STATISTICS Newsletter ©

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Chair's Message

by Beth Propst

I hope you have all had a fun-filled, event-packed holiday season. As I write this, the holidays have not yet arrived. My term as Chair of the Division is half over ... and it's all down hill from here! I have recently returned from the Fall Technical Conference, which was a fun-filled, event-packed three and a half days in Scottsdale. While there, I learned about so many exciting initiatives for the Division, I barely know where to begin. Perhaps I'll take them in order of occurrence.

Those who attended our Wednesday evening Council Meeting were able to see first-hand the mock-up of the Statistics Division Home Page, thanks to Mark Kiel. Many of you may have already accessed it by the time you read this. If you haven't, come visit us soon. The good news is that it's big and bold and colorful — the bad news is that you have to look at pictures of the officers. Oh, well ...

Don Emerling and I had breakfast one morning with Ray Waller of the American Statistical Association. He is interested in working with our Division in sponsoring courses for applied statisticians that can be offered around the country. I don't suppose a lot of you think of yourselves as applied statisticians, but you might be interested in learning some of the things that applied statisticians know. More work will occur on this in the coming year.

The Friday afternoon session presented by the Statistical Thinking Tactical Plan Team (Roger Hoerl, Don Emerling, Lynne Hare, Galen Britz, and Janice Shade) was received really well. This team will now be developing a one-day short course, which should premier in the near future. Anyone who is interested in having such a short course put on in their area (probably in conjunction with a local conference) should contact one of these folks.

During Saturday's Tactical Planning Meeting, we spent a lot of time talking about the Statistical Thinking Virtual Academy. Currently, we are planning to link it to our home page. The tactical plan team will demonstrate the Virtual Academy at the AQC Statistics Division booth. Anyone who stops by the Division booth will have a chance to experience the Academy in live-action!

Finally, the Publications Committee met, specifically to discuss the How-To booklets. As a result of this meeting, I spent some time meeting with Roger Holloway of Quality Press to present our views and hear his. Sometime between now and the end of January, key people from our Division and Quality Press will meet to frame future publications. I don't know what they will look like (where's my crystal ball when I need it?) but I am convinced it will be a significant step forward in our ability to get the kind of information people need in the hands of the people who need it and in a format that they can use.

That's it for the Fall Technical Conference. Now it's time to talk about Quality Congress. Last year we initiated a change in our newsletter schedule. Instead of a spring edition of the newsletter, we now publish a Special Publication. Our intent is to tie it to the topic of the Division session at the previous year's AQC. This year we will continue that policy. We haven't titled this publication yet, but Tom Swails (our presenter last year) will be the main author. This means that all of the Division information about Quality Congress will be in this issue (see article elsewhere in this issue). So, if you decide to come to beautiful Orlando in May, stop by and see us at our booth or at one of our meetings. Come to the Division session or our hospitality suite. And above all, keep those cards and letters (or e-mails) coming! Δ

Inside This Issue

Editor's Corner

Happy New Year! This issue recaps the activities from the Fall Technical Conference, held in Scottsdale, Arizona, and shares the continuing initiatives of the Division tactical planning teams. The Youden Address, presented by Jim Lucas, is also in this edition. We will then look ahead and discuss Division-related activities and sessions at the AQC, which will be held in Orlando, Florida.

As a reminder, there will be no Spring newsletter. As a result of the overwhelming positive feedback regarding last year's submission, a Special Publication will once again be distributed. This year's publication will be based on Tom Swails' 1996 AQC presentation entitled, "In Search of the Future: Models and Methods for Whole System Change".

In response to address corrections, several members have made requests for address changes. The Statistics Division does not keep a member address list. All newsletter labels are sent directly to the printing company by ASQC. If anyone requires a change of address, please contact ASQC. There, your information will be updated, and all publications from ASQC will be sent to the correct address. Finally, please note that my electronic mail address has changed to Shadej@Nabisco.com. (For those of you who used my old address, the new one is not as challenging!)

Janice Δ

Letter to the Editor

Dear Ms. Shade:

I have been working as an applied statistician for quite sometimes, and have worked in the quality/productivity, research and in the academia. Currently, I work as a consulting statistician.

In some past issues of the newsletter, I have read with interest, articles published on EWMA There are some statisticians who are concerned about the widespread misuse of statistical methods and perhaps EWMA will be used widely as an 'alternate' to a regular control chart.

Along with many others, I have used the EWMA and regular control charts in real life situations. In the domain of quality Improvement, with process control in mind, one has to be very careful in selecting statistical techniques and methods to be used. And this decision is by far dependent on the nature of the process and its demands rather than any personal liking or disliking of the individuals responsible for the process improvement.

I do concur with the opinion that, EWMA should not be used as an alternative to the regular control charts under regular conditions. There is no reason to do that. The regular control charts are far less complex to handle for such occasions. However, process monitoring is done with the intention of controlling the process. Any serious engineer or statistician in his/her right mind, will not go into all the trouble of installing a process monitoring system without the intention of controlling it. The whole purpose of process monitoring is to find out when the process goes out of control and then to use methods to control it.

So, if someone has initiated 'process monitoring', I just take it that there must be an intention of controlling the process. The 'monitoring' is just to know the real status of the process and a 'prelude' to controlling it. If the process is found to be stable and under control, for a fairly long period of time, the monitoring can always be discontinued, if needed. Such decisions are usually made based on other considerations.

The purpose of EWMA is to use it on specialized situations. In case the zone of acceptance is narrow, there are too many short oscillations and there is an element of prediction involved and is desired. Using EWMA instead of a regular control chart in such situations will make a difference.

It will smooth out those oscillations and help study the process. The smoothing is done by assigning variable weights to the observations instead of a constant weights as in a regular process control chart.

Usually, observations are assigned weights in a progressively decaying pattern. Thus the older observation has lesser weight than the recent observations. This decision is made by minimizing the Mean Squared Error (MSE), in prediction when different values are assigned to the weight factor.

The value which minimizes the MSE is taken as the prediction parameter for the prediction model. For a particular process, it is advisable that the nature of the process and its oscillations be studied first by recording the data, before making a selection between a regular process control chart and an EWMA chart.

To use EWMA as a prediction model is helpful in a process control situation, and Dr. Stu Hunter in his mini- paper presented a situation how it can be done.

Sincerely,
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SPAIG Update

Ron Randles
University of Florida

In 1992, Ron Iman urged the statisticians leading academic programs, and those leading corporate statistics groups, to work together to further their common goals. Since then, these groups have met jointly at the Joint Statistics Meetings and have carried out a number of initiatives, including the publication of internship opportunities for students. More recently, Ron Iman challenged both groups to form partnerships between an academic program and an industrial or governmental unit to create closer working relationships. Toward this end, a Statistics Partnerships among Academe, Industry and Government (SPAIG) planning committee met in August of 1996 to plan a partnership conference for the spring or summer of 1997 and to discuss other initiatives that would enhance these relationships.

As one of its initiatives, SPAIG is creating a WEB site which will contain a list of faculty members at academic institutions who are willing to present either seminars or shortcourses for industry or government employees. This list is created to promote interaction between academic statisticians and their colleagues in industry and government, to encourage continuing education opportunities for government and industrial statisticians and to provide speakers who might promote the use of statistical expertise and methods in industrial and government settings. Seminars are encouraged at a variety of technical levels, but must be designed to address practical statistical issues which the audience faces in their work.

The list is self subscribed. No effort will be made to screen it by SPAIG. The presenter is solely responsible for the content and style of presentation. The presence of a faculty member's name on the list does not imply the endorsement of SPAIG.

The WEB site is located at http://www.stat.ufl.edu/spaig.html. It can be accessed from the Statistics Virtual Library page, the American Statistical Association home pages, and the SPAIG home pages. The site shows instructions for creating an entry. Δ

1997 Quality and Productivity Research Conference

The 14th annual Quality and Productivity Research Conference will have a focus on Design of Experiments. It will be held in Orlando, Florida on May 12-14, 1997.

The 1997 conference program includes:

Fractional Factorials - Fifty Years from Finney by Peter W. M. John, Keynote Speaker.

Multiple Responses in Design of Experiments, session organized by Enrique del Castillo.

Design of Experiments Case Studies, session organized by Anne Freeny.

Panel Session on Teaching Statistics to Engineers and Scientists, organized by Ronald Lawson.

Pre-conference Course Examples for Teaching Design of Experiments by James Filliben, on Sunday, May 11.

Contributed Paper Session Contributed papers on design of experiments ad industrial statistics will be accommodated either in a session with concurrent presentations (including a student session), or in a poster session. Papers and posters can be published in the Q&P JSM proceedings. Send an abstract and a draft of either the manuscript or the overheads by February 15, 1997 to Geoff Vining for the non-student sessions or Lorrie Hoffman for the student session.

Geoff Vining	**Lorrie Hoffman**
Non-Student Session	Student Session
Univ. of Florida	Univ. of Central Florida
Dept. of Statistics	Dept. of Statistics
P.O. Box 118454	P.O. Box 162370
Gainesville, FL 32611	Orlando, FL 32816
Tel. (352) 392-1941	Tel. (407) 823-2289
vining@stat.ufl.edu	hoffman@pegasus.cc.ucf.edu

Tour of cleanroom for semiconductor manufacturing at Bell Labs, Lucent Technologies.

