PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

The Statistician's Stake in the Managerial Revolution [and Discussion]

M. Tribus, S. J. Morrison, B. Abraham and D. Holmes

Phil. Trans. R. Soc. Lond. A 1989 **327**, 487-498
doi: 10.1098/rsta.1989.0005

Phil. Trans. R. Soc. Lond. A **327**, 487–498 (1989)
Printed in Great Britain

The statistician's stake in the managerial revolution

By M. Tribus

American Quality and Productivity Institute, 350 *Britto Terrace*, *Fremont*, *California* 94539, *U.S.A.*

Ever since the building of the pyramids, certain ideas about management have been adopted without question by generations of managers. The modern industrial complex requires a different approach to management, one that breaks with the old traditions and even some recent highly touted fashions. The differences between the classical style and the new style are fundamental and require a complete re-education of managers at all levels.

In the new style of management, statistical reasoning plays an essential role. The applications that will be posed are often quite different than those for which statisticians have been trained.

Any enterprise that intends to compete in world markets will find it essential to be managed in the new style. In the transition process statisticians will need to learn to be mentors as well as advisors.

Introduction: the managerial revolution

It is an honour and a privilege for an amateur statistician to be invited to present this paper. I use the word 'amateur' in the proper sense, describing someone who does something for the love of it. There is a unique satisfaction in solving problems, especially those of statistical inference. Some people find their diversion in crossword puzzles; I like to do statistics. Problems of statistical inference have a peculiar hold on the mind and I envy professional statisticians for being paid to do what I yearn to find time to do myself.

My message is very simple. A different way to manage enterprises is now gaining acceptance in many parts of the world. The adoption of this new way to manage is essential to survival in any nation that wishes to compete in world markets. Statistical reasoning forms the central core of this new way to manage. There are therefore important responsibilities and opportunities for statisticians in this managerial revolution. This new way to manage will only succeed in those places where statisticians become more active in promoting not only statistical methods but also the new way to manage.

This different way to manage owes much of its character to the four statisticians, Shewhart, Deming, Juran and Ishikawa. They started this revolution; many others have now joined the fray.

In Japan, the Japanese Union of Scientists and Engineers (JUSE), which has been encouraged and guided by Dr Ishikawa from its beginnings in the 1940s, has played a very strong role in this managerial revolution. JUSE has devloped courses of instruction in management which are based firmly on statistical thinking. Japanese managers spend as much as 250 h on JUSE courses where they learn how to use statistical reasoning in managerial situations. Graduates of these courses often say, 'It's a new way to think'. Through this kind of instruction and through their administration of the Deming prize, JUSE has been an important instrument in the recovery and eminence of the Japanese economy.

Statisticians have, for the most part, considered their role to be strictly advisory, and it may be difficult to persuade them to assume a more active role.

I can picture a statistician saying his prayers at night, 'Dear Lord, use me in thy service, in an *advisory capacity* of course!'

It seems to many people that statisticians want to spend their lives in the lower-left quadrant of figure 1, and that they will assume anything except responsibility. I have marked on the figure the pathway statisticians should follow if they want to be part of the solution and not part of the problem.

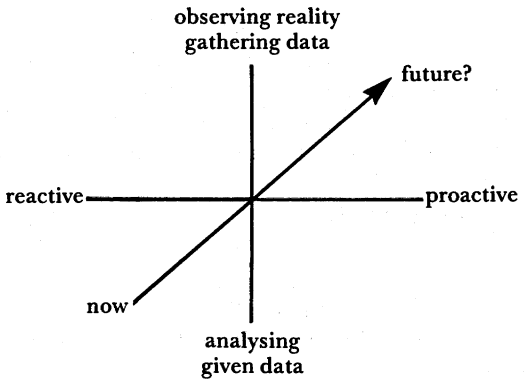

FIGURE 1. The path for statisticians who wish to be helpful in improving management in their country.

My message on that score is very clear. Your country cannot afford the luxury of only reactive statisticians. You, as statisticians, need to learn how to go out and find problems before the problems find you and your company and your country.

