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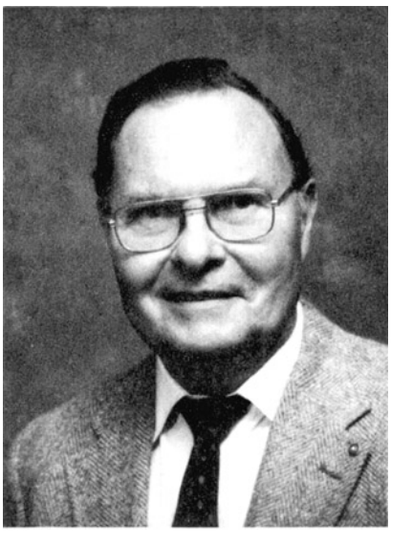

# How to Hope With Statistics

ROBERT V. HOGG*

The title of this talk, *How to Hope With Statistics*, arises from the Second International Conference on Teaching Statistics held in Victoria, B.C., two years ago. I was program chair of the conference and had all sorts of outstanding helpers. I acknowledged that help by working their names into Bob Hope's song, "Thanks for the Memories." For example:

> Thanks for the memory, of Fred Leone and his gang
> Who started with a bang
> Built our association strong until its praises were often sang
> We thank you so much.

After I did this in Victoria, a Swedish statistician, Andrejs Dunkels, who is a cartoonist, drew these two little characters. One asked, "What's the name of Bob Hogg's next book?" The other replied, "How to Hope With Statistics." Of course, the "Hope" in the cartoon referred to Bob Hope. But the more I thought about it, the more I realized that Dunkels might be onto something: Hope With Statistics. There really is hope with statistics. I would like to discuss this tonight.

In the last two or three years, I have flown in and out of Washington's National Airport several times, really more than I would have like. But there is one flight pattern I particularly enjoy—taking off to the west and seeing the Capitol, the Washington Monument, the White House, and the Lincoln Memorial on the right. It's a thrill for any American.

The Capitol and monuments of Washington are symbols of America's hopes and its promises. But as I travel around this country in my duties as ASA president, I often feel those promises are not being kept. This April, for example, Carolyn and I drove through the South when we visited a few chapters in South Carolina and Georgia. The timing was perfect as the azaleas and dogwood were at their peak. We drove back through Tennessee and Kentucky, then towards St. Louis. As we approached that city we could see the Gateway Arch, another symbol of this nation's hopes. But as we came closer, we drove through the squalor of East St. Louis—it struck me that there is not much hope there.

Another flight pattern around National Airport that I like is landing after seeing Mount Vernon, then Alexandria on the left. I can spot King Street, with the Masonic Memorial at the end. Over two streets is Duke Street. There's the church, the empty parking lot, then finally the new ASA building. Finding it is a thrill for a statistician, particularly one so heavily involved in that project.

Just as the monuments of Washington are symbols of America's hopes, the new ASA building is a symbol of the potential of American statisticians. How can statisticians—in education, in business and industry, and in government—help solve our nation's problems? How can we help restore hope with statistics?

Let me begin with my favorite subject, education, by mentioning a 1940 report of the California Department of Education in which educators listed the seven top problems in the schools. They were talking, chewing gum, making noise, running in the halls, getting out of line, wearing improper clothing, and not putting paper in wastebaskets. I was in high school at that time, and I would say those were the major problems. In retrospect, it seems like a wonderful time.

In 1980 the survey was repeated; the top seven problems were drug abuse, alcohol abuse, pregnancy, suicide, rape, robbery, and assault. There is a great difference in those two lists; it shows that something is wrong. Has America become such an old country that we cannot solve problems that are seemingly out of control—like that of drugs? I hope not, although I do not see a clear solution of the drug problem.

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In particular, there is something wrong with the way science, mathematics, and engineering are being taught in America. One of the researchers for "A Nation at Risk" said, "We are raising a new generation of Americans that is scientifically and technologically illiterate." Another report, "The Underachieving Curriculum," compared American math programs with those in other industrialized nations. U.S. student achievement was below average and student retention rates in mathematics programs were lower than those of other countries. It seems the Japanese are educating engineers and scientists, while the U.S. is producing lawyers and accountants.

