Center for Quality and Productivity Improvement
University of Wisconsin--Madison
610 Walnut Street
Madison, WI 53705

Report No. 10

The Next 25 Years in Statistics

William J. Hill* and William G. Hunter

(Contributions from Joseph W. Duncan,
A. Blanton Godfrey, Brian L. Joiner,
Gary C. McDonald, Charles G. Pfeifer,
Donald W. Marquardt, and Ronald D. Snee.)

February 1986

* Current address: Allied-Signal Corporation, 20 Peabody Street, Buffalo, New York 14210.

Support for the 25th Anniversary Conference of the Department of Statistics of the University of Wisconsin-Madison was provided in part by grants from the National Science Foundation (DMS-8414661) and the Office of Naval Research (N00014-85-G-0073).

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PRACTICAL SIGNIFICANCE

It is prudent for industrial corporations and other organizations in the private and public sectors to pause periodically to take stock of their current position, to assess current trends and future prospects, and to outline recommended actions that will promote healthy growth in the future. It is prudent for professional bodies to do likewise. To improve quality and productivity in organizations in the United States, many fundamental changes must be made. A transformation of the American style of management is needed. As one key aspect of this transformation, a leadership role needs to be played by the statistics profession. This report considers the next 25 years in statistics. It was prepared by nine statisticians with experience in industry, business, government, and education.

Key Words: Clout, communication, contributions, curriculum, competitiveness, computing, change, conversion, customers, collaboration.

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ABSTRACT

This article reports on a panel discussion that was part of the 25th anniversary conference of the Department of Statistics at the University of Wisconsin-Madison. Panelists with experience in industry, business, government, and education were asked to focus on desired directions for the statistics profession to take, especially in the next 25 years. The ideas presented are summarized under ten headings, all of which (surprisingly) start with the letter "C".

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On May 28-31, 1985, the Department of Statistics at the University of Wisconsin-Madison celebrated the 25th anniversary of its founding with a conference on the Theory and Practice of Statistics. More than 140 statisticians and other professionals were in attendance. In its first year the Department had five students and one professor, George E.P. Box, who was its founder. He envisioned a department that was deeply involved in both the theory and practice of statistics, whose faculty held joint appointments in other departments. In its twenty-fifth year, there were approximately 90 students and 30 faculty members. Joint appointments existed with the College of Animal and Life Sciences, the School of Business, the College of Engineering, and the Medical School, as well as with the Department of Mathematics, which is in the College of Letters and Science - as is the Department of Statistics.

The conference covered a broad range of topics discussed by experts mainly from outside the Wisconsin community. These topics included time series, experimental design, Bayesian inference, biostatistics, quality improvement, model-building, and data analysis. These areas over the years have been of primary interest in the Department - some have said these are some of its key strengths.

The 25th Anniversary Conference closed with a look toward the future of statistics in industry, government, and education. The focus was provided by a panel of five statisticians with many years of combined experience: Joseph Duncan (Dun and Bradstreet, formerly in the office of Management and Budget of the Executive Office of the President), Blanton Godfrey (AT&T Bell Laboratories), Brian Joiner (Joiner Associates), Gary McDonald (General Motors), and Charles Pfiefer (DuPont). Their remarks follow these introductory comments. This panel discussion is an extension of the American Statistical Association's committee reports on the needs of industry and government (see Snee et. al. (1980) 34, 65-75 and Eldridge et al. (1982) 36, 69-81.) Several of the themes raised in those reports were elaborated upon by the panel.

Over the past 25 years, the Department of Statistics of the University of Wisconsin-Madison has awarded Master's and Ph.D. degrees to approximately 365 statisticians who went on to careers in industry, government, and education. The markets recognizing the need for statistical skills have included research, development, engineering, manufacturing, health, census, and marketing

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departments in a variety of organizations. Graduates also have become professors in university statistics departments. Some might say statistics is still a relatively new product for these traditional markets. Others might argue that statistics is a mature product in need of further new markets such as executive offices, elementary and high school classrooms, university science and engineering programs, and indeed the public at large. The panel was invited to consider applications that are likely to occur in the next 25 years and accompanying educational efforts that will be needed to support these applications. What will be needed where, and how can useful things be accomplished - things that will make a difference? What will be needed to promote economic and social growth on a national scale? Who must take lead roles to make statistics an even more valuable quantitative science in business, government, and education?

In particular, the charge to the panel was to:

- Focus on directions that statisticians should be taking to meet the needs of business, government, and education over the next 25 years.
- Address the steps necessary for planning and carrying out educational programs in statistics to satisfy future needs. What should be emphasized more? What should be emphasized less?
- Illustrate points with examples and data, where possible.
- Present ideas on how statisticians can better market their skills to have more impact.
- List a set of recommendations that will be helpful to statisticians in business, government, and education.

In reflecting on the main points made by the panelists, we concluded that they could be summarized under ten headings, each of which (surprisingly) starts with the letter "C". The list below contains a few elaborations of our own, to explain as clearly and succinctly as possible what is meant by each of these terms:

(1) Clout - We need to take more initiative in influencing decision making in business, government, and education. Some of the knowledge and insights we possess are central, not peripheral, to good decision making. Too often in the past we have remained passive observers. More frequently in the future we need to be leaders.

(2) Communication - We should do more to make our publics aware of the value of statistical methods and the statistics profession, these publics being both inside and outside the organizations in which we work. Students should learn communication skills to supplement their mathematical tools.

(3) Contributions - We should take the opportunity to expand our contributions in industry, government, and education. Let's not be limited to traditional arenas and customers but reach further afield in society - to pre-college education, management, and service work, for example. Statisticians should be experts in the scientific method. In this capacity, they have many contributions to make. To mention one example, public debate on issues of importance to our society would benefit from more contributions from statisticians.

(4) Curriculum - Our curricula need to be modernized to attract and hold students. Especially in the early stages, more emphasis should be put on the planning, collection, and analysis of data. The focus should be on learning from data. The curriculum needs to put somewhat more stress on what statisticans will be expected to do upon graduation.

(5) Competitiveness - A greater effort should be focused on increasing the value of statistical services so our product is valued and bought. We must compete better to get good students to educate and important problems to solve.

(6) Computing - We need to be better trained in computing to reduce large data sets to useful, understandable results and information for decision making. We can use computers more resourcefully than we do. On the other hand, we have contributions to those who use computers. As students of how data can be most efficiently collected and most effectively analyzed, statisticians have much to contribute to those concerned with the best use of all this new hardware. Computer graphics, for instance, have enormous potential.

(7) Change - We should grasp the opportunity to influence and respond to changing societal trends. Our society's view of the value of quality and productivity, cost, and timeliness is in flux. Statisticians can make important contributions in these and related areas if they take the time to understand what their clients really want.

(8) Conversion - For businesses and governmental organizations to be more competitive, we will have to transform current theories of management and leadership to put a higher priority on approaches offered by statisticians. That is, there needs to be a clearer understanding of the benefits of scientific thinking. (Statistical methods and scientific thinking, of course, are not the complete answer here, but they are important components.)