The registration fee is $175 before April 15, 1997, $200 after April 15, and $50 for full time students. For additional information, please contact:

Jayne Ballweber
Cirent Semiconductor
9333 S. John Young Parkway
Orlando, FL 32806
Tel. (407) 345-7418

CQE's Rewarded For Volunteer Spirit

In the 1996 Winter edition of the Newsletter, a call was issued for volunteers to participate in the development process for the CQE exam. The response was a credit to the volunteer spirit of our Division. Thanks to all those who stepped forward! A total of 18 Division members were added to the pool of qualified candidates to participate at the four annual workshops. At the CQE Item Writing Workshop held in Milwaukee on 13-15 September 1996, there were 29 in attendance. Of these, 15 were Statistics Division members, nine of whom had recently volunteered. The experience was both personally and professionally rewarding. It was a great opportunity to meet others in the field and develop new relationships. And, each made a valuable contribution to the merit and integrity of the CQE credential, while reinforcing one's own knowledge and skills.

Of course, the door is always open to additional volunteers. If you're an interested CQE and would like more information, contact the Statistics Division Certification Chair:

Nick Martino:
Phone: ***(508) 534-2556;***
E-mail: ***martinnv@novachem.com; or***
Mail: ***Nova Chemicals, Inc.,***
31 Fuller St.
Leominster, MA 01453

Doug Montgomery Receives Statistics Division's Hunter Award

Douglas C. Montgomery

The 1996 William G. Hunter Award was presented to Douglas C. Montgomery at the Fall Technical Conference (FTC) in Scottsdale, AZ. The ASQC Statistics Division established the Hunter Award in memory of the Division's founding chair. The purpose of the award is to promote, encourage, and acknowledge outstanding accomplishments during a career in the broad field of applied statistics. Doug Montgomery follows Bill Hunter's model of statistical leadership as a communicator, consultant, educator and innovator, with the ability to integrate statistical thinking into many disciplines.

Doug Montgomery is Professor of Industrial and Management Systems Engineering at Arizona State University. Doug has previously held positions at the University of Washington in Seattle, at Georgia Tech, and at Virginia Tech, where he also received his Bachelors, Masters and Doctorate degrees. Doug's industrial experience includes past assignments with Union Carbide and Eli Lilly, and he has extensive consulting experience with many national and international organizations. Doug has written eleven books and over ninety referred papers in the areas of design of experiments, linear models, time series analysis, process control and operations research. He has directed 20 Doctoral and 35 Masters theses applied statistics and quality and reliability engineering, He has received the Ellis R. Ott Award, the Shewall Award, and the Brumbaugh Award. Doug is a Fellow of ASQC, the American Statistical Association, and the Institute of Industrial Engineers. He is a Past Chair of the ASQC Statistics Division. Doug is currently the editor of the Journal of Quality Technology. Doug made these remarks in accepting the award at the FTC:

"I am grateful and honored to be the 1996 William G. Hunter Award recipient. As several past recipients have remarked, the citation for this award characterizes the type of person Bill was, and to have my efforts recognized in this manner is gratifying. Bill was both a good friend and colleague. I first met him when I was invited to join the ASQC Statistics Technical Committee. As many of you know, this committee was the precursor of the Statistics Division. Many of the people on that committee played an important role in creating the Division, and in establishing its early goals and vision, including participating in organizing and sponsoring this conference. Bill's leadership in those activities have had a major impact on applied statistics and on all of us here today.

"I learned many things from working with Bill, and I would like to share two of them with you. First, statistics is an applied science, and there are important, interesting and useful applications waiting for us to find in every field. Like Bill, I am an engineer by formal academic training. Some of you are engineers; others are physical/chemical scientists, mathematicians, and statisticians. Bill was a master in looking beyond the boundaries of his own discipline to find new opportunities to apply the statistical sciences. All of us should renew our efforts to emulate him.

"Second, Bill was extremely effective in exciting people about statistics. He had a broad base of friends and professional colleagues from industry, government, and the academic community, and he enthusiastically used this network to promote not only an exchange of ideas, but advancement of the field of applied statistics. This was a rare talent that we certainly need more of today.

"We miss Bill's intellectual contributions as an engineer and statistician. We also miss his ability as a leader and organizer. The Statistics Division, the FTC, and many other organizations in the industrial and academic communities were impacted by him. Once again, thank you for this award."

Nomination forms for the 1997 award can be obtained from the William G. Hunter Award Committee Chair:

Galen C. Britz
3M Center
Building 220-9W-08
St. Paul, MN 55144
Phone: 612-736-6499

Nominations must be received no later than Monday, June 30, 1997. Δ

Statistics Division to Unveil "Virtual Academy" at AQC

While at AQC in Orlando this year, be sure and stop by the Statistics Division Booth. Featured in this year's booth will be the division's first cyberspace effort, "The Virtual Academy."

This unique website will lead the user through a variety of basic statistical concepts with fun examples and practical exercises. The content will be updated regularly as learning tools are added.

One of the primary uses of the Virtual Academy will be to introduce students in public schools to statistics If you would like to work as a volunteer when we begin this effort, please contact Marilyn Hwan at (408) 433-6362 or mhwan@lsil.com. Δ

Youden Address

SYSTEM CHANGE AND IMPROVEMENT: GUIDELINES FOR ACTION WHEN THE SYSTEM RESISTS

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Presented at the
40th Annual Fall Technical Conference

Introduction

I feel honored to be chosen to give this year's W. J. Youden address. Jack Youden was a Chemist and Statistician who had impact in getting good statistical techniques widely used. In my talk on "System Change and Improvement; Guidelines for Action When the System Resists", I will revisit some themes that I heard from Jack Youden at my first Gordon Research Conference (GRC) on Statistics in Chemistry and Chemical Engineering (in 1966). This was at the very beginning of my career as a statistician and near the end of Jack's career. In my talk I will discuss examples of the systems approach to problem formulation and solution, give some recommended changes that "we the people" can make, and offer some new technical tools.

I am a new father; my son Kerry was born on June 26. This does affect my perspective. I am looking to the future, both mine and his. I have tried to make my guidelines and suggestions appropriate for the future.

Jack Youden's Influence on My Current Research

Before getting into my main topic, I would like to show how Jack Youden is influencing my current research. A favorite data set which motivates my current research was discussed by Jack Youden (1972). It is shown as table 1 and it "lists fifteen values of the astronomical unit over the period 1895-1961. I direct your attention to an interesting feature of this table. Each investigator's reported value is outside the limits reported by his immediate predecessor. I draw the conclusion that these investigators simply do not have reliable information about their systematic errors."

Different Values Reported for the Astronomical Unit

Number	Source of measurement and date	A.U. in millions of miles	Experimenter's estimate of spread
1	Newcomb, 1895	93.28	93.20 - 93.35
2	Hinks, 1901	92.83	92.79 - 92.87
3	Noteboom, 1921	92.91	92.90 - 92.92
4	Spencer Jones, 1928	92.87	92.82 - 92.91
5	Spencer Jones, 1931	93.00	92.99 - 93.01
6	Witt, 1933	92.91	92.90 - 92.92
7	Adams, 1941	92.840	92.77 - 92.92
8	Brouwer, 1950	92.977	92.945 - 93.008
9	Rabe, 1950	92.9148	92.9107 - 91.9190
10	Millstone Hill, 1958	92.874	92.873 - 92.875
11	Jodrell Bank, 1959	92.876	92.871 - 92.882
12	S. T. L., 1960	92.9251	92.9166 - 92.9335
13	Jodrell Bank, 1961	92.960	92.958 - 92.962
14	Cal. Tech., 1961	92.956	92.955 - 92.957
15	Soviets, 1961	92.813	92.810 - 92.816

From SCIENTIFIC AMERICAN, April 1961, and Youden's "Enduring Values" (Technometrics, (1972))

Note that each reported value is outside the limits reported by the immediate predecessor.

TABLE 1

My research with my former students is motivated by the need to better understand experimental error, and how this impacts the best way to conduct an experiment. This work quantifies design aspects that I was doing intuitively. We recognize that in many experimental situations, all experimental factors are not reset on each run even when a random run order is used. For example, a mold temperature is not reset when the same mold temperature is required on successive runs. This means that the experimental errors are not independent so traditional (least squares) analysis may be inappropriate.

We are now prepared to write up the general problem, and to give guidance on how to conduct better experiments. This will be the subject of my future talks on experimental design. We have completed work on the special case of one hard-to-change factor where we use the operational definition that a hard-to-change factor is not reset when successive runs have the same level while easy-to-change factors are those that are reset on each run. This has produced some valuable insights. Huey Ju (1992, Ju and Lucas 1992) describes the variance structure for different ways of running experiments when factors are not reset. Jeetu Ganju (1994, Ganju and Lucas 1996) shows that hypothesis tests, especially on the hard-to-change factor, can be very biased and that it is difficult to detect how the experiment was run from the experimental data. Frank Anbari (1993, Anbari and Lucas 1994) shows how an experiment should be run to get the highest efficiencies.

Continued on page 6

YOUDEN ADDRESS

Continued from page 5

"Super Efficient" experiments are achieved when the efficiency is greater than 100% compared to a random run order or to (complete) randomization. It is worthwhile to show the results for a 2^4 factorial experiment that is used to estimate main effects and two-factor interactions. We use Table 2 to get the maximum variance (or expected maximum variance) of prediction over the experimental region for different ways of running a 2^4 factorial experiment. To get this maximum variance, the constants in Table 2 multiply the experimental variance, which is separated into a component for the hard-to-change factor and a component for the easy to change factors. Table 2 also contains a cost factor which is the number (or expected number) of times that the hard-to-change factor is reset.