American universities have responded by filling empty seats in math and science classes with foreigners. The National Research Council reported in February 1988 that in the years 1983 to 1985, more than half of the engineering professors in American universities under age 35 and more than 60 percent of engineering doctoral students were foreign. Today, we know the figures are even higher.

I am not against the foreign-born because this nation has accepted them and benefited from them since about 1620. Foreigners must be welcome at American universities. They expose students to other cultures and help them consider the state of their own society. But American postgraduate education cannot continue to depend on foreigners to fill classrooms as teachers and students. We must encourage more American-born to become scientists.

Foreigners, after all, will not necessarily continue to come to America to study and teach. Many who do study here are now returning to their homelands to expand educational opportunities there. Some day American programs may offer no advantages to foreign students when compared with programs in their own countries.

And, of course, many foreigners *should* return to their native lands, not because Americans don't want them here, but because their countries need their expertise to help overcome problems like poverty and widespread deprivation.

But postgraduate education is also increasingly important to the American economy. No longer will America's giant domestic market, cheap raw materials, and mass production guarantee prosperity. We need highly educated people to innovate and to adapt to a changing world. Yet only a few actions have been taken to encourage Americans to undertake postgraduate math and science education. Many more are needed.

For example, more fellowships are needed for math, science, and engineering graduate students, and the stipends they receive need to be higher. Currently a teaching assistant at Iowa makes about $7,000 after paying tuition. This does not compare favorably to the initial salary of more than $30,000 for a beginning engineer. Moreover, the recipients of the fellowships should not be taxed, as the President and Congress, in their great wisdom, decided. That's crazy.

But monetary reforms will not get at the real problem. We want students and teachers devoted to quality and learning. The key is to show that mathematics and science can contribute significantly to the welfare of our country. Educators should share with students the importance of these subjects. They then become interesting. Statisticians can really help here by clearly demonstrating that math and science are not just mental gymnastics.

But sometimes statistics is taught in a way that can kill the imagination. *Statistics: A Guide to the Unknown* was a great title for those essays written by statisticians associated with our ASA–NCTM (National Council of Teachers of Mathematics) committee on curriculum, at that time chaired by Fred Mosteller. I wish we would teach our subject in that spirit—as a guide to the unknown. That's what statistical thinking is about.

Toward this end, we have done a few things already. Our Quantitative Literacy Program, also an outcome of the joint ASA–NCTM committee, has developed materials that can be used in grades 7–12. These are excellent data-oriented statistical methods, and many teachers have been trained to use them.

We must, and will, do more—working in even lower grades to demonstrate clearly to very young children that science can be interesting and useful. They must also understand that, regardless of their financial status, sex, color of their skin, they will have the opportunity to go to college and become engineers, mathematicians, doctors, and so on—provided they prepare themselves academically. If we cannot make such a promise to those children in grade schools, then the professionals in this association better try to see that the system is changed. I believe that providing equal educational opportunities gives this country the best chance for true equality of its citizens. A wasted mind is a terrible thing; we must prevent that.

In colleges and universities we are now questioning the type of statistics courses given to liberal arts majors, to business students, to engineering students, and to others. There have been important conferences held on statistical education for engineering and business students. The quality of American products has been a driving factor behind some of these sessions. New books addressing the recommendations of the conferences have been and are being written. I hope more will follow.

I was very much involved in the conference for engineers, which will be followed by a second one next spring to be chaired by Neil Ullman. I want to emphasize the importance of such projects on improving statistical education. Those involved in the engineering conference came to recognize the importance of having knowledge of the omnipresence of variability; the high value of graphical analysis; the essentials of statistically designed experiments; basic statistical inferences; and the philosophies of Shewhart, Deming, and others concerning the delivery of quality products and services.

We must continue to stress the need for selective changes in our search for the optimal programs. It is my thought that statistics majors should see more applications and total quality management techniques than they do at present. They really learn nothing about management; yet many will be involved in it later. As a matter of fact, many of us could benefit from the use of good managerial procedures.

Our academic programs can also suggest the need for using statistics in policy-making, with students recognizing the value of good statistical measures in assessing characteristics of various projects benefiting our country. Moreover, they should know something about the "cost and benefit game" of funding some programs and not others. Statisticians can play major roles in shaping policy, and our students must realize this. We should not simply be training statistical technicians. We must broaden our goals. This means we must change our curricula.