(9) Customers - We should strive harder to meet (and, if possible, exceed) our customers' needs and expectations. We need to expand our customer base.

(10) Collaboration - Since statistical skills are used to a growing extent in many new contexts and by many other disciplines, to be most helpful we need to collaborate actively with other individuals - professionals and nonprofessionals alike - at work, in projects, at seminars, and through publications. Such collaboration, in turn, will help us become better research workers and teachers.

Participants at the conference said that statisticians can have a major impact in the next twenty-five years in many worthwhile kinds of activities, including the improvement of

- quality and productivity
- management in private and public organizations
- collection and use of business and government information
- integration of statistics into business plans
- new product development and the entire process of innovation
- ways to measure and meet customers' needs and expectations
- education in all of its aspects: grade school through graduate school, vocational, technical, and continuing education

The opportunities are everywhere. They are all around us. The only question is whether we statisticians are ready to take the initiative and seize these opportunities.

We are grateful to the panelists for accepting our invitation to participate and for their willingness to prepare written versions of the remarks they presented at the conference. Their contributions now follow.

THE FUTURE OF STATISTICS IN INDUSTRY AND GOVERNMENT[1]

Gary C. McDonald
Mathematics Department
General Motors Research Laboratories

INTRODUCTION

As this particular audience is well aware, commenting on the future is very risky business. Sam Goldwyn, the Hollywood mogul, characterized the riskiness succinctly: "Forecasts are dangerous, particularly those about the future." With this caution in mind, I do appreciate the opportunity to participate in the commemoration of the silver anniversary of the Department of Statistics and to share with you some of my thoughts -- and concerns -- on the future of our statistics profession.

The American Statistical Association (ASA) is currently developing a strategic plan to identify areas requiring particular emphasis by the ASA in a five to ten year time frame and to identify sectors to serve and services to be provided. Donald Marquardt is leading this effort and, to a large extent, this process will itself unveil and focus the future of our profession in a rather definitive fashion. The comments today touch on a few of the aspects which I believe the ASA plan will eventually address more completely. Those of you who have been involved with such long range planning I think will agree with me that the discipline of the process itself yields unexpected benefits and is often of more value than the final plan. We'll be hearing more of this as Don and his committee progress.

In preparing for this discussion, I reviewed "The Future of Statistics," the Proceedings of a Conference held at the University of Wisconsin in

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[1] Panel Discussion at the Conference on the Occasion of the 25th Anniversary of the Department of Statistics at the University of Wisconsin, May 31, 1985.

June of 1967. This was a good opportunity to ascertain how good we were at forecasting our future some eighteen years ago and to identify key issues prevailing at that time. That conference was a commemoration of the completion the Computer Sciences-Statistics Center and itself provided a note on the future of our profession and its coupling with computing.

This Proceedings highlighted three critical concerns for our profession: communication, computing, and usage. Today, as we look to the future, these three concerns still loom large and do require some rethinking on how we train and utilize statisticians. How well we continue to address these concerns will shape the future of statistics in industry and government.

COMMUNICATION

The issue of communication covers several distinct facets. These are the definition of statistics for use by industry and government, the language statisticians utilize to convey their results, and the personal communication skills of the statistician. I would like to comment briefly on each of these facets before turning to computing and usage.

The traditional view of statistics and problems of industry and government might best be described as two clouds with nebulous borders (see Figure 1) that had a significant overlap resulting in a beneficial interaction.

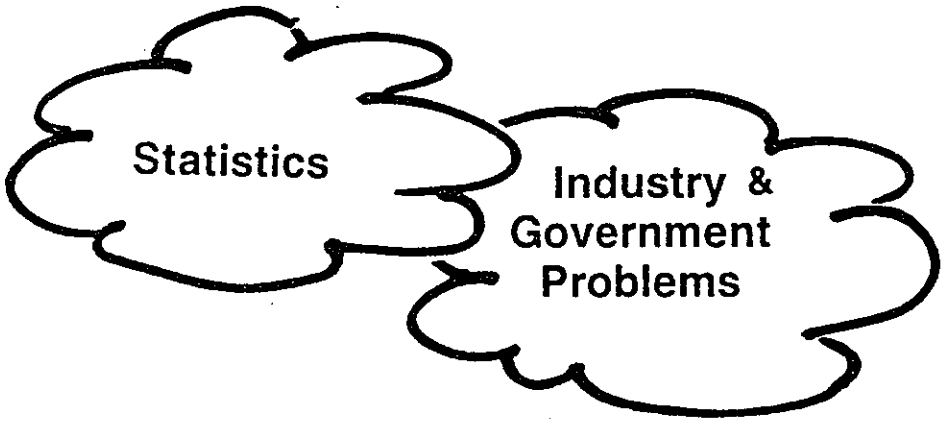

Figure 1.

While there are at least several hundred definitions of "statistics," they generally contain some common elements which suffice for my purposes here. I don't wish to divert into definitions or contribute another. Let me simply note critical elements include the collection and interpretation of data, formulation and estimation of models, and forming conclusions which include a probabilistic assessment. This probabilistic assessment is precisely what distinguishes our profession and serves to quantify the numerous sources of uncertainty arising in applications -- sampling, model specification, data variability, etc.

Let's consider what's evolved in the past few years. We've been in an economic war of quality and productivity with worldwide competitors, and statisticians such as Drs. W. Edwards Deming and Brian Joiner have expanded the battlefield to what we might call the art of management. Our traditional view has been enriched to include three clouds further straining our professional identification and definition. What is a statistician? What does he/she do to characterize their profession?

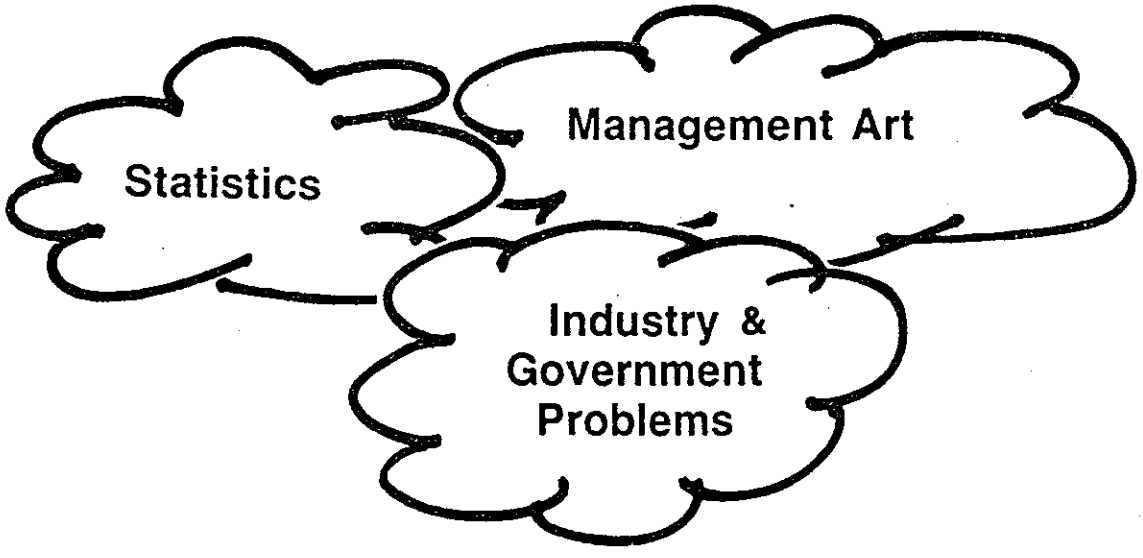

Figure 2.