When this country was at war and someone was seen not to put forth their best effort, the rallying cry was, 'Don't you know there is a war on?' Today, in many ways, this country is under siege again. When a country is economically overwhelmed, harsh social stresses are created: people lose their jobs; young people cannot find career opportunities; crime rises; political stability is undermined. In short, the very fabric of a society is threatened.

I firmly believe that the key to regaining economic vitality is in the adoption of the new way to manage. If the new way to manage is to succeed, the statisticians will have to find their way into the upper-right quadrant of figure 1. Statisticians will have to be heard. They will need to learn how to contest for power.

Fortunately, we are beginning to see a spread of this understanding in many places. In the U.S.A., the American Statistical Association has undertaken to form a committee dedicated to the promotion of the use of statistics in industry. They have put pressure on professors of engineering to include statistics in the education of engineers. In June 1988, they sponsored a conference with the title, 'In Making Statistical Reasoning Mainline for Engineers and Managers, What Works, What Doesn't and What Might?'

George Box has organized a centre for quality at the University of Wisconsin in Madison, and has joined with the School of Business to promote courses for industry.

In the U.K., the Deming Association will meet in Sheffield in May 1988 under the guidance of Dr Henry Neave, who is committed to the task of awakening managers and statisticians to their duties. This Symposium and Dr Neave's meeting suggest that at least some statisticians understand the challenge and intend to do something about it. Much more effort will be needed.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Some essential aspects of the 'new way to manage'

The essential difference between the more traditional ways to manage and the new approach lies in the way the activities of an enterprise are conceptualized. In the more traditional approach, people think about an enterprise in terms of an organization diagram. For example, when asked how the work gets done in a research laboratory, the laboratory director will probably show an organization chart similar to the one in figure 2.

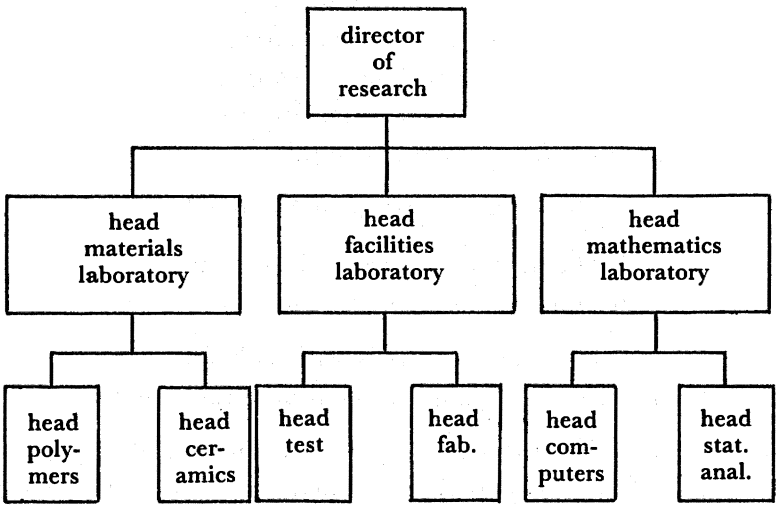

Figure 2. The traditional managers organization chart.

Figure 2 is a very simplified organization chart, drawn only to make a few points about traditional management. It is well known that an organization chart has very little to do with how work gets done. In most organizations the work gets done in spite of the organization. What these charts reveal is how authority is distributed. The first thing people do is look at a chart to see where they are placed on the organization's totem pole. Organization charts have much more to do with who gets to boss whom than with how work gets done.

The organization chart has a central place in the traditional way to manage because it reflects a value judgment that has a long history.

Ever since the building of the pyramids,
management has been a privilege,
labour has been a commodity.

This value judgement is no longer viable
in the era of the knowledge worker.

In the new era of fierce competition, it is essential that all the parts of an organization work harmoniously together. Creating harmony of purpose and activity in all parts of the enterprise is now the central challange of a manager.

The manager's job has been redefined. Whereas the people work *in* a system, the job of the manager is to work *on* the system, to improve it with their help.