Table 2

COST AND VARIANCE COMPARISON FOR WAYS OF RUNNING 2^4 FACTORIAL EXPERIMENTS

	Variance Multiplier		Cost
	S^2Easy	S^2Hard	Multiplier
Completely Randomized Design	11	11	16
Random Run Order (not reset)	11	12	9
Eight Blocks (of size 2)	11	10	8
Four Blocks (of size 4)	11	8	4
Two Blocks (of size 8)	11	16	2

From a G-optimality standpoint (which minimizes the maximum variance of prediction) the optimum way to run a 2^4 experiment is to use four orthogonal blocks of size 4 (with the hard-to-change factor confounded with blocks). The G-efficiency of running the experiment in this way is always greater than 100% where the G-efficiency is the ratio of maximum predictive variances over the region. The G-efficiency can be as high as (11/8) 137.5% relative to a (completely) randomized design or (12/8) 150% relative to using a random run order. These G-efficiencies occur when the dominate variance is associated with the hard-to-change factor.

When costs are considered, we may use two blocks to minimize the cost of information. Figure 1 shows that the decision to use two blocks or four blocks depends on the ratio (Lambda = S^2_{Hard} / S^2_{Easy}) of the two variance components and on the ratio of the costs of changing the hard-to-change versus the easy-to-change factors.

Some implications are:

1. The Taguchi recommendation for orthogonal arrays, which uses two blocks is sometimes the most cost effective way of running the experiment, but it definitely is not the way to get the most precise predictions.
2. A computer generated experiment may give the answer to the wrong design question. It attempts to find the optimum (completely) randomized experiment; even when it succeeds it may not give the appropriate design for the experimental situation.

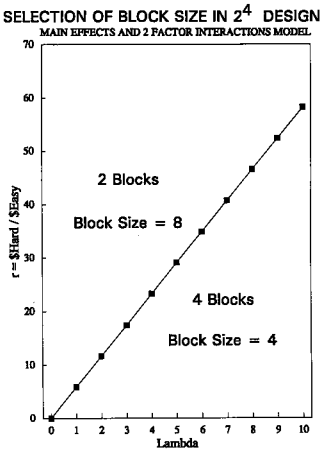

FIGURE 1

I am very excited by this area of research; it gives good guidelines for running better experiments. There are many exciting results yet to come. There are also a number of good, workable Ph.D. topics in this research area. Experimental design is my favorite research and application area. Since before the time of Francis Bacon (1561-1626) experimentation has been a primary method of gaining what Deming called "profound knowledge." Experimental design can never be reduced to a deductive mathematical method. Good intuition will always be needed. A statistician's feeling toward experimental design often reveals whether he or she is primarily a mathematician who dislikes the intuition and improvision that is necessarily involved or of a scientific bent who enjoys developing the best operational design.

The Systems Approach

Any aspect of life can be regarded as a system. I will look at three systems to point out where improvements are needed. The systems that I will consider are a world wide system, a nation wide system, and a profession wide system. I will suggest some changes that should be made.

If we consider the whole world to be a system, a strong argument can be made that the major problem is population growth. Population is increasing exponentially.

Humans have been around over 500 Centuries.
There are about 50 Centuries of written records.
It is about 20 Centuries since the time of Christ.
Population grew to one billion about 1830.
Population grew to two billion about 1930. (It doubled in about 100 years.)
Population grew to five billion about 1990. (It doubled in about 50 years.)
The next billion will take about 11 years. (Population is still doubling about every fifty years.)

The current population of the earth is at or above many estimates of its population carrying capacity. It is hard to conceive of the earth going 5 more centuries without severe problems caused by overpopulation. How many more doublings of population are needed before our quality of life must decline drastically? In five centuries we will have a 30 fold increase in population, if we slow down the population growth so that population doubles every 100 years

Continued on page 7

Continued from page 6

(25 = 32), and there will be more than 1,000 people alive for each person alive today, if population continues to double every 50 years (210 = 1024).

Some take a shorter time view, Samuelson (1996) notes that "between 1961 and 1994, the population of developing countries roughly doubled, while grain production nearly tripled. He says that the reason prophecies of food problems in the next century "seem unconvincing is that predictions like them, dating to Thomas Mathus (1766-1834) have never come true."

I believe that the population crisis must be pre-empted. We know that exponential growth can not continue indefinitely, and know that there is often little warning preceding the end of the growth. The optimum control action for rare events is to take corrective action at every occurrence (Lucas, 1989). If the event is serious then improvement is achieved by taking corrective action on the occurrence of potential precursors. I note that DuPont has a world class safety program that is based on these principles. Action is taken when there are potential safety incidents and not only after there has been an accident.

There are many precursors indicating problems are coming. These include pollution problems, the extinction of species, and (more frivolously) the fact that more full moving vans are leaving California than are going there. Can we take corrective action in time? I will publicize the dangers of overpopulation, support organizations such as Zero Population Growth, limit the number of children I have to my one son, and look for other ways I might have impact helping to solve this problem.

I will now move away from global questions, to a country wide problem and then to problems in our profession. This is because impact is proportional to both the size of the problem and to the probability of having an effect.

How Employees are Treated

A national problem is the way employees are now treated. They are much less valued and respected now than they were just a few years ago. I will use DuPont as an example even though I feel it one of the best employers; changes in the way employees are treated there are typical of changes that have been made by all employers. They reflect what "we the people" now accept; "we the people" can change what we will accept. In 1958, DuPont laid off a few hundred people from its Engineering Department. There was some immediate negative feedback; for instance, Johns Hopkins University said that DuPont recruiters were not welcome on campus for 5 years. A friend, who graduated from Johns Hopkins in 1963, got a great offer when DuPont re-established its recruiting efforts there.

From that time through the early 1990s, downsizing was carried out through Early Retirement Opportunities (EROs) which offered incentives such as the opportunity to get a full retirement at an earlier age. These EROs got volunteers for much of the downsizing. I jumped at such an opportunity in 1991; my caricature (shown as figure 2) was captured at the 1991 GRC when the ERO was rumored but not yet announced. After a quarter century with one employer, I welcomed the opportunity to try a second career. Current practice by all employers is much less considerate of employees. Unfortunately the current climate is well reflected by the Dilbert cartoon where the boss states that employees are the company's greatest resource; whenever we want our stock price to jump, we "can" a few. "We the people" have accepted this and "we the people" can change this back. A worthwhile first step is to require executives who preside over large downsizings, which are a very strong metric of management failure, to also leave without any golden parachute. Management should not be rewarded for its failures.

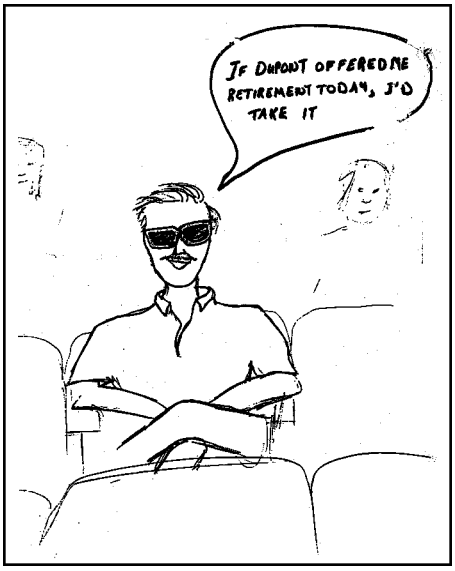

FIGURE 2

Longer term we can see implications from the structural changes that have occurred in the economy over this century. These implications come directly from the economic indicators which the government publishes monthly. (The publication of these very valuable indicators is a worthwhile accomplishment in applied statistics.) Over the last two decades the number of employees in manufacturing has dropped slightly to about 18 million. Even though the population has increased, it takes fewer workers to produce the goods we need. (The change in manufacturing employment is much smaller than the change in farm employment which dropped from 70% of the workers early in this century to 3% today.) The fact that fewer workers produce the goods we use and the food we eat is a great accomplishment. How are the benefits of this great accomplishment shared?

In Science, a good engineer today can know more mathematics and physics than Sir Isaac Newton (1642-1727), probably the greatest scientist who ever lived. We note that as scientists: "We see so far because we stand on the shoulders of giants." We can also say about our economic system: "We live so well because

Continued on page 8

Continued from page 7

our system is built on the backs of our forefathers." Are we sharing the benefits fairly? The increases in income over the last two decades have gone to the richest 20% of the population. Income inequality has increased. A worthwhile question, are "we the people" getting some of the benefits of a growing economy as increases in time for contemplation and family? (This is almost a rhetorical question.)

Almost all the employment increase in the last decade has occurred in services (from 22 to 34 million) and (to a lesser extent) in retailing (which now employs over 21 million). These two segments now account for nearly 50% of all employees; up from just over 40% a decade ago. Many of the jobs in these growing segments are low paying; this contributes to the increase in income inequality which has occurred over the last two decades. "We the people" can get great waiters when we eat out because there are so many current college graduates working in this area. Is this what we want?

A partial solution is a shorter work week; I recommend a 36 hour week with four 9 hour days. This will switch work to higher paying segments. It will reduce income inequality and make it easier for people to take some of their increased productivity as leisure time. This is now often hard to do; for example, The Chronicle of Higher Education (July 5, 1996, A6) notes that "Lawyers work insane hours because the market determining hours and wages breaks down at their firms." My cousin, who is a human resources executive with six weeks of "use it or lose it" vacation, has taken little of his vacation the last few years. The executives at his company pay lip service to a balanced life, but few of them have taken much of their vacation either. It is unsurprising that my chastising him on this has little effect compared to the actions of his peer group.