There are narrow definitions and practices of statistics which would hold the cloud intersections to very small subsets; others would allow one or more of the subsets to expand dramatically. While I don't purport to solve this intersection problem, I do feel it's critical to our communication to know where we fit into the scheme. Statistics is not a substitute for the

art of management nor is it a remedy for all industrial and government problems. It is an approach to the collection and interpretation of data resulting in a probabilistic assessment.

I am stressing this point to emphasize communication between the statistics profession and the industrial and government sectors. This clouding of facets in Figure 2 can be a serious roadblock in effective communication. Industry needs to know what to expect from statistics (and vice versa) and we should undertake to clarify these expectations. For example, the tremendous emphasis on quality control has, in part, resulted in a resurgence of control chart usage. While regimented use of these monitoring aids have imparted significant improvements in numerous processes, the statistics profession needs to contribute much more. Control charts are used frequently as a go no-go gauge without an understanding of sigma limits (the probabilistic assessment) and certainly without a quantitative understanding of the consequences of specifying alternate control limits. Again the issue and language of communication becomes critical. For management action purposes how should we specify sample size? Sample frequency? Control limits? Decision rules?

While "statistics" results in a probabilistic assessment and the above questions can be answered in the language of probability, the communication of these results and their consequences can be enhanced frequently by transforming them into a language easily understood by others. Economic consequences and opportunities often provide this alternative. Industrial managers and government administrators, often justifiably, have difficulty relating their real problems to significance levels, p-values, Type I or II errors, likelihood regions, etc. By relating such measures of uncertainty and decision variables to dollar consequences we can enhance the communication and proper usage of our probabilistic skills.

Eighteen years ago the issue of effective communication was deemed extremely serious for our profession. It remains that way today. Management consultants continually highlight the necessity for clear communications between management and employes to achieve a productive working

environment. Appraisal systems and quality circles are designed to insure a direct communication link between employes and supervisors and nurture effective interactive working skills. Good communication skills -- both written and verbal -- are a major asset (if not absolute requirement) to affect change in industry and government.

At the Research Laboratories we conduct an Effective Technical Writing course several times each year. New employes are scheduled for this course which uses H. J. Tichy's book Effective Writing for Engineers, Managers, and Scientists (John Wiley, 1966). There is a substantial time investment on the part of the employe. The course formally meets once a week for two hours over an eleven week period. This in itself indicates our genuine concern with achieving effective technical communication on an individual level. Our success as an industrial laboratory depends substantially on our abilities to communicate effectively to the Corporation the new knowledge, methodologies, and analyses which are generated in the course of our research.

Improving the quality of writing and presentations has been an important goal of the ASA. Since 1980, in conjunction with the Annual ASA Meeting, a workshop "Improving Statistical Presentations" has been held. This will again occur at the upcoming Las Vegas Meetings. Additionally, several excellent papers[2] have appeared in the American Statistician directed towards the effective writing and presentation of technical material. This material should be reviewed periodically by each of us. Effective communication is a goal which I don't believe is ever fully reached. It requires persistence, effort, and an occasional reminder of its importance. Students should be exposed to such resource material early in their academic programs.

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[2]Ehrenberg, A.S.C. (1982). Writing technical papers or reports, The American Statistician, Vol. 36, No. 4, 326-329.

Freeman, D.H. Jr., Gonzalez, M.E., Hoaglin, D.C., and Kilss, B.A. (1983). Presenting statistical papers, The American Statistician, Vol. 37, No. 2, 106-110.

COMPUTING

The second critical concern is computing. The 26 April 1985 issue of Science, "The Computer Issue," is devoted to assessing the impact of computers in such areas as numerical computations, organic synthesis, economic analysis, production agriculture, sociology, etc. Daniel Koshland, Jr., in his editorial, notes that since von Neumann's studies in the 1940's, computers have increased in speed by a factor of 1 billion and have become cheaper per computation by a factor of 10 million. The articles in this issue dramatize the fundamental impact that computing advancement is making in our thinking and approaches to a wide spectrum of problems. Leontief et al. in their article on "New Approaches in Economic Analysis" state that "detailed factual information about every kind of activity performed in the many different sectors of a complex modern economy has become available." Heise and Simmons in their article "Some Computer-Based Developments in Sociology" discuss rather impressive implications for statistical analysis and data collection. A new generation of computer intensive statistical techniques implementing structural equation methods continues to evolve allowing investigators to formulate and analyze complex causal models involving dozens of (imperfect) measurements. All of these articles indicate that the computer has and will be a surrogate for "real" experiments, a data collector and sorter, and a tool for extensive sensitivity analyses.

Current automobile assembly processes are capable of making many measurements on each item processed. This industry is certainly not unique. In many cases sampling is not the problem -- information overload is. The challenge now becomes to sort the appropriate signal from the multitude of data upon which to base process control. As a consequence of computerization, meaningful data generation has eliminated, in many instances, the issue of sampling variability and this source of probabilistic assessment. Estimation of gauge repeatability and process identification for control purposes now are of paramount interest.

Today as a result of expanded computer capability, we can realistically assess sensitivity of statistical conclusions to the mirad of building block assumptions upon which they are constructed. Empirical studies such as assessing health effects of air pollutants or the impact of auto safety regulations on traffic fatality rates, usually evolve through a path such as that given in Figure 3.

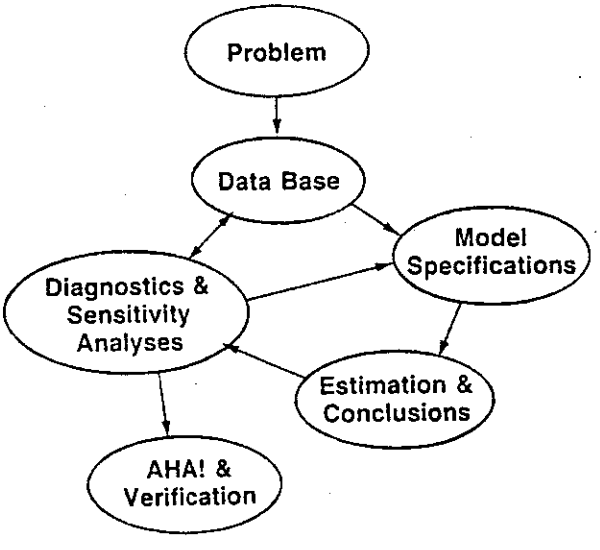

Figure 3.

Diagnostic techniques are evolving rapidly to highlight interesting phenomena in data structures which suggest avenues for further exploration. Computers have been a key agent replacing our notion of performing the analysis with a more enlightened notion of performing lots of systematic analyses.