In graduate studies, we need to create real communities of scholars. One way to move in this direction is to have projects on which the faculty and graduate students can work. The space program at Iowa is an example of such a project. While our statistics group will probably never have anything that big, we are trying to get smaller projects—with John Deere, Rockwell-Collins, and Amana. Iowa does not have a lot of industry; we must reach out. We are! We have made a substantial contact with Ford and would like to talk to others. However, I make this plea not only for Iowa, but for all universities to establish stronger academic/industrial relationships.

This country really needs more advanced institutes, vehicles through which young Ph.D.'s can interact with senior scientists. The statistical societies are exploring ways to fund one or more institutes in statistical sciences. Already Arnold Zellner has made one excellent and very substantial proposal to NSF. In these institutes, there should be involvement by people from universities, industry, business, and government working on truly cross-disciplinary projects. This approach is needed to ensure that we solve the right problems and that there is relevance in the results.

In addition, sabbatical programs—not just in academia, but in business, industry, and government—must be expanded. People in the latter fields might exchange positions with professors in universities.

In this changing world, everyone—including workers—must have some opportunity for continuing education. Many short courses in quality control and statistics are given. Are they the best? Are they really enhancing the competitiveness of U.S. industry? We must ask this not only about the short courses, but about all continuing educational activities. At least by asking, we suggest that we could improve—and we probably can in most instances. On-the-job education is extremely important; let's do it well.

We have started to make substantial changes in education; let's continue those and do more, always recalling that learning must be gratifying. One reason that there are too few students who want to study and teach math and science is that learning in these areas is not enjoyable. Unfortunately, most students see studying as something people have to do, not something they want to do. This situation must change.

It is not solely the teacher's responsibility to make learning interesting. Students need to work hard. Parents need to be involved and respect teachers. If something isn't enjoyable, people need to have the courage to say it need not be that way. In a certain sense, as my son says, "It should be fun." And, indeed, it could be. That is the key to continued progress in American mathematics and science education.

While education is our hope in the long run, more immediate gains can be made in business and industry. Consider the 1920s, when the British bought lots of well-made American products like tires and patent leather shoes. Henry Ford, Harvey Firestone, and others started plants in England to avoid the tariffs. Then, after World War II, British industry began to decline.

Today we buy well-made Japanese products. The Japanese are, in turn, buying American industries—even Firestone. With the dollar down, they are cheap. What will happen to American industry? Are we headed for a similar decline?

As business becomes bigger, quality suffers. The human aspect in the quality process is forgotten. Workers should enjoy their work, use their talents satisfactorily, grow in their employment, and see how they have contributed to the final product in some responsible way. People's prides need that sort of recognition. "Too big" has forced many of my friends into retirement because work is not fun anymore.

Let us recognize our faults and difficulties and get busy and try to solve them in the best way that we can. President Reagan once implied we could cure America's problems the John Wayne way—that is, through "true grit": holding our shoulders back, standing tall and making zero defectives today. But alone, "true grit" is *not* the answer. Workers have not changed and they operate the same old machines as yesterday. They need help, or—as Ed Deming says—a road map.

Clearly, we must *change*. But how? There is where statistics can help—why there is "hope with statistics." Collect information. Analyze data. Explore more with carefully designed experiments. Analyze again and again. Use the scientific method—statistics is at its heart.

Statistical thinking can direct change in industry. Product and process designs must use statistical design of experiments. A good process can be listened to with Shewhart techniques—and extensions of them. Take action and make changes when appropriate. If the results of a process are not optimum, consider evolutionary operation—the famous EVOP of Box and Draper—or other appropriate statistical procedures. Make the changes in a direction that approaches an optimum. We will never get there, but we must continue to try.

While considering quality improvement, I must note that two members of the association sent me copies of an article that was in the *New York Times* concerning "Improving Quality, the Japanese Way" on July 20, 1988. It suggested that Genichi Taguchi had invented design of experiments, statistical quality control, and loss functions. Moreover, it implied that the traditional statistical method for searching for an optimum was to "change one factor at a time." Hogwash. What about R. A. Fisher, Walter Shewhart, and the many other fine statisticians who had

worked in these areas? I was mad and, as President of ASA, I responded to this with a letter to the editor.