In the old way to manage, the manager is expected to define clear responsibilities for all the

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

people, according to their place on the organization chart, and to give them targets for their individual performance, rewarding them accordingly. In the new way the manager focuses attention on the systems, practices, procedures and protocols, in other words, the system as a whole. The challenge is to develop a sense of teamwork and to find ways to improve the processes whereby work gets done. In the new way to manage, improvement is a way of life. The old adage 'if it isn't broken, don't mend it' gives way to 'stress the system to find its weakest points, then improve it'.

This new philosophy requires managers to develop new skills. Most of these new skills are not taught in schools of management today. Indeed, many of the skills that are taught in schools of management can, on close examination, be seen to be more related to getting and holding onto a privileged position than to making the enterprise healthy.

I work closely with an engineer who was born and educated in the Soviet Union. He defines the relation of a manager to the Soviet system like this.

The workers work with *both* hands.

The managers work with *one* hand.
(With the other they hold onto their chairs.)

Top managers work with *no* hands.
(They need both hands to hold onto their chairs.)

Mr Gorbachev will find that the new way to manage has a very tough time gaining acceptance in the U.S.S.R. Unfortunately, my remark about Soviet managers all too often applies to the managers in many of our own corporations. Inside the modern corporation, the environment often resembles a Soviet bureaucracy. At least that is what several of my friends recently returned from the U.S.S.R. tell me.

In the old-fashioned way to manage, the primary objective of managers seems to be to develop the skills which help them to go up that organization chart, not to improve the system.

This emphasis on getting up the organization has an interesting side effect. Everyone strives to look good in the eyes of his immediate superior. When there is a problem, everyone tries to hide the problem by writing reports which suggest that there is no problem or the problem lies elsewhere. Reports to superiors are 'sugar coated'. Each manager up the chain of command puts another layer of sugar on the report until when it finally reaches the top, the hapless executive cannot tell if anything is really wrong, and if it is, how to put it right.

In the new way to manage, each manager instructs those at the lower levels to 'serve the customer'. The objective is to make every process serve the next step in the process. The new kind of manager concentrates on seeing how to improve the way the next person in line is served. The new way to manage follows the dictum, 'Everyone has a customer. The next person in line is your customer. Each person should strive to pass only quality work to the customer. Only customers can define the meaning of the word 'quality'.'

In the traditional approach to management, despite the slogans, it is understood within the enterprise that customers are there to be exploited, not served. Figure 3 illustrates the traditional approach.

Under the new way to manage, each manager is expected to inquire into how well the internal customers are being served and to seek ways to help subordinates to do a better job.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

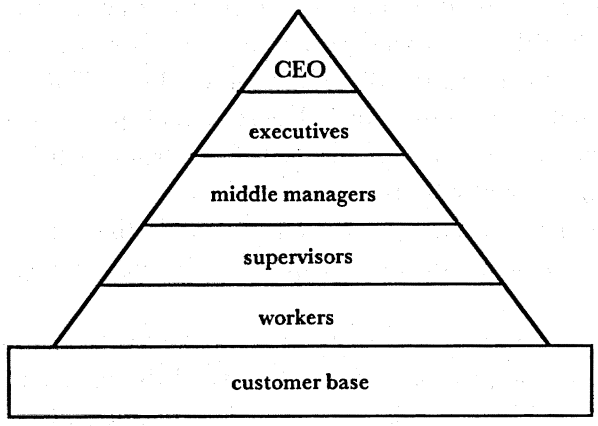

FIGURE 3. The traditional view of the relation of the enterprise to the customer. CEO is chief executive officer.

Figure 4, from Don Nordeen of the General Motors Company, illustrates the new approach.

Of course, the entire approach will not work if executives at the top do not follow it themselves. The person at the top must be more than a manager. The CEO must be a leader.