USAGE

Now to the third critical concern -- the usage of statistics. In the 1967 Proceedings, John Tukey stated that if statistics is to be effective, its techniques must be kept easy enough to use, the test of 'easy enough' being whether or not they are used." The criteria suggested for 'easy enough' still applies today but not so much from a numerical or computational perspective. A personal computer can mask lots of detailed mathematical computations and still preserve a user friendly environment. Whether or not techniques are being used will be increasingly determined by the questions they address. Are these techniques providing meaningful insights into questions deemed interesting by the user?

Too often, I believe, the statistical analyst role is viewed as that of a technician rather than that of a professional analyst. Their skills are thought to be those that can be acquired in a few courses by a good engineer or manager with no previous background in the subject matter. I don't believe that this view represents statistics at its best and is certainly not the image which attracted me to the profession. Setting aside the possibility that my perception is incorrect, let's explore some reasons which might account for this image and thereby suggest countermeasures.

One reason is the training in some university statistical laboratories--where the apprentice is presented data by a client and asked for an analysis. Note the statistician is not the problem finder! If it wasn't for someone else coming to the office, there would be no need for the statistician! The goal of the analysis is frequently quite pragmatic (complete a thesis or paper) and the environment does not provide adequate feedback on how the statistical analysis did or didn't affect the operating environment. While the statistical laboratory does provide a real opportunity for the individual to interact with a broad range of users and develop skills in the computing areas, it can engender a passive attitude

towards problem identification and formulation. In the extreme, statisticians become a relatively rare luxury appended to the real heart of an organization -- the problem identifiers. They are, in a sense, second class citizens relying on someone else's initiative to provide their "grist for the mill."

To grow and remain a vital profession in demand by industry and government statisticians need to be active in the problem identification stage. They should be asking interesting questions and not simply responding to questions which are delivered by management, colleagues, or regulators. By identifying and formulating critical issues, by collecting and interpreting meaningful data, by quantifying uncertainty with a probabilistic assessment and by following the problem and solution to its implementation, statisticians will enhance their image and value as professionals.

SUMMARY

Let's recap the major issues and what might be done to enhance the contributions of our profession to industry and government. The issues are communication, computing, and usage. Within communication we need to retain identifiable characteristics of our profession. I suggest that formulating conclusions based on probabilistic assessment is one fundamental characteristic. Due to the language of our methodologies we need to stress and teach effective personal communication skills and encourage the translation of our conclusions into forms easily understood.

Dramatic improvements in computing resources continue to impact every facet of our lives. The opportunities for statistical insight to sort the "wheat from the chaff" expand accordingly.

The usage of statistics in industry and government continues to be determined by the sharpness of questions addressed and the clarity of answers provided. An environment which nurtures active participation by statisticians in problem identification and formulation, solution, and implementation will enhance the appreciation and need for statistics as a profession by industry and government.

THE FUTURE OF STATISTICS IN INDUSTRY AND GOVERNMENT

Presented by
Joseph W. Duncan
Corporate Economist & Chief
Statistician
The Dun & Bradstreet Corporation
(formerly Chief Statistician,
Office of Management & Budget,
Executive Office of President,
Washington, D.C.)
Department of Statistics
25th Anniversary Conference
May 31, 1985

My opaning premise is that we are becoming a "statistical society". By that I mean, as citizens, analysis of statistics is now a routine part of our thinking and behavior. Consider the following:

1. Gross National Product data are headline stories in print, visual (TV) and audio media.

2. Many workers have contracts based on the Consumer Price Index (CPI); others evaluate their actual wage gains by comparison with the CPI trends.

3. Newspapers and magazines feature sample surveys often including estimates of sampling error involved in the individual surveys (e.g., New York Times, Newsweek, Time, Washington Post, etc.

4. Industrial production lines often function on the basis of "statistical" quality control. Even white collar offices use statistical methodology to determine production "targets".

5. The personal computer is creating a demand for better data and analytical techniques.

6. Many colleges and universities have broadened the role of courses in statistics to provide more fundamental background for other studies.

Our challenge today is to consider how the profession of statistics should develop to meet the changing needs of business, government, and academic. The panel is designed to cover various facets of activity of "the statistical society". My responsibility is to focus on government statistics. In order to respond to the time constraints, I will focus on one particular area -- economic statistics generated by the federal government.

Obviously, government statistics are important to business as a gauge of markets, economic trends and conditions and as a major input for overall business and consumer optimism (or pessimism). Likewise, it is clear that academic developments in both theory and applications provide important foundations for determining what to measure and how to measure it -- in the area of economic activity.

The proposition I present today is that the statistical profession is not moving forward to develop the public (political) statistical system that is the major contact point for many citizens in their involvement with the art and science of statistics.

There is much evidence of this problem. Today, as I was traveling to Madison for this conference, the well known publication USA Today included a front page story which states: "The quality of government data is deteriorating". The headline for this story states "Change In Index Baffling".

A report released recently by the Congress states: "If any further cuts are made in many of these statistical budgets, the basic quality of the information base that the nation's leaders use to guide their decisions will be in serious jeopardy. (This quote is from the press release of Congressman Jack Brooks from the House Government Operations Committee.

There are many examples of current difficulties. I will offer three examples. They are:

1. The Standard Industrial Classification has not been revised since 1972. The Office of Federal Statistical Policy and Standards which I headed proposed recommendations for 1982, but we also recommended that they be killed since the Office of Management and Budget was unwilling to fund the recoding of data at statistical agencies other than the Census. This would have resulted in even worse data with the Census data being totally incomparable with data from BLS, IRS, and other major statistical agencies. Presently, while two-thirds of our economy is in the service industry, two-thirds of the SIC codes are in the manufacturing sector. (For further discussion of this point, see "The Economy Has Left The Data Behind", Joseph W. Duncan, The New York Times, Sunday, June 30, 1985.)

2. Profits are an important factor in future investment in plant and equipment to modernize and expand existing capital facilities as well as for activity by new business ventures. During recent years the reduction in the statistics of income sample has been accompanied by statistics indicating a declining share of profits in the Gross National Product occurring. For example, the corporate sample declined from 105,000 firms in 1969 to 93,000 in 1981. When this is coupled with the IRS estimate of a 75% increase in the universe of firms, the sample proportion has declined from 6 - 3% of the universe. I do not

mean to imply that the relative decline of profits is a statistical mirage based on a smaller sample. But while improved sampling and estimating methodologies may have minimized higher sampling errors due to smaller sample, there are no studies of the effect that smaller samples may have on longer run trends. A significant policy implication of the decline of the statistics of income sample is that profits data are essential for developing the new tax laws. We are in a major period of redefinition of business taxes. Do we know what we are doing?

3. The only major initiative of recent years in the statistical system has been the Statistics of Income and Program Participation (SIPP). Unfortunately, this survey is seriously flawed. While there is considerable attention to current income and current consumption, there is limited information collected concerning the asset base of the household. For elderly families, in particular, the extent to which they own their home or receive rent controlled or otherwise subsidized housing requires more detailed information than is collected from the survey.