Members of our association must react to situations that are wrong and make suggestions on how to improve them. In recent years, sometimes with the urging and help of my sons, I have done much more of this, writing letters or even guest editorials. I really wish that I had done more in my younger years. I mention this to encourage many younger and smarter statisticians in ASA to be more involved in many of the important problems of today. This country needs your help.

Business and industry must realize we now have a global market—really *one* marketplace. It doesn't matter where you live; you buy the best from that one market. This requires a world-class product of high quality, sold at a reasonable cost, delivered in a timely fashion. Many of these products will have short life cycles. This suggests small batch production from flexible, high-quality, often small industries, many of which will use robots. These changes in industry create the need for new and special, possibly highly automated, statistical techniques.

It is difficult to change. Many business persons remember the "happy days" of the early 1950s. Their sons and daughters, now in control of those businesses, want those days back. Even Bob Hogg wants the "statistical good news of Hogg and Craig" to go on forever. But statistical theory and methods are changing—and so are demands in business and industry, too. Still, the National Research Council's Manufacturing Studies Board in the October 1986 issue of *News Report* indicates that the majority of U.S. companies are clinging to their old ways: "Others should change, not me." "You must be referring to my neighbor." We must learn to give up short-term gains for long-term good.

The statistical profession might also help in finding solutions for other problems of our country, many of which, of course, are related to troubles in education and industry. This country is really one big system to analyze. This is exactly the type of situation in which statisticians should be utilized.

- There is the trade deficit. The U.S. is now the greatest debtor nation. We owe about 500 billion dollars to foreigners now and may owe 2 trillion by 1995.
- American products are being bought now because they are cheaper, not necessarily better.
- There is not enough savings; we are living beyond our means as a nation and as individuals.
- Productivity and quality are not increasing substantially; the U.S. has a lower growth rate than any major industrialized nation.
- Businesses are paying big dividends, but not modernizing industry. We have the nicest homes of any industrialized country, but the oldest factory machinery.
- Differences between the "haves" and the "have-nots" are increasing. Do executives really deserve more than 50 times the income of their workers?
- There are urban problems like crime, gangs, poor transportation, AIDS, and homelessness. (Even Iowa City has a few homeless people now.)
- The health-care system needs a major overhaul.
- There are environmental difficulties like acid rain, nuclear fallout, smog, water pollution, and erosion. Those not living in farm states might not be aware of how names of herbicides have changed. They once had innocent names like Atrazine and Treflan; now they have action names like Command, Prowl, Round-Up, and Counter. I look for herbicides called Obliterate and Annihilate in the future to fight an ever-growing stable of weeds like woolly cupgrass, black nightshade, and lambsquarters. What are the new, more powerful herbicides—and insecticides—doing to our water?

If I were President—not of the ASA, but of the U.S.A.—I would get a team of outstanding persons, including lots of scientists and, of course, statisticians. The team would first list all possible programs: for the military, for agriculture, for the environment, for economic development, for the development of energy, for health care, for education, et cetera. The team would then assess the importance of each of these programs; assign some utilities, if you like. I wouldn't even mind a few probabilities where appropriate. Here we will have some disagreements. That's good; the team members must think hard. Compromises are needed. We also need the best possible statistical measures of each situation. Then, and only then, can we truly start doing the right thing for our country. Our new President clearly needs a scientific adviser who has his respect—and his ear—and I would like that person to be of Cabinet rank.

For example, take the space program—manned or unmanned flights? Or should we forget the entire program and spend our money elsewhere? Certainly this is a real possibility. Costs must be listed as carefully as possible, along with the benefits. Let's compare the Challenger disaster and the unmanned Pioneer 10, which was launched in 1972 and is now over 4 billion miles in space. It was the first craft to reach Jupiter and is still sending information back. Play the "cost and benefit" game. The answer is clear, except to a few persons who need the glamor and thrill of manned space flights to hold their interest. So, according to Hogg, we should have unmanned flights. Obviously, some disagree. Possibly a harder decision is "how many?"—including zero as a possible answer. After all, this program competes with all other programs. That is what this assessment is all about. It's difficult; we need the advice of experts based upon good, solid statistical measures and decision rules.