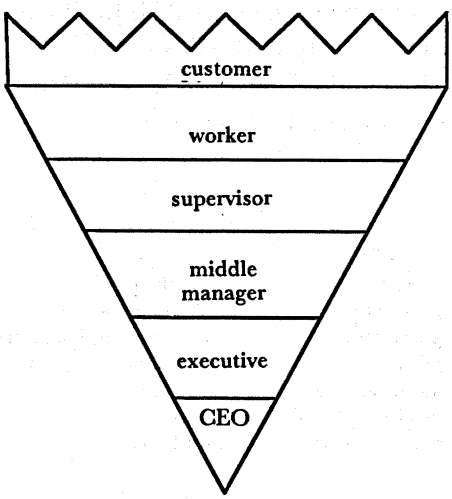

FIGURE 4. The new way to manage; the customer is 'king'.

Unfortunately, when the phrase 'quality management' is used, too many people think at once of statistical quality control or, even worse, the inspection of mass produced products to see that the bad stuff does not reach the customers.

In many companies there is a belief that, because their employees are not involved in repetitive work, there is no use in trying to apply quality management techniques. First of all, this attitude betrays a confusion between statistics and quality management. Quality management encompasses much more than statistics; it is a style of management which treats quality as a 'means', not an 'end'. Quality management uses the rule, 'quality is never your problem, quality is the solution to your problems'.

According to this rule, whenever there is a problem, the manager examines how the work

is being done and concentrates attention on the improvement of each and every process associated with the work. When this kind of management is used, one can see that while the goods and services flow 'downstream' there is another flow of information about needs for quality and quantity which flows 'upstream'. The system of 'just-in-time' delivery of products is based on this idea. The information about needs flows from each internal customer to each supplier and controls the flow of materials and services.

In the new way to manage, each manager checks to see that those at the lower levels are working to improve the system and are helping their subordinates to better serve their customers.

Another important characteristic of quality management is to focus on processes. Pay close attention to the quality of the process and the quality of the product will take care of itself.

It is essential to distinguish between the concepts of *quality* and *features*. Features are what you put into your product or service to appeal to the customers you have elected to serve. Quality has to do with the integrity with which you provide those features. If you watch only the products you are guiding your operation on a lagging indicator. Paying attention to processes means watching leading indicators. Managing by watching products instead of processes is like guiding an automobile down the highway by watching the white line in the rear view mirror.

The principle of improving processes to improve products applies to services as well as goods. Table 1 lists various products and the processes which produce them. If there is dissatisfaction with the product in the right-hand column, the dissatisfaction can only be removed by paying attention to the entry in the left-hand column. Only one of the seven processes described here has goods as its output; all the rest produce services.

TABLE 1.

process	product
design	specifications
production	the goods and services
purchasing	materials and services
sales	customers
maintenance	services
product planning	strategies
management	guidance

This line of reasoning brings up the cost of quality. Unfortunately, many people still believe that high quality means high cost. This is not true. The following principle is based upon many years of observation. The best way to reduce the cost of goods and services is to increase the quality of every process in the system. When the system is working smoothly, without flaws, blunders or errors, and without the need for rework, the product will be of high quality and low cost. Customers and workers will be happier and the company will prosper.

Another rule of managerial decision making is due to Juran. Juran has observed that when things go wrong, most often it is a problem with the system, not the people. To quote Juran, 'Whenever there is a problem, 85% of the time it will be with the system, 15% of the time it will be with the worker'. Most people have trouble with this rule.

Under the new way to manage, we should expect bosses to be much more humane in their approach. To test this hypothesis, I have shown table 2 to over two thousand people. When I

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

TABLE 2. NUMBER OF FLAWS PER WORKER PER WEEK.

	1	2	3	4	5	6	7	8	9	10	11	12	sum
Mary	0	0	0	0	0	0	0	0	0	0	0	0	0
Joe	0	0	0	0	0	0	0	0	0	0	0	0	0
Eva	1	0	0	2	0	0	3	0	0	1	0	0	7
Fred	0	0	0	1	0	0	2	0	0	0	0	0	3
Jim	0	0	0	0	0	0	0	0	0	0	0	0	0
Ed	0	0	0	0	0	2	0	0	0	0	0	0	2
Kate	0	0	0	0	0	0	0	0	0	0	0	0	0
Carl	0	0	0	1	0	0	0	0	0	0	0	0	1

asked them what they would do if they were the supervisor of these people, I got similar answers from all of them: 'Fire Eva', 'Counsel Eva', 'Put Eva on notice', 'Ask Mary to tutor Eva', etc.