These examples are only part of the full list of weak statistics which could be identified as problem areas in a rapidly changing society. They underscore, however, the importance of strong academic research to define new statistical constructs, of strengthened government statistical activities to measure activities at a more appropriate level, and of general statistical efforts to explain the true meaning of the results which are available.

How Can Statisticians Have More Impact?

On the basis of my eight years experience in Washington, I have reached a fundamental conclusion. This conclusion may sound somewhat simple, but it is as follows: As a group, statisticians are a weak political force.

Despite this fact the statistical profession can have an important effect on political activities. Statisticians are well recognized for their technical expertise. They can be effective if they help thought leaders and political leaders understand the importance of sound statistical concepts and measurement programs.

Statisticians can also work with political leaders to help them tc understand the nature of statistical measures which underline basic policy decisions.

Conclusion

In my view, the role of statisticians outside of government has been woefully ineffective in improving the fundamental statistical database which is the primary source of much of our decisionmaking. Specifically, academic institutions need to work more aggressively on fundamental measurement concepts. Second, students of statistical programs should be trained in the limitations of current government statistics and in methods for improving upon those limitations. Third, political, business leaders, and even government statistical leaders should be educated on proposed improvements.

As I stated at the cutset, we are a "Statistical Society". The challenge tc the profession is to make the "Statistical Society" more astute in its use and interpretation of statistics. If we remain "blind" in our applications, we will be mislead and our public and private decisions will often be incorrect.

THE FUTURE OF STATISTICS IN INDUSTRY AND GOVERNMENT[1]

CHARLES G. PFEIFER
DONALD W. MARQUARDT
RONALD D. SNEE

ENGINEERING DEPARTMENT
E. I. DU PONT DE NEMOURS & CO., INC.
WILMINGTON, DELAWARE 19898

I. INTRODUCTION

For our statistics profession to have long-term vitality we must respond to changing needs and environments. Only through adapting the way we communicate, teach, research, and practice statistics can we continually improve the usefulness of our services. In this rapidly changing world, it is timely to evaluate where we are today, where we would like to be in the future, and what programs are needed to get us there. In the following sections, we review progress to date, identify some key directions requiring increased emphasis, and discuss two strategies that can enhance the contributions of our discipline. Our objective is to encourage statisticians individually, and as a profession, to seriously consider what they are willing to do about the future. We focus on how statisticians can better meet the needs of our customers and add value in the markets we serve.

II. STATISTICS 1985

Today, statistical methods and techniques are widely applied to solving problems, planning data collection, understanding data relationships, and making decisions. Statistics is and has been an indispensable part of research and application in the Physical and Engineering Sciences, Biological

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[1]Presented in a panel discussion at the 25th Anniversary Conference on the Theory and Practice of Statistics, Department of Statistics, University of Wisconsin-Madison, May 28-31, 1985.

and Life Sciences, Social and Behavioral Sciences, Econometrics and other fields. Over 190 U.S. colleges and universities either offer degrees in statistics or provide a statistics emphasis (AMSTAT News, November 1984). Service courses in statistics are usually available as electives in many science undergraduate degree programs and are required in some. Statistics education is an integral part of some science graduate programs as well. Published research in many disciplines frequently is based on (and justified by) statistical findings.

Most professional statisticians are engaged in the practice of statistics. Many are employed by industry and government. A growing number of academic statisticians are doing consulting. Nearly all large manufacturing companies employ statisticians and some have statistical consulting or service groups. Application areas include experimental design, quality control/assurance, modeling and market research. Governments employ people with a wide range of statistical training and skills who provide a broad gamut of statistical services. The federal government as of 1978 employed nearly 4000 people with the title of statistician (Eldridge, et al, 1982). Typical areas of emphasis include sample surveys, demography, biostatistics, analytical standards, and computer applications.

To offer one indication of how far statistics has come, Science 84 (November 1984) recognized statistical decision procedures for interpreting data in the face of uncertainty as one of 20 discoveries in science, technology, and medicine that "...rank among this century's most significant historical developments in any field." A condition for selection was that the discovery "...must have had a significant impact on the way we live or the way we think about ourselves and our world."

III. A TIME FOR CHANGE

The statistics profession can take a great deal of pride in its accomplishments in research and application in the last century. However, we must ask, "Are we putting our collective resources to work in a way that results in maximum benefit to both society and the profession?" We think not. In fact, we believe the opportunities for improvement remain enormous.

To realize our profession's potential, we need to focus on a process for change -- individually and collectively. There are many trends taking place in the world today that have affected and will continue to affect our profession's future. Some examples include rapid improvements in computer hardware and software capability, industry's evolving strategies to improve competitive position, increased automation of work functions and data collection, and government's growing responsibilities to protect the environment. At the same time, our profession continues to be plagued by a lack of public understanding of just what we do and the contributions we make. Somewhat paradoxically, we are struggling to provide an adequate supply of educated statisticians to meet demand.

We believe that focusing on the following areas will be necessary:

- o Identifying how we can better serve our customers
- o Developing programs to increase the value of statistical services
- o Improving the marketing of our services

Some ideas on how we can accomplish these goals are discussed in the following sections.

III.1 BETTER MEET CUSTOMER'S NEEDS

We might well do a self-analysis by asking, "Who are our customers and are we meeting their needs?" The "end products" of the university "manufacturing process" are people educated in statistics. The graduates in turn are "supplied" to employers who largely consist of academia, industry and government. The needs of academia are primarily for research and teaching, while those of industry and government are for application, teaching, and development. We feel most would agree that universities have done a good job in preparing statistics graduates for careers in academia, especially for the research function. They have not done as well in preparing them for careers in industry and government, where more emphasis on the practice of statistics and related personal skills is

warranted; but the trend is clearly improving. Universities can and should offer interesting, motivating, and relevant statistics training to students in subjects such as science and engineering. Such students have all too often been left with negative experiences, which translate to missed opportunties.

We believe that a larger proportion of university research should be motivated by real problems. That does not mean research not so motivated will not eventually contribute to solving real problems. It does mean that there always are critical needs to solve existing problems that will have impact that will be recognized outside the statistics profession. As any industrial statistician will tell you, the practice of statistics ferrets out many unique and interesting problems. Some of our field's most impressive accomplishments are the result of solving real problems (Box 1980). Continual improvement in supplier-customer (university-industry/government) communications (Hunter 1983) will help improve relevancy of research.

III.2 INCREASE THE VALUE OF STATISTICAL SERVICES

The vitality of the statistics profession lies in its ability to help advance scientific knowledge and solve important problems for the betterment of society. Statisticians performing consultative and collaborative functions are uniquely able, by virtue of their interaction with broad vertical and horizontal cross-sections of organizations, to provide leadership which can effect change in the way people think and act (Joiner 1985). The fundamental changes taking place today in the management of American business and in the use of computers provide many opportunities for the statistics profession to have a major influence on business and enterprise and, in turn, on our society in general.

These changes are largely the result of severe competitive pressure, especially from abroad. Many industries' very existence is being threatened. Organizational philosophies, structures and systems are being reviewed and revised. Quality improvement has been a major theme. It is now generally recognized that quality is profitable (see eg, Garvin 1983)

and has the single biggest effect on improved productivity and competitive position. Companies such as AT&T, Du Pont, Ford, General Motors, Hewlett Packard, IBM, Kodak, 3M - to name a few - have begun to undertake intensive efforts at establishing and managing quality programs.

