically, the department at Florida prided itself on a balance between statistical theory and applications. Rumors suggest that the department is moving to become the "Cornell of the South" or the "Berkeley of the Southeast."

Mainstream statistical journals, in general, do not have industrial statisticians as associate editors or as review board members. As a result, they often have no concept of industrial statistics problems and issues. A recent paper that appeared in the Journal of the American Statistical Association (JASA) is a prime example. I know many colleagues who refuse to submit papers to JASA. It is one thing to get your paper rejected; it is quite another to have your paper rejected on the basis of an uninformed review by people who actually work in other research areas.

Academic statisticians face huge pressures, now, to bring in major amounts of research money. Too often, at least on the statistical side of government granting agencies, the people making the decisions about grants know little or nothing about industrial statistics. A few years ago, Carnegie-Mellon received a huge National Science Foundation grant to work on industrial statistics. The results that I know about were all Bayesian and computationally intensive. I have heard of no results that led to practical solutions for real industrial problems. Frankly, academic statisticians face huge pressures to pursue the trendy topics that may bring in research money.

Where are the good industrial statistics departments today? Many of the departments historically known for producing good industrial statisticians long ago made the transition that appears to be taking place at Florida. Who are the academics that can replace George Box, Stu Hunter, Bill Hunter, Ray Myers, and Doug Montgomery (who is, by the way, nowhere near retirement)?
These are academics who: wrote articles useful to practitioners; consulted widely in industry; wrote important textbooks; won the Brumbaugh Award; and, except for one who died before he could be so honored, won the Shewhart Medal. And, these people have provided significant leadership to the industrial statistics community. In addition, they have played important roles in training today's industrial statisticians.

It is important to consider upper management today. My sense of upper management at most corporations is that it does understand the need for improvement, and it is honestly prepared to commit substantial resources in the pursuit of improvement. However, it is often poorly informed on where to go for help. Typically, members of upper management are not comfortable with technical issues, especially statistical issues. Even those who were technically trained are often uncomfortable with such issues because they have been in the management ranks, away from dealing with technical matters, for too many years. Upper managers speak the language of money, not statistics. Since they often are poorly informed on where to go for help and since they are not comfortable with statistical issues, they seek consultants with whom they are comfortable.

Professional consultants have an extreme range in technical ability from very good to truly horrible. The successful ones all speak the language of money, which makes them attractive to upper management. These consultants are business people themselves. They have a strong propensity to massive self-marketing. I fear that in some cases, these consultants spend more time and energy on self-promotion than on the proper application of the industrial statistics tools to solve their clients' problems! Most consultants do not publish in the peer-review literature. Several consultants tend to self-publish their work, avoiding the peer-review process. Two years ago in his Youden address, Doug Montgomery spoke eloquently about the role of peer-review in industrial statistics. Peer-review ensures that the techniques and methodologies advocated have sound merit. We do not need "cold fusion" in industrial statistics. Self-publication, combined with self- promotion, can lead to highly questionable practices. Some consultants actively disparage statistics and statisticians, saying that statisticians actually get in the way of improvement. These consultants leave the clear message that only they, the consultants, know the proper way. Almost all of the consultants tend to take far too much credit for what they really do.

The current reality is that industry needs academia and academia needs industry. They are in a highly symbiotic relationship where each individual's success depends on the others. The primary missions of most universities are: education; research; and outreach. The symbiotic relationship between industry and academia permeate all three areas.

Academic departments of statistics do the vast majority of formal statistical education of the people who go into industry, both as statisticians and as engineers. What will be the quality of this education as academic departments move further away from the historic areas in industrial statistics? Who will teach engineers and even statisticians the fundamentals? Industry must get involved with academic departments if it wishes to defend the quality of the students coming out of universities.

Here is a rather novel idea: have universities graduate "green belt" engineers and statisticians. A green belt should have sufficient training in appropriate statistical

Contined on page 17

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 16

methodology to make an impact soon after being hired into industry. A retired vice-president from IBM once told me that he expected engineers to be trained in: Experimental Design; Process Control; and Reliability.

Certainly, these three areas should form the core for any "green belt" training. Engineering curricula usually require at least one capstone course. In the case of our green belts, such a capstone should involve participation in a real improvement project that leads to documented savings. Frankly, most universities could implement such a curriculum relatively easily. ABET, which accredits engineering programs, requires at least one course, or its equivalent, in probability and statistics. This green belt curriculum would probably require two statistics courses plus the capstone project, which should be an integration of both the engineering and statistical training. Unfortunately, the reality is that several obstacles lie in the way of any such program. I will discuss those obstacles (the least of which is finding qualified people to teach the courses) later.

The academic mission of research leads to the development of improved statistical methodologies. As corporations continue to cut back on overhead, and as they move to become "leaner and meaner," statisticians in industry are less and less able to do fundamental research, much less publish in such journals as Technometrics and JQT. In today's environment, industry is ever more dependent on the research provided by their academic industrial statistician counterparts.

Academics do much of their outreach through continuing education programs. Historically, industry has compensated for the lack of university training in industrial statistics through training programs. Companies with large statistics groups often would conduct this training purely internally. Companies who lacked the critical mass of statistical talent would bring in people, often academics, from outside the company. Some university departments have learned that they can capitalize on this need for training and have started public short course programs specifically for people in industry.

Another form of academic outreach to industry involves assistance on hard, practical statistical problems, particularly as the cutbacks in overhead take their toll. People in industry often do not have the time to ponder what is the best approach for attacking a real problem. "Quick and dirty" is the best they can do. Academic researchers, however, do have the time and the talent to address these issues.

Academia also needs industry. As we have seen, industry is a major customer of academia's products, both students and research. As a consequence, industry must assume a major advisory role to academic departments of statistics. Failure to do so will increase the rate at which historically applied departments try to become theoretical departments of statistics. Industry needs to develop appropriate avenues to route important, practical research problems to the right academic industrial statisticians.