A related area is the marriage penalty. There is a big marriage penalty for families with both persons working. Taxes are higher and benefits can be smaller than those that would be obtained for two single people who choose to live together. While all political parties claim to be pro-family, this unfairness persists. The solution to this unfairness is simple. The law should be changed to allow married couples to calculate taxes and benefits as though they were two single people living together. This simple change would immediately increase the number of marriages.

The Statistics Profession

I will now examine the impact of the Statistics Profession, some of its problems, and what George Box calls "the disastrous effect of Mathematics on the statistics profession." Many articles have discussed the lack of recognition, respect, and the low impact of Statisticians; a good list of references is contained in Hoerl et. al. (1993). Problems that statistics departments are having have been documented in the President's Corner of Amstat News by Ron Iman (1994). Princeton, the University of Delaware, and the University of Arizona have eliminated their statistics departments, and for most departments enrollments are declining or stagnant. If only American-born students are counted, the enrollments are declining in virtually all graduate programs. An American born Ph.D. is a recognized minority in the mathematical sciences.

A specific example of declining enrollments comes from two Communications in Statistics articles describing the history of the Florida State Statistics Department; one is for the first fifteen years up to 1974 (Bradley 1990) and the second is about the fifteen years from 1974-1989 (Leysieffer 1990). The first covered a period of growth and leveling off while the second covered a period of declining enrollments which appears to be accelerating. It is great to report on a success. The Texas A&M statistics department has grown recently partly because it teaches more graduate students from outside the department than any other department. Such outreach success stories are possible at most universities, we should have more of them instead of having other departments teach their own statistics courses. Such success stories require that statistics departments have, as part of their vision, excellence in the teaching and design of service courses. It appears that excellent service courses are almost sufficient to give departmental growth because statistics training is so broadly useful.

The Market for Statisticians

If we consider the Statistics Profession to be a system, the cause of some of these problems becomes apparent. By comparing the current market for statisticians with the potential market, we can see the growth potential that has largely been missed. A recruiter categorized 13,000 American Statistical Association (ASA) members as 9,000 from academia and government and 4,000 from industry. Of the industry statisticians, 3,000 are in pharmaceuticals, while the remaining 1,000 are in the rest of industry. Now consider the potential industrial market.

Business Week reports that the pharmaceutical segment is 300,000 people. The rest of manufacturing is about 18 million, 60 times as large. Penetrating this market with one statistician per 500 workers, only 20% of the penetration in pharmaceuticals, would mean 36,000 statisticians. Penetrating the services sector (which has 34 million workers and includes the academic sector) and the retailing sector (with 22 million workers) at a one per 1000 rate gives the potential of over 50,000 statisticians in these two segments. There is the potential for over 80,000 statisticians in industry. This information is summarized in table 3.

Continued on page 9

Continued from page 8

Table 3

THE MARKET FOR STATISTICIANS

MARKET SEGMENT	STATISTICIANS* CURRENT	STATISTICIANS* POTENTIAL	EMPLOYEES (in millions)
Academia	9,000	9,000	
Government			19
Industry	4,000		18
Manufacturing			
Pharmaceuticals	3,000	3,000	0.3
Other		36,000	17.7
Services		30,000	34**
(excluding Academia)	1,000		
Retailing		20,000	22

* Categorization of 13,000 ASA members
** Includes Academia

This potential market has not been penetrated because it is not being served well. Ron Iman (November 1994) reports the following scorecard for how the ASA is meeting the needs of Bachelor and Master degree level Statisticians, the degree level of much of this market:

Journals	D
Meetings	C-
Section Activities	F
Professional Support	D-
Continuing Education	C

This report card also applies to Ph.D. statisticians in industry (and not in Academia, Government, or Pharmaceuticals).

A statistics degree is very much a research degree (and not a professional degree). It is researchers teaching researchers to be researchers. It does not prepare students for other areas of society. A majority of the people getting Statistics degrees have their undergraduate training in Mathematics; our profession has not managed to appeal to many physical scientists or engineers. Now that Colleges are no longer growing rapidly, the problems with this system are becoming apparent. There is a large unemployment rate; according to the Chronicle of Higher Education (March 15, 1996), the unemployment rate in the Mathematical Sciences is 14.7% (for the 1226 Ph.D.'s awarded in 1994-95; the highest rate ever reported) and the underemployment rate (e.g. postdocs) is 30%.

The research emphasis is, to a large extent, concerned with mathematical techniques rather than to the larger problems of society. This is a major reason that much statistics research has little impact. I can note that in the over 30 years that I have been a statistician, The Journal of the American Statistical Association has not published a single high impact article in either Quality Control or in Experimental Design. (There could be an exception in the biological area as I don't follow that literature carefully.) Jack Youden was one of the first who recognized the problem of an overemphasis on mathematical technique. I still remember his comments at my first GRC. After a recent Ph.D. described his new, quite mathematical, technique Jack asked: "So you think you've done a neat thing don't you? Well just wait five years; when nobody uses it, how neat will you think it is?" Jack stated an excellent scientific criteria; the value of a new technique is in its long term utility and impact. This is a valid way for us to be evaluated.

A specific example of poor training for most of the industrial market comes from my experience in the interview process for new statistical consultants in DuPont. As part of the process, the potential employee is interviewed by a group of experienced consultants. In my part of the interview process, I usually discuss a consulting scenario which requires an experimental design. I describe five experimental factors with cost and time constraints which limit the experimenter to about 20 runs. A very good experiment for this scenario is a half replicate of a 2^5 experiment. Over one-third of the Ph.D. statisticians that I have interviewed were unprepared to handle this scenario. Either they do not know how to obtain a half replicate of a 2^5 or how to ask appropriate follow-up questions. A large fraction of graduate Ph.D.'s do not have skills that are widely needed in consulting and statistical practice.

The Scientific Versus the Mathematical Approach

A difference between the scientific and the mathematical approach can be seen by comparing my research in advanced quality control methods, primarily Cumulative Summation (CUSUM), with some of the more mathematical work on optimum detection schemes. There are both complementary aspects and differences in value systems that lead to differences in research approaches.

As background I note that I started studying quality control in the 1960's because I sometimes take a contrarian approach. I chose the quality area because of a course in the History of Science that I took from Joe Beer at the University of Delaware. A science hero of mine is Vesalius who was the first person to carefully perform autopsies. He made many scientific discoveries because before his time it was sacrilegious to cut open the human body, and as the field was new, opening it (pun intended) led to many discoveries.

Since I had only heard negative things about the Quality area from the Yale Statistics Faculty, comments such as "quality might have a modicum of interest at the lowest levels of the production process," I felt that interesting results could be found there. This has proved true both as a research area and as an area of statistics that has had high impact during the last three decades. In DuPont, the impact of our groups work designing and implementing quality systems was documented by DuPont's Chief Executive Officer (Heckert, 1986). The quality system led to $30 million in operating cost improvements in a single DuPont division and then spread throughout much of DuPont.

Continued on page 10

YOUDEN ADDRESS

Continued from page 9

CUSUM quality control schemes were an important subsystem in our quality system. Important results about the optimality of CUSUM schemes were proved by Lorden (1971) who showed that they were asymptotically optimal and later by Moustakides (1986) who proved that a CUSUM based on a Likelihood Ratio is optimal in the sense that it will give the fastest detection for a given false alarm frequency. Note that virtually all the work on optimality properties concerns a simple hypothesis versus a simple alternative. There is almost no work on composite hypothesis; the results for composite hypotheses are not so mathematically clear cut. In practice, the vast majority of control schemes are for two-sided control or for other composite hypotheses. Mathematical statisticians suggest research into such things as modifying the optimality criteria and seeing how the optimum scheme changes. Such research still only considers a simple hypothesis versus a simple alternative.

I suggest that there is much more potential impact from considering a composite hypothesis, but note that this research area is now so deep and narrow that more "digging" is unlikely to produce many valuable "nuggets." New results are likely to be difficult to achieve, very technical, and have little impact. This type of criticism can validly be made about much of the current research in mathematical statistics. Much of this research contradicts one of my father's favorite sayings: "The profound is not necessarily complex." Mathematical technique and sophistication may appeal to the mathematically inclined statistician; however, it will produce little benefit for society and turn most people off.

How I Became a Statistician

The statistics profession is ingrown; for example, its main source of students is mathematics majors, only a small percentage of its students are from the physical and engineering sciences. A major cause is very high technical mathematics barriers which deter students from outside of mathematics. An example that comes immediately to mind is the 709-710 course sequence at the University of Wisconsin. I note that Scott Vander Weil and I, both engineering undergraduates, were accepted at the University of Wisconsin but chose not to attend. High math barriers do keep out students with a strong science background. They should be lowered.

My masters experience can also serve as an example of problems that science majors can have in Statistics Departments. I did my masters work in statistics at Yale after obtaining an engineering undergraduate degree from Penn State. Science or engineering students have fewer undergraduate mathematics courses than mathematics majors. My 28 credits in mathematics, while more than most engineers, was only half the number of credits of some my fellow students who were mathematics undergraduates. I did not do particularly well and obtained my master's with the minimum passing grade. The program was not well designed for a science or engineering background.