To convince ourselves that the statistics profession can do better, we need only look to the Japanese. All the press about the success of the Japanese quality revolution and the important role that statistics has had, presents evidence that statistics is a necessary and critical ingredient to maximize the values of goods and services and to improve competitive position.

Classical statistical quality control methods have been available and used for over 50 years. Only recently have these techniques and other graphical and statistical methods enjoyed widespread application in the U.S., largely due to the business and computing changes to which we have referred. Since we have the attention of the business world, the time is right for upgrading technologies to meet the needs of various industries. In many cases, more efficient technologies already exist and are becoming widely used (eg, CUSUM control charts in place of Shewhart charts). In other cases, many opportunities for innovation remain (eg, control and release strategies for short production runs). We need to take better advantage of the power of the computer. There is no reason that we can't catch the Japanese or even "leapfrog" them (Marquardt 1984) if we properly utililze the computer to embody sophisticated and powerful statistical techniques in simple, easy-to-use packages.

III.3 IMPROVE THE MARKETING OF OUR SERVICES

Our discipline is poorly understood by others. Misconceptions of what statistics is all about are pervasive. The distinction between a professional statistician and a user of statistics is muddied. In general, we lack identity. Our profession has not successfully clarified these distinctions or promoted a broad understanding of the usefulness of our discipline. As long as we call ourselves statisticians and the layman identifies statisticians principally with those who compile sports

statistics, we will continue to reinforce the blur. Until the public, business and government, management, and science professionals better appreciate the important role that our discipline has in making sound policy decisions and advancing scientific knowledge, our profession will fall short of its potential to contribute to improving society.

In spite of the lack of broad understanding of our value, we are likely to be faced with a supply deficit of statisticians, according to a National Science Foundation report (AMSTAT News, April 1981). Only the deficit for computer professionals among science and engineering specialties is as severe. Further, with the increased industrial need for statisticians as a result of the quality revolution in the last few years, we can only expect deficits have increased. Moreover, Young (1980) noted a 10-year decline from 3.8% to 0.7% of incoming college freshmen planning to major in Mathematics and/or Statistics. Since statistics students have typically been recruited from undergraduate math majors, this statistic seems especially disheartening.

Clearly more needs to be done to attract students to statistics. Careers in the practice of statistics have much to offer. What other profession affords such breadth of application to other disciplines, employs such knowledge of math, computing, business, and other sciences, and provides such scope for interpersonal skills? Apparently, we have not adequately communicated these features to high school and college students.

In recent years, there has been growing understanding in the profession of the need for increased emphasis in the areas mentioned. For example, articles by Snee, et al (1980) and Eldridge, et al (1982) have addressed educational needs for preparing statistics students for careers in industry and government, respectively. Hogg (1985) has presented summary recommendations of the 1984 Conference in Statistical Education for Engineers. The American Statistical Association's Committee on Quality and Productivity has begun to synergize efforts in statistical education and management awareness. High school education in statistics is receiving attention from various sources such as the Quantitative Literacy Project (sponsored by ASA), the Visiting Lecturer Program (sponsored by Committee of Presidents of Statistical Societies), and the Delaware Voter Preference Survey (sponsored by Delaware Chapter ASA).

IV. TWO STRATEGIES FOR THE FUTURE

In the preceding section, we briefly discussed three areas we feel require increased emphasis for the profession in the years ahead. What can individuals practicing statistics in industry and government do to enhance the contribution that statistics can make? We offer two strategies that nearly all professional statisticians can continually work toward.

IV.1 LEADERSHIP AND INFLUENCE IN STATISTICS PRACTICE

The way we view ourselves is the way we behave. Typically, applied statisticians have viewed themselves entirely from a supportive role. We're behind the scenes offering help in someone else's research or experimental program, providing guidance, design, analysis, and interpretation of results. Consequently, we're viewed in many cases as subordinates and, cannot possibly provide the strong influence that is needed. We need to think of ourselves more as drivers rather than passengers. Leadership is the key. Leadership translates to the ability to guide, influence, and impact an organization in a lasting way. Leaders advocate the use of statistical products and services proactively rather than reactively. Our expertise is best used to "prevent problems" and "do the right job, and do it right the first time." If we teach this quality philosophy to our clients, we should practice it as well. For example, reactive salvage operations on poor quality data seldom can be justified on the basis of cost-benefits.

Dalton, et al (1977) describes a four-stage professional career model, the central activity of the fourth stage being that of shaping the direction of an organization. There is no reason why many professional statisticians cannot behave in a fourth-stage manner very early in their careers.

The following is a list of some recommendations for achieving a leadership posture in industry. Many apply to government and other organizations as well.

- Focus your attention broadly on the big picture. Understand the needs of the organization and work with the organization.

- Think and act like a scientist. Don't be afraid to speak out and present your conclusions, even when they're not popular. Offer recommendations, not just interpretations.

- Document your analyses, conclusions, and recommendations. Send copies of your reports to various levels of management in the client organization.

- Become "totally involved" with clients, organizations, and product lines (Marquardt 1979).

- Look for opportunities to market your contributions and recommendations. Seminars to management and jointly-authored publications or technical reports with clients are examples.

- Be sensitive to the needs of management. Avoid jargon. Speak the business language by relating ideas and results in terms of dollars, productivity, costs, benefits, and the like.

- Consider career moves to management that may afford greater influence and direction.

- Promote regular use of statistical methods.

- Get involved in activities with high visibility and influence such as quality policy committees, standards development, and dealing with customers.

- Develop marketing skills and approaches that heighten the visiblity and value of statistics.

- Enhance your image as a state-of-art expert by keeping up with the literature and being involved in professional societies at local and national levels.

Leaders teach others to become leaders by providing examples of ways to demonstrate leadership and being role models for others. We must think of ourselves as scientists who can make a difference, for otherwise, using an analogy of Bross (1974), we will assume the role of "shoe clerk" - the first lesson of which is "Anyone who acts like a shoe clerk will end up being treated like a shoe clerk."

IV.2 EMBODIMENT OF STATISTICAL EXPERTISE AND METHODS IN ORGANIZATIONAL FUNCTIONS

Much of statistical consulting is performed on a one-on-one basis. That is, a particular person has a particular problem and he or she needs some statistical help. In most instances, the entree to such statistical services depends critically on recognition by the client or client's management that the problem at hand could benefit from some statistical advice or analysis. The result often is a local solution to a local problem. In such interactions the statistical contribution is usually not as great as it could be or as widely recognized throughout the client organization as it should be. We need to look for ways to better market our services and tools so that they're used more extensively throughout all parts of an organization.

One way to do this is to embody statistical expertise and methods in procedures, processes, or systems in organizational functions that ensure regular and routine use in meeting business needs. As an example, the Japanese are renowned for taking American technology and optimizing its application. They use basic graphical, diagnostic, and statistical problem-solving tools as part of a "data analysis process." Here, statistical tools have been built in to the routine day-to-day functions, resulting in impressive benefits and recognition.