People were often surprised when I told them that the numbers were produced on my computer with the help of a random number table. Even though I introduced these data just after announcing Juran's rule, people did not start by thinking that most probably the problem was in the system. They blamed the worker. In one instance, even after I told him how the data were gathered, one manager said to me, 'Even so, I would still talk to Eva'. In four years, only one person, a statistician, suggested that the first thing to do was to examine the data.

AN IMPORTANT TOOL FOR MANAGERS TO LEARN

One of the most important new skills managers need to develop is the ability to examine how work gets done and how to improve it. When the task is to make a pair of shoes or to produce a steady stream of circuit boards, it is not too difficult to see what is going on. But today is the era of the knowledge workers whose output is not a physical item, but rather an intellectual product. The processes they use are not so easily seen by those without the proper training.

An important tool of management is the flow chart drawn on a 'people coordinate'. To illustrate how this tool may be applied and its importance to statisticians, consider a process which might be used to initiate the development of a new product. I have chosen this kind of process as an example because the output is intellectual; it is more typical of what knowledge workers produce than the output of manufacture which is so often used in this field.

The symbols used in the flow charts which follow are shown in figure 5. At the top we use a 'people coordinate' which shows how people interact with one another and with the process.

Figure 6 shows an overview of the start of the process. The shadowed box in figure 6 indicates that more detail is available on a separate diagram, as in figure 7.

If we return to the manager's redefined job, it may be seen how diagrams such as figures 6 and 7 may be helpful. For example, this portrayal of the work process can be used as the basis for a discussion by all the people who participate in it ('improve with their help') to verify that it represents the way the work is actually being done. We find that, in general, managers do not know what is going on. When challenged to develop a flow chart, they invariably find that the way the work is done has little to do with their understanding. They often find that the workers have devised their own procedures simply because the ones the manager (or the production engineer) has developed are unworkable. Many times people do what they do because 'we

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

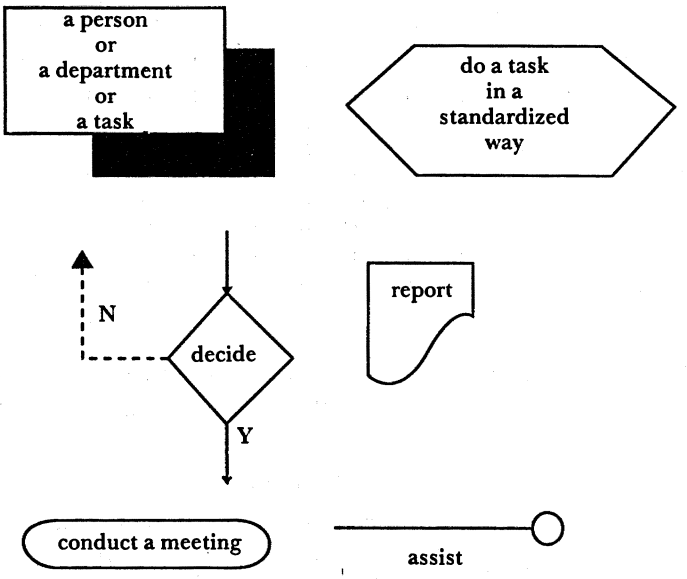

FIGURE 5. Symbols often used in flow charts. The shadowed areas indicate that there is backup material on another diagram.