Many of my job interviews were with general management consultation firms. This was the "hot," high paying area in 1965. I wondered why I had gotten no good job interview offers from the management consulting firms. A few years later, Bob Kennard (of Ridge Regression fame who was then manager over DuPont's statistical consultants) told me that the department head had given me a very poor recommendation and that the department head did not understand that performance in one (highly mathematical) system did not predict performance in another system (which had a large scientific component). DuPont's statistical management, which knew the faculty well, discounted the negative recommendations; while general management consulting firms gave the negative recommendations more weight. It is ironical to note that had the department head's recommendation not been so negative, I might have switched fields instead of remaining in statistics where my impact has proven that his judgment was incorrect.

After four years at DuPont, I took a leave of absence to get my Ph.D. at Texas A&M under H. O. Hartley. After my Ph.D., I again interviewed widely and concluded that DuPont was the best match with my skills and aspirations. I had a fun and challenging quarter century there.

New Directions are Needed

Statistics departments should place more emphasis on training professional skills. These require courses that develop the skills and tools that will be required in various consulting or problem solving scenarios (Hoerl et al, 1993). An excellent training program, that I was intimately involved in, is the intern program between DuPont's Statistics group and a number of Universities. It has now trained 35 interns. I'll mention two; Kymm Hockman who, as the CPID chair-elect chairs next years Fall Technical Conference (FTC), was the first intern I directed and Scott Grimshaw of BYU who co-authored one of the papers at this years FTC.

Better professional training will not only increase the quality of statisticians, but will also increase their prestige. There is an extremely great need for people with statistical expertise who are able to communicate this expertise to others. Comparisons can be made with physicians whose training is largely professional, yet whose expertise is respected and whose prestige is high. More professional training will also lead to better (more useful) research which will be more widely used as the research will be more broadly based. It can also lead to better statistical education. The Graduation rate at most medical schools is higher than 90%, the graduation rate can be much lower in graduate schools. For example, since its inception in 1963 the Yale statistics department has had 151 students (17 are current) and it has graduated

Continued on page 11

Continued from page 10

63 Ph.D.'s for a yield well under 50%. Any process with a success rate lower than 50% definitely has room for improvement.

The system resists taking a larger view; for instance consider Virginia Tech's search for a new department head. One applicant was an excellent applied statistician who had extensive managerial experience and who has won virtually all the awards in applied statistics. He was not chosen. This indicates the all too common bias (in statistics departments) against research which is not sufficiently mathematical, yet which has more impact than much that gets published. Virginia Tech was unable to agree on an external department head, lost a position, and had to fill the position internally. Similar infighting was the cause of the demise of the Ph.D. program in Statistics at the University of Delaware (Roselle, 1995).

Concluding Remarks

I have used a system approach to discuss a world wide problem, a nation wide problem and a profession wide problem. For the world wide problem of the population explosion, I wish to increase awareness and help efforts to take corrective action in time. If "we the people" do not act in time, nature's control action will be draconian. Nationwide, I have pointed out negative changes that have occurred in the ways employees are treated. If "we the people" do not work to make things better for employees, things are likely to get worse. I wonder if this talk can help induce some needed changes in the statistics profession. In science we know that current researchers are seldom convinced by a new paradigm. Change occurs because the old researchers die out while new researchers adopt the paradigm.

In an ingrown field such as Statistics, even the contractions of their departments may have little effect. The department members congratulate themselves about the good job that they are doing while the department implodes about them. Since Statistics departments are not satisfying the larger needs of our technical, data rich society, other departments are filling the void. Industrial engineering departments are a prime example; an excellent example is the department at Arizona State. This is a reason that Daryl Pregibon stated (at last years FTC) that he has more confidence in the future of statistics than in the future of statisticians.

I will close by making explicit what Bill Meeker said was implicit praise of the Iowa State statistics department. This is also a department that has grown recently. It has a commitment to service courses with many joint appointments, and it attracts many of its graduate students from outside of mathematics. It has also produced many good students and much high impact research. I hope that I have also implicitly praised other statistics departments. Δ

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Mini Paper

Nonstatistical Skills That Can Help Statisticians Be More Effective

Ronald D. Snee

Abstract

The new economic era we live in has resulted in a variety of new work situations for statisticians. Many are asked to be a member of a team that involves several different functions of the organization. Statisticians are also asked to work with groups in nontechnical areas. These groups tend to have less experience with data-based problem solving methods but, nonetheless, are working on problems critical to the success of the organization. Many statisticians have the opportunity to work with mid- and upper-level managers. All of these opportunities require new skills in addition to our statistical skills. Some of the more widely used skills and methods that can help statisticians become more effective are discussed. It is also shown how these new skills have much in common with statistical thinking.

Today's Realities

Today's rapidly changing world is creating new opportunities, challenges and demands on each of us. Global competition is forcing changes in all aspects of our society including business, government, education and healthcare. Customers are demanding more. They want, and deserve, better products faster and at less cost, delivered with more care. We have to change how we manage all aspects of our organizations if we are to meet these challenges successfully.

This need to change is expanding the use of statistical thinking and the role of statisticians. The expanding role brings with it the need to develop new skills to take advantage of the opportunities. In particular, statisticians will need to develop a variety of nonstatistical skills. Hoerl et al. (1993) identified five key "Nonstatistical Survival Skills":

- Understanding Total Quality Management philosophy,
- Developing knowledge of the economic and technical aspects of the business,
- Organizational development skills,
- Consulting skills, including communication, and
- Teaching skills.

Each of these skills is essential. This article identifies other nonstatistical skills that can help statisticians be more effective in today's environment. The skills identified fit well with statistical tools and methods and statistical practice in general. The use of these skills is of course optional. It should be recognized, however, that failure to become proficient with these skills can greatly reduce the impact of statisticians. Stated bluntly, those who fail to broaden their skill base run the risk of significantly reducing their value to their employers.

This article begins by identifying the new trends that are affecting statisticians and the increased demands associated with the trends. Next, key skills that statisticians can use to deal with these demands are examined. The article concludes with a discussion of the links between nonstatistical skills and statistical thinking.

Trends Affecting Statisticians

A major change affecting statisticians is the need for organizations to improve their performance. This change has placed enormous emphasis on the need to use data effectively throughout an organization, and has led to numerous changes in the worklife of statisticians. Some trends associated with this change include the following (Table 1):

- The statistician's role is expanding from one-on-one consulting with an individual client to working with the whole organization. Thus a new dimension "The Organization" has been added to the work of statistician (Snee 1991). The statistician must be able to assess the organization's readiness to adopt new practices, and be able to provide guidance on what kinds of training and education will help increase this readiness.
- Teams are being used with increasing frequency, many are tackling ever-larger and more complex problems. Expert statistical guidance is essential to solving such problems. Furthermore, many teams are cross-functional in nature, and often the members of teams have never worked together before. As a result, statisticians find that many teams have complex organizational and interpersonal issues that must be worked through if the team is to accomplish its goals. Working together effectively is a skill that must be developed.
- As improvement efforts and teams become more commonplace, statisticians are moving outside of their traditional areas of expertise such as research, development and manufacturing. They now find themselves working with all business functions. The people they encounter in the nontraditional areas typically have less technical savvy and training. The language and concepts of measurement, data, plotting, math, etc., are by and large unfamiliar to these new audiences.

Continued on page 13

Continued from page 12

- Statisticians are also finding themselves working with more managers at all levels in the organization. The statisticians thus get involved in strategic and managerial issues in addition to improving operations which until recently has been the main use of statistical thinking and methods.
- The work of these teams and managers is to improve the organization. To help make things better. As a result statisticians find themselves working with ideas on how to improve (soft data) as opposed to hard data. As a member of the team, it is the statistician's responsibility to help the team analyze the collection of ideas to identify the key needs of the organization and what changes should be made.

Table 1- Trends affecting statisticians

From		To
One-on-one consulting	→	Working with teams
Being an expert	→	Member of cross-functional teams
We help others improve	→	We help others and improve our own organizations
Work with R&D and manufacturing	→	Work with all functions
Work with professional staff	→	Work with professional staff and management
We solve problems	→	We improve organizations
Work with data	→	Work with data and ideas

Having to focus on the organization as a whole and all its separate departments, working with teams and managers who face complex nonstatistical issues, and dealing with ideas in addition to hard data require new skills. Informal problem solving approaches used by many statisticians do not work well in this new environment. But statisticians should not lose sight of their traditional role as experts in the design of studies and the collection and analysis of data. Instead, they must integrate the new skills with their statistical skills and create new approaches to working. This will result in statisticians making greater contributions to the organization.

Table 2 - Nonstatistical Skills for Statisticians

- Leading teams and dealing with group dynamics
- Problem solving methods
- Project planning and management
- Finding structure in ideas
- Education of diverse groups

Nonstatistical Skills for Statisticians

Some fundamental nonstatistical skills that can help statisticians respond to the trends discussed in Section 2 and Table 1 are detailed in Table 2. This list is not complete but summarizes some of the broadly useful, effective methods. Each of these skills is discussed below. Further details on these methods and other useful tools and methods are contained in the books by Brassard (1989), Doyle & Straus (1982), GOAL/QPC (1994), GOAL/QPC and Joiner Associates (1995), and Scholtes (1988).

Leading Teams and Dealing with Group Dynamics

Statisticians are often asked to advise improvement teams. In this role they work with the team and team leader on project planning, training, coaching, and they intervene with the team's work when needed.

One skill essential to effective teamwork is the ability to run effective meetings. This includes defining a purpose, identifying desired outcomes and developing an agenda for every meeting. It is also important to recognize the three phases of a meeting: before, during and after. Each phase serves a different purpose, and each is necessary to achieve a well-designed and implemented meeting that produces the desired results without wasting participants' time. Well-designed and run meetings help the team work together more effectively.