That is not to say that statisticians haven't made many important contributions to industry. They have. What is different is that in too many situations, the contribution is narrow or partial. It is not surprising that statistics is not widely recognized as a valuable and

indispensable part to producing high value goods and services. The perception is changing, with the increased attention on quality. The opportunity to impact on a wide basis is before us.

There are many examples in industry that could, and in many cases should, routinely involve or require statistical expertise or methods. Consider the following:

- Statistical methods integrated into a conceptual framework and implemented by software that meets specific organizational needs.

- Participation in the development of standard operating procedures for maintaining on-line quality functions.

- Standards for specification and review of test methods and procedures to properly assess accuracy, reproducibility, and calibration requirements.

- Use of experimental design protocols in strategies for product development, product optimization, and process optimization studies.

- Planning and analysis reviews with other scientists for all experimental efforts.

To effect these approaches usually requires a great deal of perseverance in selling management on the ideas and helping get organization buy-in. The examples sound easy enough, but to effect procedural changes in a business organization usually requires much effort, commitment, and leadership. In Du Pont, many in our group have been active for many years developing a comprehensive quality management system that is an integral part of the business functions in many organizations. Such systems activities serve to enhance the identity of the statistical scientist and collaborator and promote statistics as a widely valued component of an organization's business.

V. SUMMARY

Our thoughts, which have many similarities to the recommendations of Peters and Austin (1985) for business and other enterprises, are intended to inspire thinking about the future of statistics. Our profession has made some remarkable contributions to the way people behave and think. We feel, however, that the potential for greater impact on business and society exists. The realization of this potential is highly dependent on improving our profession's services.

Each professional has the responsibility to examine his or her personal agenda and commit to doing some thing to improve the marketing, teaching, research and practice of statistics. Many ideas have been suggested in recent articles (eg, Bradley 1982, 1983; Minton 1983) and in this discussion about what directions should be taken and what strategies should be used. Now what is needed is a sustained process to identify the most important changes and to develop and implement programs to make these changes a reality. Major change will begin only through the dedicated efforts of individuals and small groups. The effort will greatly benefit both the profession and society.

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TRANSFORMATION OF THE AMERICAN STYLE OF TEACHING STATISTICS

By Brian L. Joiner
Joiner Associates Inc.
Madison, Wisconsin 53705

This country is facing increasingly serious economic competition, and we statisticians have an opportunity to make major contributions. Some of us can help with the transformation of the American style of management (Deming, 1982; Joiner, 1985). Others can play an important role by leading the transformation of the American style of teaching statistics. This note is about the latter.

We have historically done a very poor job of teaching statistics; we will have to make major changes in the way we teach if we are to do our part to help America regain a leadership role in the international economic competition.

If we look at what we have been doing in the key introductory college course -- Statistics 101 -- we must give the classical version of that course a grade of "F". It is an abysmal failure. It has failed year after year, semester after semester and we still persist in teaching it more or less the same way we have been teaching it for 40 years!

I recently heard from a well-known statistician whose daughter, at his urging, had taken a Statistics 101 course in college. It turned out to be such a miserable course that his daughter has said she will never take another statistics course. This, unfortunately, is more the rule than the exception.

As we think afresh about the teaching of statistics, we should begin by being clear about the focus of our subject. Statistics, I believe, is best defined as "The science and art of obtaining and analyzing data." The key word here is "data." The focus of our subject is data, not random variation, although an understanding of variation is often important in interpreting data. Nor is our focus probability, although some understanding of probability is often useful.

We must learn to distinguish between what is the essence of our subject -- data -- and the tools which are useful in the proper collection and analysis of data.

The exploratory data analysis version of Statistics 101 is a bit better, in my opinion. I'd give it a "C". It at least addresses what you do with data once you have it. However, it misses the other, and perhaps more important part of statistics -- how to get good data in the first place.

In Statistics 101, we invariably get people bogged down in computations and formulas before they have any chance to see "why." We get people into statistical inference well before they have any idea why you would want to do that. We get them bogged down in degrees of freedom, standard deviations, square roots, (n-1)s and other such obscurities before they have any concept what these mean or why anyone would want to use them.

By implication of what we teach, students come to think that all data are good data, with a normal distribution and, more importantly, are statistically independent. We teach them to take any data presented to them and act as if it were fine to go ahead and compute t-tests and such things.

This is not the real world. You would never do that on anything that was important to you personally. At least, I wouldn't.

I was told of a very famous theoretical statistician who had a serious illness in the family. He started gathering data on that illness and looking at it using simple charts. He used none of the esoteric tools he had spent his entire career developing. He used the simple, basic charts and approaches that we skip in Statistics 101 in our rush to more sophisticated techniques.

The problem is compounded because most people who teach statistics have never practiced statistics. Thus, they have little feeling for what it is really like to gather and analyze useful data. Even those who have practiced statistics have seldom used it in their own lives on something that is really important to them. Many students still get advanced degrees in statistics without having ever had the experience of designing, carrying out and analyzing a single experiment or survey.

We have been so wrapped up in the elegance of formal statistical inference that we have missed the fact that that is not where people are starting from, nor is it where many of them should ever end up. Deming's work on analytic versus enumerative studies (Deming, 1950) is fundamentally important here, but almost totally ignored.

The goal we must seek is universal statistical literacy -- to have everyone in society data literate. Every one should know the basics of data collection and the basics of data analysis.

It seems relevant to suggest some recommended changes for Statistics 101. First, the focus of the course should be on data, not on inference or probability. In fact, it is my belief that there should be no probability or formal inference in this first introductory course.

Instead, the students should design and carry out experiments and surveys. They should collect and analyze their own data (An excellent reference is Hunter, 1976). The emphasis should be on the importance, and the difficulty, of getting good data. It is only by students actually going out and trying to gather data on some issue of importance to them that they can begin to appreciate the difficulty of getting meaningful data. They will then be in a much better position to appreciate and to learn useful approaches for the gathering of data.

Second, we should teach methods for the analysis of data. In this, we should focus on the creative plotting of data and on effective table construction. Creative plotting is, of course, very important but effective table construction, as Ehrenberg (1982) has shown us, cannot be neglected. Neither is sufficient alone; we must teach both.

Third, students need to become familiar with such basic concepts as operational definitions, types of data, stratification in design and in

analysis, blocking, pairing, confounding, lurking variables, pilot studies, and so on.

Fourth, we should show students simple, realistic models of sources of variation and use simulation (including computer simulation) to illustrate the effect of these models. We need to help them get a feel for what data look like when various plausible models are in effect.

Finally, we should ham it up a bit -- make the course more interesting. We can include things like taste testing experiments, appropriate simulations such as the Deming red bead experiment, living histograms and other activities that are fun and informative.

In summary, these are some of the fundamentals people need to have before they can go very far in understanding how to gather useful data and make sensible analyses. And these are some of the ways we have missed the boat in the way we have taught Statistics 101, our one and only shot at teaching most people statistics. They tend to come out of the current course disliking statistics and adamant that it is not useful. Indeed, they are right -- what we teach in that course is not useful. We must change the content to make it both more appropriate and more interesting.