Finally, academic departments, across the country, face major budgetary problems. Industry can facilitate change in academia by becoming a strong, reliable source of funding, much like what occurs in engineering.

Obstacles

First, consider the academic side. One major problem is academic arrogance. Too many academics still cherish the ivory tower. They do not want to be tainted by the real world. Their attitude to industry is too often, "Give us your money, and we will work on the projects we think you need. Please do not bother us by what you really want or need!" Accountability is not a concept many academics understand.

Academia tends to respond slowly. Academics work according to the academic calendar. Frankly, their first responsibility is to cover their classes and their research assignments. From an industrial perspective, academics tend to work at a glacial pace on industrial problems. Yet, the issue often comes down to priorities.

Changes in academia often require a large amount of "consensus." Academic institutions have large amounts of inertia. Many people do not understand the freedom that comes with being a faculty member. Faculty members do not have supervisors in the same sense that people in industry do. Before becoming a department head, someone told me that leading faculty is like herding cats. Generally, change only comes if it is truly compelled by some outside force.

Some changes require participation at the highest levels of administration. The green belt proposal is a prime example. At Virginia Tech, such a program would require the approval and the full participation of both the College of Engineering and the College of Arts and Sciences. Academics tend to protect turf. Engineering curricula are already packed with topics, many of which reflect nothing but tradition. Why are chemical engineers still required to take dynamics? Getting an engineering program to yield one course to the Statistics department is like asking someone to cut off his/her foot. Such a change could only result if senior management at companies that recruit at Virginia Tech demands it. If vice-presidents from Du Pont, Shell, and General Electric demanded such a green belt program and their companies would refuse to recruit from Virginia Tech unless it were implemented, the Provost would have the program in place over night. Short of such a demand, I doubt that Tech would implement such a program.

Finally, some changes in academia require significant funding. Grant expenditures form an important measure of the quality of research institutions. As pressure builds to increase grant expenditures, faculty members will commit more of their time to activities that will provide the biggest

Contined on page 18

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 17

payback. In this environment, industry cannot complain about academia ignoring their problems if industry is unwilling to commit the financial resources required.

The primary obstacle on the industrial side is that the statistical points of contact are, at best, middle managers. Outside of the pharmaceutical industry, where the FDA requires statistics to be central to the business, where are the vice-presidents who are also statisticians? Don Marquardt was never a vice-president. He was very well respected, but he was never promoted to vice-president. Gerry Hahn is not a vice-president. Ron Snee was a vice-president, briefly. My father worked for Du Pont for many years. After the Du Pont family started to let non-family members run the company, the CEOs often were Ph.D. chemists or chemical engineers. Du Pont has many scientists and engineers as vice-presidents because these activities are considered central to the business. We can name countless companies that have engineers, accountants, and sales/marketing people as vice-presidents because these roles are considered central to the business. How many companies today consider industrial statistics so central to their activities that they feel compelled to have industrial statisticians serve as vice-presidents?

Industrial statisticians tend to rise to middle management but not higher. As a result, the people who understand the issues do not control money or policy. The people who control money and policy do not understand the real statistical issues. In this environment is it any wonder that so many consultants make so much money doing so little that is technically correct? Industrial statistics is too often viewed as purely technical support, lumped in with the latest human resources fad of the week. We cannot expect industrial statistics to command the true respect it deserves until we have industrial statisticians serving as vice-presidents. Then, and only then, will industrial statistics be considered as central to the business. I have a friend, who, when she reads this comment, will say, "But Geoff, I work daily with vice-presidents. They find what I do important." There is a huge difference between "important" and "central." "Important" can still be viewed as an overhead expense that can be cut at the drop of a pin. "Central" is exactly that. It is part of the company's core and not part of the overhead. Cutting overhead is viewed as cutting fat. Cutting the core is viewed as cutting bone and muscle. As long as industrial statistics is viewed as technical support, we should continue to see consultants making large amounts of money that should go to fund either industrial or academic efforts in industrial statistics.

Road to Improvement

Industrial statisticians find themselves in an exciting, dynamic time. Clearly, there are major challenges, but there are equally major opportunities. The key to improvement is an appropriate dialogue among the key players. Bob Hogg attempted to start such a dialogue in the late 1980s. He brought together top industrial statisticians from both industry and academia. Such specific recommendations for engineering statistics courses evolved from that conference. I submit that the Hogg Conference, although well intentioned, was a disappointment. More than ten years later look at the impact this conference had on engineering statistics courses: not much. The impact on the relationship between industry and academia is even less.

What are the lessons we can learn from the Hogg Conference? To have a significant impact on the actual state of industrial statistics, we need a conference where the true players are present. We need the real corporate decision makers, the vice-presidents. Even better would be to get the CEO's to attend. Our historic statistical contacts in industry do not have the clout necessary to lead the reforms. We also need the academic decision makers present. I as a department head cannot do much to achieve true educational reform, but provosts can. Provosts and deans are the academic decision makers, not department heads. It is important to keep in mind that vice-presidents, provosts, and deans are the decision-makers, but they do not understand the real issues. They can make things happen. Hence, they need the leading industrial statisticians, both in industry and in academia, to guide them as to what is important and what needs to be done. All four groups need to be involved in this dialogue. The Hogg Conference failed because the real decision-makers were not a party to the discussions. The dialogue outlined above will also fail unless there is strong commitment to the appropriate follow-up activities by all involved. We are talking about serious commitments of time and money, which is why the decision makers must be centrally involved. The keys to success are strong, committed leadership by both industrial and academic statisticians and strong, committed buy-in by all the players. We need some Jack Youdens to lead the way!

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