Another whole set of skills revolves around effective decision making. Most often, it is best for the team to push for consensus—meaning that all team members will actively implement and support the decision even if they aren't all totally happy with it. But sometimes it's not possible, or perhaps even necessary, to reach consensus. In such cases, voting may serve the purpose. Voting is especially useful in exploring issues and quickly finding out how different people feel about the issue. A useful strategy is to use voting to reduce the number of options the team faces and then use discussion and consensus to reach a final decision.

Facilitation is yet another useful skill. To facilitate means to make the work of the group easy. Facilitation is often thought of in the context of meetings, where it can mean anything from helping the team move efficiently through the agenda to helping resolve group conflict.

Problem Solving Methods

Statisticians pride themselves on their ability to solve problems. Indeed problem solving is the focus of much statistical work. Statisticians can do two things to improve their effectiveness as problem solvers: spend more time on the implementation of solutions and provide clients (particularly teams) with a method for solving problems.

When working with an individual client, statisticians rarely think about the formal approach being used. Generally speaking, the client and statistician work together to identify the problem and the needed data. They may also collaborate on the collection, analysis, and interpretation of the data. This leads to solutions for the problem or identifies the need for more data to be collected. The implementation of the solution is generally left to the client, the person who brought the problem to the statistician.

Continued on page 14

MINI PAPER

Continued from page 13

This informal approach has two key limitations. First, most of the attention goes to problem solution, much less to problem identification and little if any to implementation. Second, this informal approach often does not work well with groups. Let's examine each of these issues in more depth.

Problem solving has three main phases: problem identification, problem solving and solution implementation. Following the Plan-Do-Check-Act (PDCA) cycle, solution implementation also includes checking the effectiveness of the solution and adopting the solution as standard practice when is deemed effective. Successful implementation is essential to the project's success and must be part of the problem solving process.

In many cases, however the client comes to a statistician looking only for help identifying a solution. This can lead to solving the wrong problem if the problem was not properly identified in the first place. It also often times results in too little attention being paid to the implementation of the solution by statisticians. We often hear the comment that "we did some good statistical work but it was not used." Statisticians must pay more attention to the implementation phase if their work is to be effective and have impact.

The second limitation of the informal approach to problem solving used by statisticians is that it doesn't work well with groups. Teams function best when their thinking is aligned in a common direction. Using a common problem solving methodology helps achieve this alignment. Everyone can see what needs to be done and where the team is in the problem solving process.

The PDCA cycle is a more formal approach to problem solving and is useful in those situations where the solution or end result is known but considerable planning and work must be done to implement the solution. The PDCA cycle gives the team a process to guide their work. It also makes the important check and act steps an integral part of the work. Becoming skilled in PDCA can help a statistician understand and predict what a team should be doing and when in order to achieve its purpose.

There are many other structured problem solving processes to choose from. A key requirement is that the process include all aspects of the PDCA cycle. The main point is that it's important to use a problem solving process. It is less critical which particular process the team uses. One useful process is shown in Figure 1. Other effective processes are discussed in the publications by Joiner (1994), Gaudard, Coates, and Freeman (1991), and the Xerox Corporation (1993).

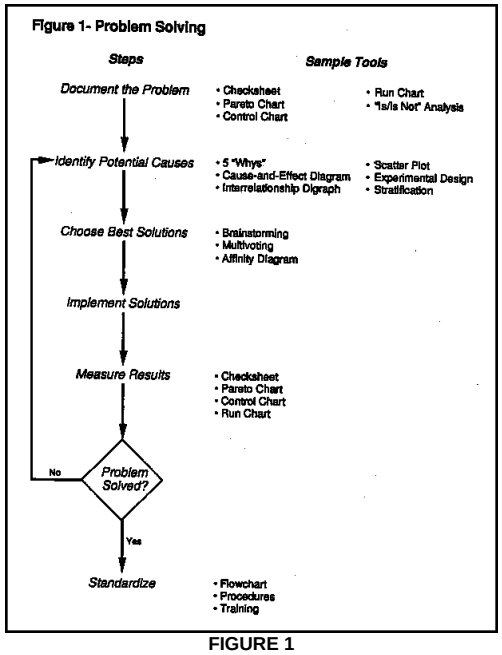

FIGURE 1

Another key mindset that enhances problem solving is that of focusing on the problem solving process and bringing in the tools as they are needed. This approach is contrary to the more common approach of selecting a tool (e.g. Time plots, frequency plots, scatter plots, etc.) then trying to figure out how to use it. This latter approach generally leaves people confused as to what tool to use under which circumstances.

Integrating the tools into the problem-solving process creates clarity around the need for and use of the tools. Figure 1 shows some of the key tools used in the different steps of the problem solving process.

Two other skills that are generally useful in problem solving are brainstorming and flowcharting. Brainstorming is used to generate ideas about what actions to take or issues to consider, such as thinking up possible solutions to a problem (Figure 1). The process enables the group to utilize its creative energies and get everyone involved.

Though brainstorming is generally used in working with groups, it is also useful in individual work. Writing down all your ideas on a subject without critical review until the list is complete is an effective way to identify and organize one's thoughts on a particular issue.

Flowcharting a process creates a useful picture of what happens, in sequence (see Figure 2). Creating a picture of the process is an important step in problem solving because it helps people visualize the process steps and identify trouble spots. The flowchart also helps the team understand the context for the work to be done and what role they play in the process. Flowcharting is particularly effective in nonmanufacturing situations in which it is difficult to see the process in operation. Flowcharting is also, of course, key to understanding and controlling manufacturing processes.

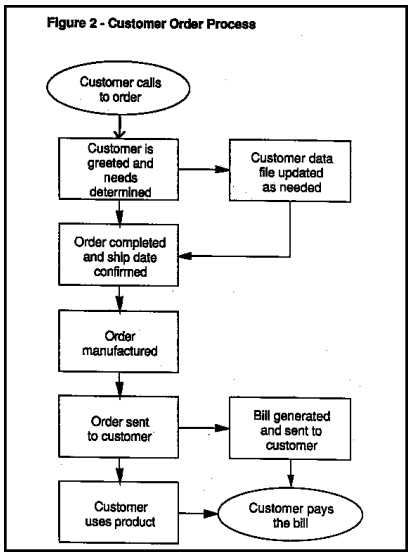

FIGURE 2

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One team commented, "Working with the flowchart as a focal point made it easier to make changes in the process. We were not questioning each other's purpose or job; we were all looking at a common process and trying to figure out how to make it better. Flowcharting helped to depersonalize and de-departmentalize the process."

Project Planning and Management

When two people work together (e.g., statistician and client) informal planning is usually sufficient to guide the work. As more people are involved the projects generally get more complex, larger in scope, and require more time to complete. This results in the need to carefully plan the work of the group and to set up a system to monitor progress relative to the plan.

The project typically begins with some type of planning work. It is often pointed out that you should "plan the work and then work the plan." Paraphrasing John Wooden, renowned UCLA basketball coach, "Failing to plan is planning to fail."

Planning can be done in many ways, with the end result being a sequential list of blocks of work that need to be done to satisfy the goals and objectives of the project. One possible process is for the team to brainstorm the blocks of work that need to be done. This list is refined, put in sequential order, and start and completion times determined. The plan is periodically reviewed during the life of the project and revised as needed.

Three tools that are useful in creating the plan, visually displaying the plan to all interested parties, and monitoring the progress of the work versus the plan are the basic flowchart, deployment flowchart, and Gantt chart.

The basic flowchart displays the key blocks of work that the group needs to accomplish. Typically, the project plan is at a high level noting the 4 to 10 key blocks of work and the sequence in which they are to be done. An example of a plan to develop a sampling process is shown in Figure 3.

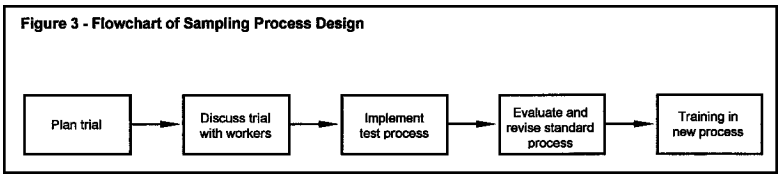

FIGURE 3

The deployment flowchart visually displays these key blocks of work in two dimensions: sequence and responsible person or group. The result is a visual display of "who does what, when." The deployment flowchart of the project plan shown in Figure 3 is displayed in Figure 4.

The basic flowchart and/or the deployment flowchart are useful to get agreement on the work to be done and responsibilities and as a periodic check on progress. The Gantt chart is useful for monitoring progress. The Gantt chart is a two-dimensional display with the sequenced blocks of work running down the left hand side of the chart and the projected start and completion dates for each block of work running across the top of the page (see Figure 5). The Gantt chart is typically reviewed at each team meeting and revised as needed.

Figure 4: Deployment Flowchart of Sampling Process Design

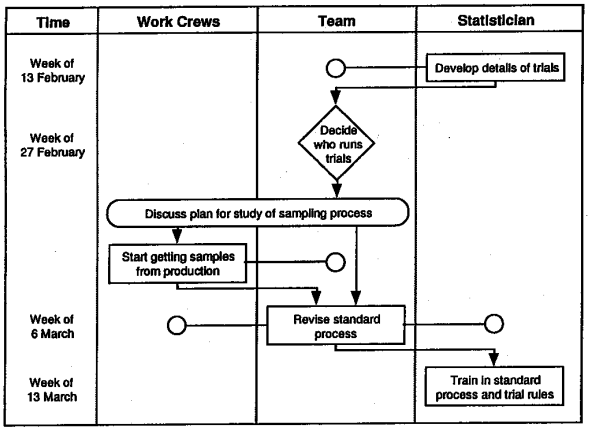

FIGURE 4

Finding Structure in Ideas

When selecting improvement projects, searching for solutions to problems, creating strategies, etc., by brainstorming or other methods, one ends up with a long list of ideas. This is particularly true in dealing with management issues where hard data are often not available, and a team's perception and views are used to chart direction and solve problems.

Figure 5: Example of Gantt Chart

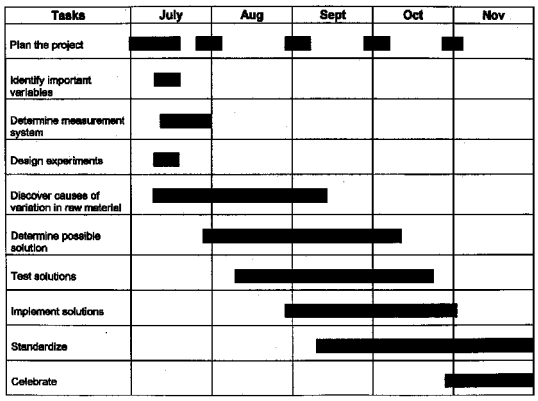

FIGURE 5

Ideas can be thought of as soft data. Just as a statistician can find structure in a body of hard data, one can find structure in a list of ideas. Given a list of n ideas, it is rare that all n ideas are independent. Typically, there are only a "vital few" key ideas in the list. The ideas are frequently interrelated with some ideas representing causes and others describing effects. Two tools that can help analyze a list of ideas for structure are the affinity diagram and the interrelationship digraph (Brassard 1989).

Continued on page 16

Continued from page 15

The two tools are used in the following way. The affinity diagram is used to group or cluster ideas. The ideas are written on cards, one idea per card. Ideas that are similar in nature are clustered together. Each cluster is studied to identify the key theme of the cluster. This theme becomes the "header" for the cluster. It is not uncommon for a group of 20-30 ideas to be grouped into five or six clusters. The headers for the clusters identify the key themes or dimensions in the group of ideas. This structure is further studied for "cause and effect" using the interrelationship digraph.

The interrelationship digraph is constructed by placing the "headers" in a circle and using an arrow to show which headers are linked to and "cause" the other headers to happen. There may be no links between some headers. Each arrow can have only one head - - - two-headed arrows are not allowed.

After all the links have been identified, each header is labeled with the number of "In" arrows (effects) and "Out" arrows (causes). The headers with the largest number of Out arrows are the key causal ideas (also called drivers).

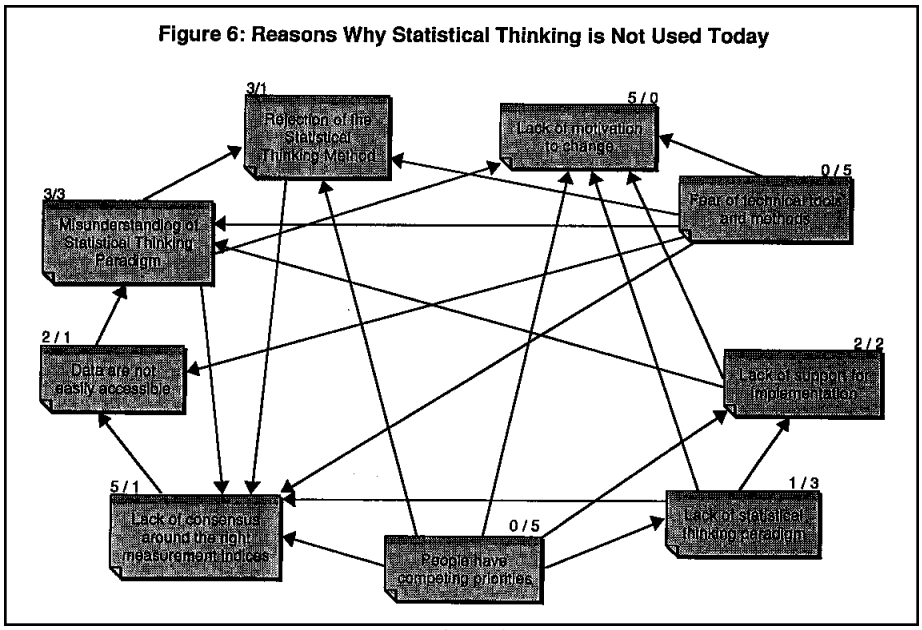

FIGURE 6

Figure 6 shows the interrelationships digraph for "reasons why statistical thinking is not used today" constructed by the Statistical Thinking Group at the 3M Company (Hare, Hoerl and Snee, 1995). The nine headers were obtained from an affinity diagram of a much longer list of reasons.

A study of the In arrows and Out arrows shows that there are two key causal factors: "Fear of technical tools and methods" and "people have competing priorities." Each of these headers has 0 In arrows and 5 Out arrows. This analysis indicates that these two issues must be addressed if people in the organization evaluated are to make greater use of statistical thinking.

After experiencing the use of the affinity diagram and the interrelationships digraph, one will not likely be comfortable in the future discussing a long list of ideas or items. There is almost always some structure to be found that will provide insight and simplify the interpretation.

Education of Diverse Groups

Education and training is an important activity for statisticians. Indeed Hoerl et al (1993) indicated that effective training skills are critical to the survival of statisticians. It should be recognized that the participants in educational and training events have diverse backgrounds, perhaps even more so than ever before as the use of statistical thinking expands. The participants have different experiences, different needs and different learning modes. Our educational and training approaches should take these differences into account.

Behavioral scientists and educational researchers have found that people take in and process information in different ways (Herrmann 1989, Markova 1991). People have different preferred learning styles. Many of these differences are related to how we use the left and right sides of our brains.

Herrmann (1989) identified four learning styles. Some people learn by their feelings, hence the learning experience must be personalized for them (nurses, teachers, sales persons). Some need facts to learn and enjoy analyzing, reading texts and studying theories (lawyers, engineers). A third group need form or structure to learn (accountants, administrators). They enjoy details, learn by testing theories and appreciate guided practice. The last group are future orientated, think holistically and intuitively (CEO's, artists, entrepreneurs). They need opportunities to be creative and to transfer knowledge into their field of study.

Much more could be said on this subject. It suffices to say that statisticians will be more effective if they recognize that different people work and learn in different ways. Designing meetings, team endeavors, and educational and training events that take these differences into account will make the work more effective and increase its impact. Further discussion of educational approaches that take different learning patterns into account can be found in Hoerl and Snee (1995) and Snee (1993).

Continued on page 17

Continued from page 16

Table 3 - Links to Statistical Thinking

Method/Tool	Link
Affinity diagram	Cluster analysis
Meeting design	Process thinking
	Reduce variation
	Create alignment
Ideas	Soft data
Structure in ideas	Modeling
Learning styles	Variation
Interrelationship digraph	Cause and effect modeling

Links to Statistical Thinking

At first glance many of the skills and tools discussed in this article may appear to be outside the field of statistics. Deeper analysis reveals however that many of these approaches have links to statistical thinking. Some examples are summarized in Table 3.

The affinity diagram forms clusters of similar ideas, hence a link to cluster analysis. Constructing an interrelationship digraph is a form of cause and effect modeling. Designing a meeting with a purpose, outcomes and agenda uses process thinking to reduce variation and create alignment (agreement) on needed actions. Ideas can be thought of as soft data. Searching for structure in ideas is a form of modeling. Finally, recognizing differences in learning styles is understanding variation and designing events that compensate for that variation. Many of these skills may be considered "low tech" but are nonetheless effective. In the end our goal is to be effective.

So we have come full circle. We started out discussing nonstatistical skills and found that the skills discussed are in fact linked to statistical thinking. The major difference being the absence of hard data. Much work is not centered around hard data. Statisticians will have to deal with this reality if they are to expand and increase their impact.

My Message

My message is quite simple. In order to improve their performance, organizations are adopting new approaches to management and operations. These new approaches are expanding the use of statistical thinking. New skills are needed if statisticians are to take advantage of these opportunities. Statisticians must be able to deal with group dynamics, provide teams with problem solving methods, effectively plan and manage projects, analyze ideas as well as data, and effectively work with and educate groups that have diverse backgrounds and learning styles.

My message is much easier to state than it is to implement. Personal learning and change is required. Change is always difficult and painful. Someone once said that the only person who enjoys a change is a wet baby. Ignoring the opportunities presented by the new economic era we live in may result in even greater pain. We have to learn to work in a new way. Δ

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Statistical Thinking Interactive Session Results of Questionnaire

An interactive session on the topic of Statistical Thinking was presented at the 1996 Fall Technical Conference in Scottsdale, Arizona. The session, presented by the Statistics Division tactical planning team to "Demonstrate the Broad Effectiveness of Statistical Thinking", begin with a brief discussion of the term Statistical Thinking and tips on applying the concept at the strategic, managerial and operational levels. The audience was separated into teams and given one of three case studies in which to review and propose a solution. Audience solutions were then shared as time permitted. Finally, the responses from a panel of experts were discussed and distributed to the audience. (The panel of experts was comprised of H. Hacquebord, L. Nelson and R. Snee.)

At the end of the session, the audience was asked to complete a questionnaire in order to assist the tactical planning team in determining future training needs. Participants (N=67) were instructed to read and respond with a rating of 1 (low) to 7 (high) for each question. Results of the survey were as follows:

Statistical Thinking is:

1 - Not Beneficial 7 - Beneficial

Response	Count	
1	0	
2	0	
3	0	
4	0	
5	5	*****
6	22	**********
7	40	**********

Additional information is:

1 - Not Useful 7 - Useful

Response	Count	
1	0	
2	0	
3	0	
4	4	****
5	4	****
6	30	**********
7	29	**********

I would attend additional seminars:

1 - Disagree 7 - Agree

Response	Count	
1	1	*
2	0	
3	1	*
4	3	***
5	9	*********
6	27	**********
7	26	**********

I would recommend a seminar to a colleague:

1 - Disagree 7 - Agree

Response	Count	
1	1	*
2	1	*
3	3	***
4	11	***********
5	10	**********
6	26	**************************
7	15	***************

Future Publications should be in form of:

1. Traditional "How to Series"

1 - Disagree 7 - Agree

Response	Count	
1	4	****
2	6	******
3	6	******
4	9	*********
5	13	*************
6	15	***************
7	14	**************

2. Kit which includes CD ROM, disk, Gold Memory Jogger

1 - Disagree 7 - Agree

Response	Count	
1	0	
2	2	**
3	3	***
4	8	********
5	15	***************
6	19	*******************
7	20	********************

3. Internet Site

1 - Disagree 7 - Agree

Response	Count	
1	4	****
2	7	*******
3	4	****
4	12	************
5	8	********
6	12	************
7	20	********************

Additional comments emphasized the importance of demonstrating real life situations in training material, and the value of applying Statistical Thinking to day-to-day job responsibilities. Participants were interested in future publications and seminars designed to coach and facilitate implementation of the concept, particularly at the strategic and managerial levels. This included teaching materials which would be used in the educational and industrial systems. Other input included publishing articles in business magazines, and using examples which demonstrated impact to the bottom line.

Based on the responses, there is a strong interest in future publications on this topic. The team plans to publish additional articles, incorporating suggestions from the questionnaire. A tutorial "kit" is planned for 1998.

The tactical planning team would like to thank the participants for completing the questionnaire. Any other comments regarding this subject can be directed to either one of the team members.

G. Britz, L. Hare, R. Hoerl, D. Emerling, J. Shade

1996 FTC Short Course Summary

A total of 290 registered for the FTC held in Scottsdale, Arizona on October 24-25, 1996. The two pre-conference short courses presented on October 23rd were attended by 107 people; 72 took the Multivariate Control Charts and Process Monitoring Course offered by Douglas Montgomery and George Runger and 35 took the Statisticians as Change Agents Course conducted by Robert Lynch.

These Division sponsored pre-conference short courses are relatively inexpensive, costing $150 with lunch included, yet are presented by leading professionals. Courses will again be offered at next year's FTC. Δ

AQC Meetings

The Statistics Division will be holding several meetings in conjunction with the Annual Quality Congress. The 1997 Annual Quality Congress will be held May 05-07 in Orlando, Florida. Our Tactical Planning meeting will be held Saturday, May 3rd in the afternoon and Sunday, May 4th in the morning, with some working groups meeting on Sunday afternoon as needed. The Council meeting will be held on Sunday, May 4th in evening from 8:00 PM to 10:00 PM.

Our Annual Business meeting will be on Monday, May 5th from 5:30 PM to 7:30 PM. Refreshments will be provided at this meeting. You don't have to stay the entire two hours. It's a good chance to meet the officers and committee chairs and get some good food, too.

Other Division sponsored events include the booth (in the Exhibit Hall), the hospitality suite (inquire at the booth or one of the above meetings to find out where), the Division session (Improving Measurement Processes as well as Industrial Processes), and the Division sponsored pre-conference short course (Davis Balestracci presenting "Statistical Thinking as a Conduit to Quality Transformation in Health Care, Service, and Management").

We're all hoping to see you in Orlando—both old friends and new faces! Δ

Division Council Meeting

The Statistics Division Council meets formally twice per year - in the Spring at the Annual Quality Congress, and the Fall at the Fall Technical Conference.

A council meeting was held in conjunction with the Fall Technical Conference in Scottsdale on October 23, 1996. This article briefly summarizes the meeting. Anyone interested the full minutes of the meeting may obtain a copy by contacting Bob Mitchell, Secretary. The meeting was well attended by Council members and other interested Division members.

JL Madrigal reported that membership was 9,882. Partial results of the latest membership survey indicate that even though our member satisfaction rating is 98%, our members are asking for more frequent and simpler case studies and mini papers.

Don Williams reported that the Division had a current cash balance of $98,267.

The Statistics Division has been in the mode of deficit spending for the past several years. Declining membership and increasing Newsletter costs are causing concern that the Division may not be able to meet its financial obligations unless there is a dues increase. A majority of polled Division members support a dues increase of $2 to $4 to continue funding our activities. Based on this feedback, the Council approved a $2 dues increase.

Beth Propst announced that the Division will hold several meetings in conjunction with the Annual Quality Congress. A Tactical Planning Meeting will start at 12:00 p.m. on Saturday, May 3 and continue on Sunday morning, May 4th until 12:00 p.m. The council meeting will be held Sunday, May 4 from 8:00 - 10:00 p.m. The Annual Business Meeting will be Monday, May 5 from 5:30 - 7:30 p.m. All interested members are invited to attend any of these meetings.

Mark Kiel demonstrated the webpage to the Council. ASQC has volunteered to put the Statistics Division homepage on its server. The STATS www homepage will be html-linked to the ASQC webpage.

Nick Martino recognized the excellent response to requests in the newsletter for CQE assistance in generating new questions for the CQE exam. A note of thanks is elsewhere in this newsletter. Δ

AQC Short Course Statistical Thinking as a Conduit to Quality Transformation in Health Care, Service and Management

The short course will begin by discussing "Data Sanity: New Perspectives for Statistics" setting the stage for the remainder of the course which emphasizes the simple, efficient, planned collection of data through statistical thinking. The need for data as a basis for action is also stressed. A "data inventory" series of questions is introduced so that people can assess the current state of their organization's data collections.

The second portion of the workshop, "Process-Oriented Thinking", introduces and expands upon the concept that all work is a potentially measurable process. The Six Sources of Problems with a Process, a virtually universal sequence for assessing and improving work problems, is covered, as well at introducing the cultural thinking to look at processes, not people.

The third portion of the course, "A Perspective of Statistical Thinking and Theory", is extremely interactive, The class works as teams on data sets that have come across the instructor's desk in his consulting experience. At the end of each exercise, the results are thoroughly discussed and related to previous material.

By attending this workshop, the participants will be able to:

1. Expand their current awareness of variation, becoming process-oriented in regard to

Continued on page 21

AQC SHORT COURSE

Continued from page 20

problem identification, becoming chart-oriented in regard to data collection and display, and reacting appropriately in response to variation.

2. Make routine data collections more simple and efficient by asking better questions.
3. Understand that projects are necessary, but no sufficient for organizational transformation,
4. Come to the realization that whether or not people understand statistics, they are already using statistics, and should be able to recognize eight common statistical "traps used in many data reports and displays.
5. Utilize three simple techniques (run charts control chart, analysis of means) for diagnostic purposes.

Instructor Biography

Davis Balestracci is a Statistical Specialist for HealthSystem Minnesota. He has a BS degree in chemical engineering and an MS degree in statistics.

In his fifteen year career, Davis has developed a special interest in effective statistical education for everyday work and has given talks and seminars on his unique approaches at the local, national and international level. From 1985-1991, he worked for 3M, during which time he won two corporate quality awards and two process technology awards for his innovative uses of statistical methods. Since 1989, his interests have evolved to adapting the manufacturing model for quality improvement to business management and service industries. He has co-authored a book, Quality Improvement: Practical Applications for Medical Group Practice, which is published by the Center for Research in Ambulatory Health Care Administration (CRAHCA). Δ

1997 Technical Session Sponsored by Statistics Division

Larry Haugh

The Statistics Division Session at the Annual Quality Congress in Orlando will be moderated by Mary Leitnaker, a professor of statistics at the University of Tennessee, and a recent co-author of The Power of Statistical Thinking: Improving Industrial Processes (Addison-Wesley, 1996).

The two hour session is scheduled for Tuesday, May 6, 1997 (3:30-5:30 PM) and will incorporate discussion and case studies on improving measurement processes as well as industrial processes. Wes Anderson of Eli Lilly and Company and a colleague from their company's Clinton analytical laboratory will describe the use of statistical methods for improving measurement processes and the results they have achieved by this work. Anthony Cooper of Six Sigma Associates and Marjorie Green of Allied Signal will also give presentations on the role of statistical thinking in studying processes prior to conducting designed experiments. Examples of these studies and the resulting benefits in the use of designed experiments will be described.

This sounds like a session you won't want to miss! Δ

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Winter '98	16	8	Nov. 14, 1997

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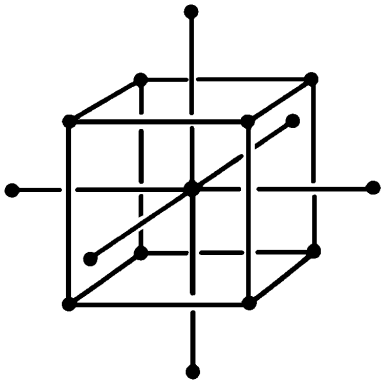

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