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FUTURE DIRECTIONS IN STATISTICS

By

Blan Godfrey

AT&T BELL LABORATORIES

Holmdel, New Jersey 07733

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I agree with Brian that significant improvements are needed in the management of American industry and government, but I find all too often these days many executives fired up about quality and productivity leading the charge up the hill with no battle plan. The sad truth is that the thousands of troops (the engineers, the factory workers, the administrators, and the marketeers) following these executives up the hill are armed with sticks and stones, completely unprepared to do battle in the modern competitive world.

What can we do to change this in the next 25 years? I want to focus on three areas:

- A much closer coupling between statistics and computer science
- The teaching of statistics
- Getting the word out

STATISTICAL COMPUTING

I believe strongly that the key to getting good statistical methods used widely in industry is the creation of good statistical software packages, software packages that make it easier to do the job right than to do the job wrong. Good statistical software allows the user to concentrate on the problem, the solution of the problem, what the solution really means, and how the solution can be implemented rather than becoming bogged down in numerous

technical computational details.

The use of this software changes the whole scope of applied statistics. This software permits the exploration of a wide range of problems in the classroom. This software helps the student become well versed in problem solving strategies. Methods are not learned one at a time or in isolation, but rather methods are learned in connection with solving the type of problems that the user of statistical methods is going to face in the real world. If we are really going to help change American industry the good applied statistician in the future must be as familiar with the computer and the available statistical software as Fisher was with his tables or Walter Shewhart was with his sampling bowl.

When we have really good statistical software the way engineers, scientists, factory workers and managers view statistics will completely change. They will be able to tackle many problems that now require statisticians or statistical consultants and, all to often, are simply ignored and unsolved.

At AT&T Bell Laboratories we have been putting sophisticated methods for reliability prediction and evaluation, reliability estimation, experimental design and data analysis into the hands of engineers for the past several years. We are now beginning to give factory workers, administrative staff, and even managers basic statistical methods that allow them to analyze data from many sources and to construct good graphical presentations of the data and and the results. The use of the software supporting many of these methods is creating a revolution in the use and understanding of statistical methods from storeroom to boardroom.

All of the advantages of this new software will be wasted if we don't create a new awareness of the importance of statistical methods in government and industry and a new understanding of statistical methodology. To do this we must make major improvements in the teaching of statistics.

TEACHING OF STATISTICS

For too long we in the statistics profession have tolerated poor statistics teaching which produces courses that are often rated as the worse course or the most useless course that graduates in other fields claim they have ever taken. We too often teach what appears to the students a collection of unrelated methods illustrated by examples taken from coin tossing, card playing and dice rolling. And then we expect the students to be able to translate this wide variety of methods with simple gambling examples to complex industrial problems involving the application of a large number of methods.

We've ignored for too long the results of studys of people like Ernie Rothkopf, now Dodge Professor of Telecommunications at Columbia University, of how people learn. Ironically many of Ernie's experiments involved teaching basic statistics for two reasons. Statistics is something that most students know nothing about prior to the course, and statistics is a subject that is so easy to teach that it is simple to measure the effectiveness of different methods of teaching. These studies have shown that it is very difficult for students to translate from one type of example to another especially years after the material was presented. Students taught in the standard ways are able, months later, to solve problems involving coin tossing, card playing and dice rolling. But they are unable to translate these basic methods to real world problems.

Many leading statisticians have realized this for years. I heard very clearly at the Hogg Conference last year a strong emphasis on case studies and real problems. I heard people pushing for students to design experiments, to conduct the experiments and to present the results of the experiments in class. We have found the use of case studies at AT&T Bell Laboratories to be very effective in our workshops on reliability prediction, reliability estimation and experimental design. I think it is very important to carry this philosophy to every "service course" that statisticians teach. We need to show people in every field how statistics can be used to help them do their job better.

If we are really going to help others use statistics there is another problem with which we must deal. This is our tendency to pounce (with great glee) on anyone who has attempted to use statistics to solve a problem. No matter how well applied the method was, or how much impact the result had, we delight in publically denouncing the particular application by showing what should have been done, how much more efficiently we could have gotten the same result, and how the poor engineer's results are not unbiased, consistent, best asymptotically normal or even admissible. Rather than encouraging the wide use of statistics our action are often interpreted (correctly) as showing that it is dangerous to the careers of nonstatisticians to attempt to use statistics.

A major goal of all statisticians for the next 25 years must be to create an environment where statistical methods are widely used throughout industry and government (and even by other academic departments) by all types and all levels of employees. We can make remarkable progress towards this goal by combining a new dedication to excellence in teaching using real world case studys and examples and new statistical software that makes even sophisticated methods understandable and easy-to-use.

Recent activities are very encouraging. These activities are addressing the fundamental problem of getting statistics used by engineers, factory workers, high school students, business workers, grade school students and maybe even one of these days by politicians. A shining example of these efforts is the work of the American Statistical Association/National Committee of Teachers of Mathematics to bring statistical methods into the secondary school curriculum. Another encouraging effort is the Bob Hogg led conference on the teaching of statistics in engineering schools and industry. Bob and Harry Roberts are expanding this work under the auspices of the American Statistical Association's Quality and Productivity to the teaching of statistics in business schools. Other noteworthy examples include Brian Joiner's and Bill Hunter's work here in Madison, Brian Joiner's work with the Philadelphia Area Council for Excellence and, of course, Ed Deming's continuing efforts everywhere.

PUBLIC RELATIONS

To get statistics widely used in government and industry we must be far more aggressive in our public relations efforts. In the past few years the statistics profession, primarily stimulated by the ASA Committee on Quality and Productivity, has made a start. Articles have appeared in the *Wall Street Journal* and *Boardroom Reports* on using modern methods for robust product and process design, in the *Philadephia Inquirer* and the Madison, Wisconsin *Capital Times* on the application of statistical methods in both government and industry, and in many newspapers served by UPI and AP about the Hogg Conference and the Mohonk Conference. Many business magazines have carried stories about how statistical methods can help improve quality and productivity and the bottom line. Company wide seminars at du Pont, General Electric and AT&T called Statistics Days have brought the message to thousands of employees. Many companies have have internal front page or complete issue news stories on the revolution of the application of statistical methods within American industry.

We need to appreciate the impact that the popular press can have on our profession. Bradley Effron's and Carl Morris' article in *Scientific American* on James-Stein estimation inspired a complete change in the way AT&T measures and reports quality throughout the company, NBC's ninety minute special, "If Japan Can, Why Can't We?" made thousands of American executives aware of serious problems in American quality and productivity and led to changes in the careers of many statisticians.

We have a long way to go before we can come close to the passion for statistics in Japan, a country with a national statistics day with a graphical statistics contest that attracted over 29,000 entries, a country where the leading newspaper has a column every Friday on statistical quality control, where the Tokyo train schedule is a bivariate stem-and-leaf diagram, where almost every factory worker uses basic statistical methods daily, and where over one-million designed experiments are conducted in industry every year.

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