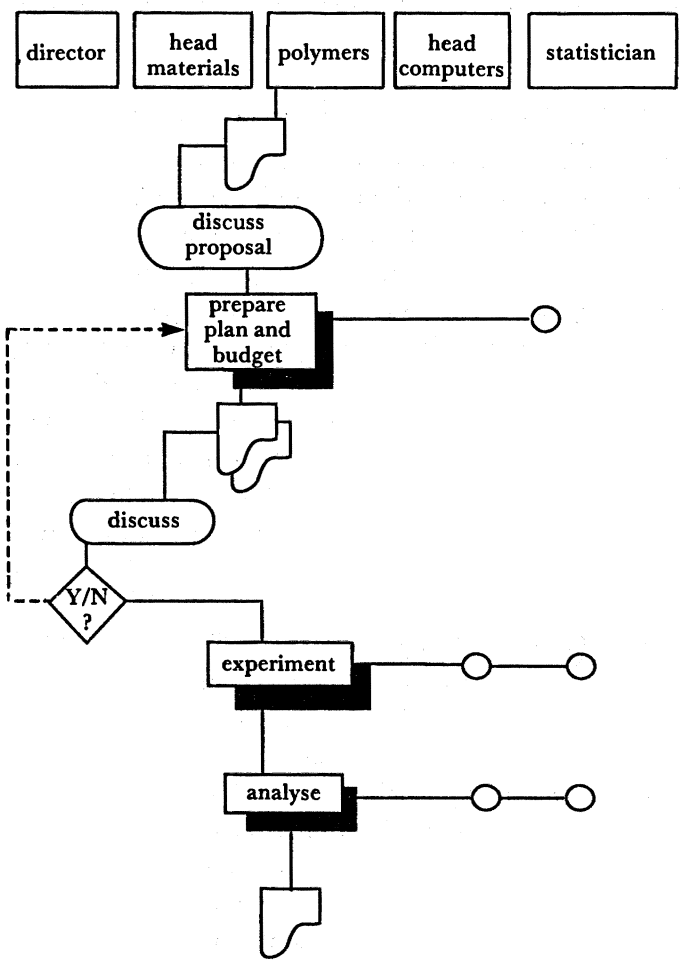

FIGURE 6. Flow chart depicting how a research project is initiated.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

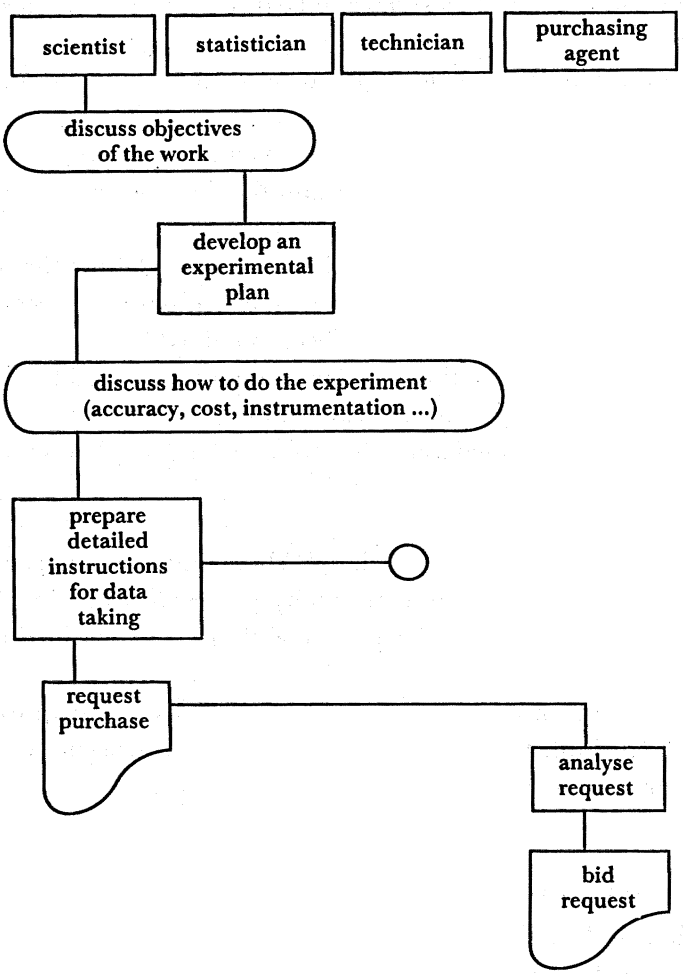

FIGURE 7. A more detailed view of the planning process. Each box, representing a task, may be examined in ever finer detail to the level of complexity required.

always did it that way'. When this analytical tool is used, people become aware they indeed are living 'unexamined lives'.