I do not pretend to be an expert on this or any other program I have mentioned. As a matter of fact, I recognize that many in this audience know much more about statistics than I do. So, as I tell my students, possibly I do not know what I am talking about; but if I did, I would be right.

I am certainly not the first to suggest the need of valid statistical measures. While writing this speech, I thought of the fine letter Florence Nightingale wrote to Francis Galton in 1891 on the subject of a university professorship in statistics. In that she mentions problems concerning food, education, child labor, crime, workhouses, and other

troubles of that day. She pleas "for some teaching how to use these statistics in order to legislate for and to administer our national life with more precision and experience." As a nurse, she was concerned about people.

Karl Pearson makes the following observation about her:

> Florence Nightingale believed—and in all the actions of her life acted upon that belief—that the administrator could only be successful if he were guided by statistical knowledge. The legislator—to say nothing of the politician—too often failed for want of this knowledge. Nay, she went further: She held that the universe—including human communities—was evolved in accordance with a divine plan; that it was man's business to endeavor to understand such a plan and guide his actions in sympathy with it. But to understand God's thoughts, she held we must study statistics, for these are the measures of his purpose. Thus the study of statistics was for her a religious duty.

(Oh, how I wish my students would study statistics with that sort of conviction.)

Obviously we cannot cure all ills with statistics. However, the statistical profession has not done a very good job communicating with the general public about what can and cannot be done with statistical techniques. Too often people think that statisticians put all the emphasis on the averages—not recognizing that we are very much interested in the study of variation.

I have often suggested that more statisticians should even enter politics. I have kidded certain of my friends about becoming senators, congressmen, governors, and mayors. The titles actually appealed to some of them, but they had never thought of it before.

Tonight, we recognize our new fellows of ASA. Maybe they will be such leaders—the sort of leaders to show the country how to hope with statistics. But I'm asking not just them, but each of you to be this kind of leader.

Statisticians like you, Dick Anderson. Yes, I know you are a professor emeritus doing some consulting and trying to cut down on work a little. But you have the energy—you are articulate and an effective statistical communicator. When is the last time that you called on a high school math or science teacher? Asked if those students would like to hear about some good applications involving important projects? Do it soon, Dick.

But as good as you are, Dick, possibly it might be more important for our women, our minorities, and our disabled to visit high schools—or even grade schools. How about Maria Gonzalez? Kimmy Bowman? Allan Sampson? You might believe that you cannot do much by talking to one or two classes in a high school or a small college. However, if you can capture one inquisitive mind for statistics—or, more generally, the mathematical sciences—you have had a very successful day. I will contact Lynn Steen, Chairman of the Conference Board of the Mathematical Sciences, to see if we cannot create some massive informal visitation effort in high schools and colleges.

If you can't become a congressman, try to influence one. If you can't become a senator, try to support the ones who can do the greatest good. If you don't become a governor, try to help create "quality communities" within your state. If you can't be a mayor, help with the troubles of the city; it's a big statistical problem involving assessment. Even if you're not president of a school board, try to stimulate better math and science education in your community.

Champions of causes, pioneers, leaders are in demand. Decide tonight that you will be one of them. Make a commitment. Statistics will help; it is a guide to the unknown. There is hope with statistics. I'll write the book: *How to Hope With Statistics*. But you know about it already and do not need to read it.

It has been a great honor for me to be your president. It's lots of work, but it's always enjoyable meeting with you on my many visits around the country. One person as president can do very little, a point that I have discussed with Dick Anderson a number of times. But if each of you would decide to do a little more—to hope more with statistics, we would be better off—and I would have been somewhat successful. So if you see a problem, try to do something about it. Be a Florence Nightingale—get involved—because as statisticians we can help, even if only 5, 10, or 15 percent of an appropriate team.

As I close, I hear that echo from another recent convention, changed somewhat: Hope With Statistics, Hope With Statistics, Hope With Statistics, Hope With Statistics! Like a locomotive in the night! Who are its engineers, its leaders? Let them be you and me—with the help of our friend, statistics.

> Thanks for the memories, I really hate to part
> I've loved it from the start
> Please Hope With Statistics from the bottom of your heart
> I'd thank you so much.

[*Received September 1988.*]