The technique has several interesting features.

1. The diagram has a horizontal 'people coordinate'. When an activity occurs under the name of a person or department, it means that that person participates in the activity. The vertical line at the top of the activity indicates the person in charge.

2. Moving down in the diagram corresponds to the passage of time.

3. A horizontal line defines a 'supplier' and a 'customer'.

4. A dashed line flowing upwards indicates a wasted effort.

Once a diagram such as the above has been drawn, the skilful manager can raise a number of important issues.

1. Whenever there is a horizontal line, it represents a 'supplier' and 'customer' relationship. The manager can inquire,

(*a*) Does the supplier understand what it means to provide high-quality goods or services?

(*b*) Have the supplier and customer talked to see if there are opportunities for improvement?

(*c*) What are the barriers which ought to be removed (by the manager) to make it possible to do a quality job?

2. Whenever there is a decision symbol, the manager can inquire,

(*a*) Do the people who feed information into the decision process understand the basis for the decision?

(*b*) Has the decision-maker promulgated reasonable rules for the decision process?

(*c*) What is the history of the process? How many times has it been necessary to 'loop around the process' before a decision has been obtained?

3. Whenever there is an indication that one department is supposed to assist another (a circle on the same line as a process) the manager can inquire,

(*a*) What is the mechanism whereby the service is rendered? How well has the customer been served?

(*b*) What gets in the way?

Diagrams such as these also raise the question, 'Who, if anyone, is in charge of this process?' In many companies it is found that there are many processes which just happen. People are doing things the way they have always been done with no one identified as being responsible to see that improvements are made.

Of course, these diagrams provide an excellent basis for a statistician to define areas where data collection can be fruitful. Furthermore, if the manager is working with such diagrams, it will be evident to him why a statistician can be of assistance.

Why statisticians should be proactive

In this brief review, only a few of the principles used in the new way to manage can be presented. With these as background, let me now turn to the role of the statistician.

It is rare to find a statistician who feels that the work he does is fully appreciated in the enterprise. This is to be expected in the old way to manage. However, in the new way to manage, every manager should be able to do and understand a statistical analysis. Statistical reasoning should be at the core of his thinking.

Statisticians have an important role to play in the training of the other people in the enterprise. If everyone is to help the managers improve the systems, everyone in the enterprise will need to know elementary statistics.

I have only talked about flow charts, but there are many other techniques of importance in the new way to manage such as control charts, run charts, scatter plots and the like. Managers interested in improving things will be forced to learn about the design of experiments. They will have to learn that it is foolish to try to improve a system which is out of control. They will appreciate statistics and competency in statistics when they understand that their survival depends upon it. Under the old system they had very little need; they just made demands on everyone and neglected their responsibilities to improve the system.

Every engineer needs to know enough statistics to make use of designed experiments. The companies that know how to compete do not pretend that they live in a deterministic world. Their employees know that variability is present in everything and needs to be taken into account. Who will be there to guide their learning and provide the consultation?

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

The task before us is awesome. The entire workforce will need to be trained to use elementary statistical reasoning. Who will supervise the training if not statisticians?

With an educated laity there will be more work for the professionals. Therefore, I say that statisticians have a very important stake in how this revolution turns out.

Under the new way to manage, the bosses will see that statistics is every bit as important as accounting and will pay the head statistician just as well as the vice president of finance. Because statisticians are trained to think in statistical terms, they can see many things about an organization which cry out for statistical analysis. They need to be empowered to go out and find these problems. Until they are, they need to be more forceful. If some of you don't get fired for overstepping the boundaries of your jobs, that will be evidence that you are not trying hard enough. In this war it is likely that a few soldiers will have to be killed.

To summarise, statisticians need to become more active in this managerial revolution because, comrades, come the revolution, you will be recognized for your worth and for your ability to contribute. It is in your interest and the interest of your fellow citizens that this revolution succeeds.

Discussion

S. J. Morrison (*University of Hull, U.K.*). I wish to make two comments on Dr Tribus's paper, one on quality management, and one on statistical training.

It is appropriate that management is the topic of the opening paper of this conference, for it is axiomatic that quality begins in the boardroom rather than on the drawing board. Statistical control charts do not solve problems they merely identify them. The problems do not get solved unless management is committed to solving them.

For far too long there have been too many firms lacking in this commitment, and too little evidence of management training on the scale that is needed. In 1983 a survey of the whole of higher education in the U.K. revealed a proliferation of the teaching of quality assurance in higher education and further education colleges, but virtually nothing in business schools and management education departments of universities. The emphasis seemed to be on the training of technicians rather than on the training of management.

Until quality management is introduced as a principal subject in management education we are unlikely to see the new generation of quality-oriented managers that is needed to get British industry back on the rails. In enlightened firms, it is recognized that quality cannot be 'bolted on' to the product after it has been designed and made. Similarly, there is no good reason for bolting quality management on to young managers after their basic training; it should be an integral part of it.

Dr Tribus gives statistical reasoning an essential role in the new style of management, but what sort of training is necessary for this to be accomplished? Driving schools do not teach their pupils the principles of mechanics, electronics, thermodynamics, tribology, etc.; they teach them how to use the vehicle that puts these technologies at their disposal. Similarly, engineers need to be taught to use statistical methods, and managers to understand them. Neither need to be taught mathematical statistics. Mathematical statistics and applied statistics are two distinct skills which should not be confused.

M. Tribus. Mr Morrison's views correspond entirely with my own. After the meeting he gave me a copy of one of his essays on the importance of education in quality management. I wish it had been distributed to all those who attended.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

B. Abraham (*Institute for Improvement in Quality and Productivity and Department of Statistics and Actuarial Science, University of Waterloo, Canada*). The Institute at which I work has been involved in statistical training in industry for the last two years. Top managment and engineers seem to be very enthusiastic. However, middle management who are instrumental in approving release for further training, the running of experiments, etc., do not seem to be convinced. Could Dr Tribus make any suggestions to get these people interested?

M. Tribus. Mr Abraham raises the question of how to involve middle management. The answer depends upon where you are in the enterprise. If you are also in middle management, you can only look after your own operation and try to make of it an example that does not, however, invite enmity. If you are below that level, it is not within your province to do anything. If you are in the upper levels of management, however, there are many things you can do. First, you can be an example of what you preach. Second, you can ask your subordinates what they are trying to improve and how you can help. You can recognize good progress in quality improvement.

What I am stressing is that this change in culture cannot be 'managed', rather it must be lead.

D. Holmes (*School of Information Science and Technology, Liverpool Polytechnic, U.K.*). I wholeheartedly agree with Dr Tribus and join him in his plea for interested statisticians to rise to this challenge which is of vital importance to competitiveness within the U.K.

In my experience the hardest part managers face is identifying their customers. For example, it is not hard to convince them that a dangerous child's toy is junk at the design stage; however, getting them to identify a customer who would want such an item is asking for a value judgement on relevant quality levels. The concept of an 'ideal customer' is well known in the catering industry, where refusing admittance is of vital importance to long-term survival.

In the new operating philosophy it is essential to work in teams whose purpose is to be loyal to the product and not to the department or profession. It seems hard for statisticians to define their customer set! What are Dr Tribus's views?

M. Tribus. Dr Holmes asks on behalf of statisticians 'Who are our customers?' The purpose of an enterprise is to create a customer. There is no customer until someone creates a product. In that spirit I would turn the question around and propose, as I did in the lecture, that statisticians become much more active (I believe the current fad is to say 'proactive') in creating customers. My friends who are involved in statistics in Japan say that the biggest problem is to persuade a statistician to forget that he is a statistician. And do not try to define the 'customer set'. It is not a given set. You must create it and the sooner you set about learning how to create customers, the sooner you will be part of the solution.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES