From Consulting to Collaboration to Leadership: Increasing the Impact of Statistical Practice

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*W. J. Dixon Award Winners

Abstract
The W.J. Dixon Award for Excellence in Statistical Consulting is given by the American Statistical Association to "a distinguished individual who has demonstrated excellence in statistical consulting or developed and contributed new methods, software, or ways of thinking that improve statistical practice in general". In this paper, five of the seven recipients of this award to date share their experiences and perspectives through ten "stepping stones" that move from consulting to collaboration to leadership.

Key Words: Consulting, Collaboration, Leadership, W.J. Dixon Award, Mentoring, Relationship, Organizational Impact, Video

1. Introduction
The W.J. Dixon Award for Excellence in Statistical Consulting is given by the American Statistical Association to "a distinguished individual who has demonstrated excellence in statistical consulting or developed and contributed new methods, software, or ways of thinking that improve statistical practice in general" (American Statistical Association 2015). The award has been given out each year since 2009, and to date there are seven recipients:

2009: Doug Zahn, Zahn & Associates
2010: Dallas E. Johnson, Kansas State University
2011: Michael H. Kutner, Emory University Rollins School of Public Health
2012: Gary Grove Koch, The University of North Carolina at Chapel Hill
2013: Ronald D. Snee, Snee Associates, LLC
2014: Frank E. Harrell Jr., Vanderbilt University School of Medicine
2015: Janet Wittes, Statistics Collaborative, Inc.

Each of these award recipients has made unique contributions to the field of statistical consulting as detailed by their award citations (American Statistical Association 2015).

Reasons the first two recipients received the award are detailed in Vance (2014a) and Vance (2014b).

In this paper, five of these seven individuals share perspectives, experiences and advice that fall under the umbrella of ten stepping stones. These stepping stones take a practicing statistician from an early interest in consulting through becoming a leader of statisticians in fields of research. They are:

1. Gaining Interest in Consulting
2. Strengthening Technical Skills
3. Understanding and Interacting with Clients
4. Developing Relationship Skills
5. Practicing Client Centered Collaboration
6. Recognizing the Importance of Collaboration to Research Practice
7. Collaborating to Improve your Own Practice
8. Taking the Lead in Research
9. Taking the Lead Among Statisticians
10. Leading the Way for Statisticians in Research

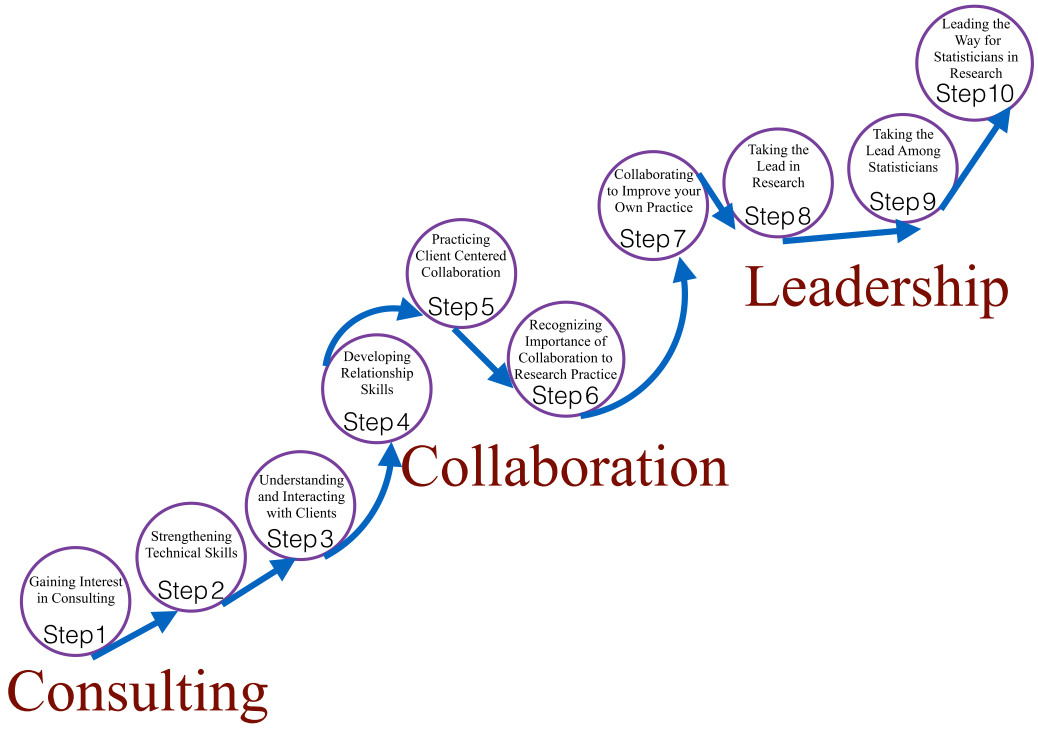

Figure 1: Ten stepping stones from consulting to collaboration to leadership.

These stepping stones are not meant to be a prescriptive "one-size-fits-all" path for finding success in the world of statistical consulting. Rather, these steps were determined after collaboration among the authors, and are a common thread that brings together their individual journeys. Readers should consider these in the context of their own career path, and reflect on how these shared perspectives may help them to increase the impact of statistics in their own personal statistical consulting practice.

2. Consulting

The online Oxford Dictionaries define consultation ("consultation, n.1.1") as follows:

> A meeting with an expert or professional, such as a medical doctor, in order to seek advice.

Just as a medical doctor answers a medical question for a client, we here consider a statistical consultant to be one who answers a statistical question for a client. Our authors highlight the following three steps through the realm of statistical consulting: gaining interest, strengthening technical skills, and understanding and interacting with clients.

Individual statisticians certainly have a variety of interests that draw them in to the world of statistical consulting, and Dallas Johnson provides background on what that entailed in his personal journey. Gaining strong technical skills is perhaps an obvious prerequisite to engaging in consultation. Prior to answering a variety of questions from a number of statistical areas, one must have the related technical expertise and the confidence to exercise it. Frank Harrell discusses important principles to which consultants should adhere, along with the importance of being guided by statistical principles during consultations. The final step highlighted here is understanding and interacting with clients. To make an impact on those who seek statistical expertise, it is important to understand the context in which one is answering statistical questions. Ron Snee describes the model used at DuPont to connect statisticians to their clients and their clients' projects.

2.1 Stepping Stone 1: Gaining Interest in Consulting (Dallas Johnson)

I received a B.S. degree in Math Education from Kearney State College in Nebraska in 1960, and I taught high school mathematics for 5 years. In 1965, due to the Soviets putting Sputnik into space, I received a National Science Foundation Fellowship to earn an M.S. degree in Mathematics from Western Michigan University to improve the quality of my teaching. Based on a two-semester sequence in Math Stat out of Hogg and Craig, I decided to pursue a PhD degree in statistics.

I went to Colorado State University on an Instructorship in mathematics in 1965 where I taught four courses in Intermediate Algebra during the fall quarter. After that, I began teaching four courses in statistics per quarter while taking courses towards a PhD degree. After two years, my wife and I determined that my progress towards the PhD degree was going too slowly and I gave up the instructorship paying $7800 per year in favor of an NIH Fellowship providing statistical support to the College of Veterinary Medicine paying $3200 per year. One main consulting project was to help a Vet Med PhD student studying the effect of anesthetics on miniature pigs, where we designed a 6x6 crossover design with 6 pigs and 6 treatments. This was my first exposure to messy data as there was an enormous amount of data, and two of the pigs died prior to completing their 6 periods of study.

Upon graduating in 1971, I went to University of Missouri-Rolla (UMR) on a typical Arts & Sciences teaching/research appointment. I did almost no consulting at UMR except for helping to determine if an elementary school being constructed over abandoned coal mines was going to be safe for use or not.

In 1975 I went to Kansas State University, a land-grant college, on a teaching and research half-time appointment in Arts & Sciences and a consulting half-time appointment in the Agricultural Experiment Station. I held this position until I became department head of statistics in 1994; after becoming department head, I continued to consult but at a much reduced rate.

Consulting in a university environment is extremely rewarding. You are helping with a wide variety of clients ranging perhaps from researchers in animal nutrition who collect their grab samples out of the stomach of a cow by going through a window placed in a cow's side to a researcher studying parents' abilities to cope with the stress of having a child with Down Syndrome. A typical consulting year for me would be to help 90-100 researchers from 20-25 different departments for a total of 500-600 consulting appointments per year.

I also taught professional workshops for 24 years in the Analysis of Messy Data and Applied Multivariate Methods—these workshops led to my authoring a textbook in multivariate methods (Johnson, 1998) and co-authoring a three-volume set of books on the Analysis of Messy Data (Milliken and Johnson, 2009, 1989, and 2001). These books and the professional workshops also led to many consulting opportunities in the so-called "real world".

2.2 Stepping Stone 2: Strengthening Technical Skills (Frank Harrell)

It is important to know the most important principles of statistics and to have your blood pressure rise when a client wishes to deviate from those principles (it can be important not to show the blood pressure rise, though). Some of the many important principles are to know what you don't know and to have a parameter for it, to preserve the information in the data (e.g., by avoiding categorization), and to avoid arbitrary analytical decisions that other reasonable statisticians would not make. Let your consulting, whether related to design or analysis, be constantly guided by statistical principles.

Some of the key principles of statistics that have guided me are:

- Use methods grounded in theory or extensive simulation
- Understand uncertainty and bias
- Design experiments to maximize information and understand sources of variability
- Use all information in the data during analysis
- Use discovery and estimation procedures not likely to claim that noise is signal
- Strive for optimal quantification of evidence about effects
- Give decision makers the inputs that optimize decisions
- Present information in ways that are intuitive, maximize information content, and are correctly perceived

Based on statistical principles, be prepared for key arguments:

- "We need to do it this way because our top journal publishes articles doing it this way."
- Avoid arbitrary decisions especially when they are based on things that don't exist such as thresholds

- Dichotomania: the urge to slice and dice nice continuous variables out of fear of algebra

I find it important to give the client/collaborator what she really needs, rather than giving her what she wants.

Some of the technical skills that have served me well in consulting and collaboration are:

- Statistical computing
    - Expertise in modern languages leads to increased efficiency in consulting and more rapid adoption of modern statistical methods. Either be great in statistical programming or work with persons who are.
    - Mastering statistical computing enhances the ability to quickly simulate properties of a proposed statistical approach
    - Knowledge of statistical computing languages enhances our ability to factor out analysis components to create generic software tools to make future consultations more efficient
    - Script everything for maximum reproducibility.

- Examples of statistical methods that I use repeatedly:
    - Bootstrap, nonparametric smoothers, flexible handling of nonlinear effects in regression, semiparametric regression, multiple imputation, U-statistics, Bayesian modeling
    - Statistical presentation graphics.

2.3 Stepping Stone 3: Understanding and Interacting with Clients (Ron Snee)

Many statisticians work with individuals and teams to solve problems, discover new knowledge and improve operations. Our job is to help these people (called clients) be successful. Effective working relationships are often a characteristic of successful projects. The question then is how to develop these relationships.

I worked in DuPont's Applied Statistics Group for 16 years as part of my 24 years at DuPont. A model we used and which is used by other organizations is to assign statisticians to specific products, services, plants, laboratories and other types of groups. The assigned statisticians are held responsible for:

- Getting to know the people, products, processes and problems in the assigned area
- Providing useful solutions to problems
- Anticipating the organization's needs and identifying opportunities for high impact projects
- Having influence and impact on the organization
- Facilitating training for the organization as needed
- Being an effective team member

Working in this way the statisticians got to know their client organizations as well as individual clients. Working relationships were enhanced. The organization developed an

understanding of how statisticians and statistical thinking and methods could contribute to the success of the organization. Over time the statisticians became an integral part of the client organization, often carrying the organization's business card and attending client picnics and celebrations.

Statisticians were rewarded and promoted based on their impact on the business of the organization and the influence the statisticians had in their client organizations. Typically, the more senior the management the statistician worked with, the more important the problems the statistician worked on and the greater the impact the statistician had on the client organization. Such statisticians were often promoted beyond the typical career level to senior ranks of DuPont's internal consulting organization.

Some major problems statisticians had the opportunity to work on included development of product quality management systems for DuPont's businesses, product performance studies for products sold to major DuPont customers, and environmental studies the results of which were presented at public hearings and in legal proceedings, including the US Supreme Court. Such studies typically involved millions and sometimes hundreds of millions of dollars.

These assignments were not for the statistician's entire career. Over time with the agreement of all parties involved, the statistician's assignment would be changed and the statistician would work to help improve the performance of the new assigned organizations.

3. Collaboration

The online Oxford Dictionaries define collaboration ("collaboration, n.1") as follows:

> The action of working with someone to produce or create something.

Collaboration in the environment of the statistician can be defined through the creation of new knowledge. Consulting, as previously defined, involves answering a client's statistical question. While this is educational and helpful when done correctly, a statistician can sometimes go further to aid his or her client by helping to answer research or business questions in addition to providing statistical advice (Vance 2015). This requires a wider perspective on the parts of both the statistician and the client, as well as an agreement between the client and the statistician about the extent of the statistician's ownership of and responsibility for the work.

The stepping stones highlighted in this section are: developing relational skills, practicing client-centered collaboration, recognizing the importance of collaboration to research practice, and collaborating to improve your own practice. Doug Zahn begins by discussing the development of relational skills that are important to entering into collaborative relationships with clients. These skills are the gateway to a connection with clients and gaining an understanding of how statistical methodology fits in to the bigger picture of client research. Dallas Johnson then describes some examples of client-centered collaboration, which follows once a consultant has learned to hear and understand the deeper research questions behind a client's quantitative efforts.

Next, Mike Kutner describes an occasion on which the intersection of statistical and medical practice was key to making a decision concerning the ability to perform a

responsible research study. The recognition of the importance of collaboration to research practice provides a consultant with the "big picture" of what he or she can contribute to science or industry through the combination of strengths that each collaborator brings to the table. Finally, Doug Zahn describes collaboration with one or two partners to strengthen one's own abilities as a statistical consultant, particularly through the partner's use of mutual video review. This type of collaboration provides a consultant with a meta-view of his or her practice, and allows one to improve for the benefit of oneself, one's clients, and the mutual work in which they are participating.

3.1 Stepping Stone 4: Developing Relational Skills (Doug Zahn)

Relationships are critical to success no matter what you do. The good news is that you can intentionally develop them. A valuable tool for this journey is the definition of working and synergistic relationships.

In a working relationship both parties agree to tell the other the truth, their own truth, not some universal Truth. Being human, there are times when you will not do this, either intentionally or unintentionally. As soon as you realize that you have not told your partner the truth, clean it up. To do this, first acknowledge that you did not tell the truth without attempting to justify your actions by a series of excuses. Second, apologize for what you did and, third, ask what you can do to heal the fracture that your action caused in the relationship.

Admittedly, all three steps are uncomfortable. Rigorously following these steps may serve to remind you to tell the truth when you are tempted not to in the future. Though uncomfortable, it is essential to heal the fracture in your relationship.

In a synergistic relationship, the two parties first have a working relationship. Then each unilaterally gives up the right to make the other person "wrong." One makes another person "wrong" by engaging in any of the multiple activities that communicate to the other that we think they are an idiot, at best. These activities include the raising of an eyebrow, a particular squint of the eyes, and scoffing—verbally or nonverbally. Again, being human, there are times when you will notice having one or more of these reactions in an interaction. As soon as you realize that you have done this, engage in the cleanup activity described two paragraphs above. Synergistic relationships are difficult to develop and well worth the effort. The safety that is present in them magnificently enhances creativity.

Speak intentionally. This is an essential part of developing relationships.

- Make complete requests: specify precisely all tasks you are requesting and by when they are to be finished. There are three possible responses to a valid request: accept, deny, and deny with a counter-offer. If you notice that you are not willing to accept any response to your request other than "accept," then you are making a command rather than a request.
- Make complete promises: specify precisely all tasks you are promising to do and by when they will be done.
- Using manipulation and force will jeopardize your relationships.

Listen intentionally. This is another essential part of developing relationships.

- Listen to what you say. A clue that I do not always do this is when I ask a client, "What did I just say?"

- Listen to what your partner says, asking for clarification—rather than guessing—whenever you think you may have misunderstood a word.
- Listen to what your partner hears you saying. This is often not what you intended to say. The only way you can discover that this has occurred is to ask your partner what she or he heard you say. The benefit of discovering miscommunications far exceeds the discomfort of asking what was heard.

3.2 Stepping Stone 5: Practicing Client Centered Collaboration (Dallas Johnson)

My consulting activities generally involved one or more of the following: designing an experiment, suggesting methods for analyzing the data generated, interpreting the results of the statistical analyses, discussing how the results can be presented to the client's professional colleagues, and responding to referee comments before papers are accepted for publication.

3.2.1 Typical University Statistical Consulting Projects

One of the first researchers that I helped was a graduate student in agronomy. He was studying whether certain genes in wheat plants would help a plant be resistant to damage from greenbugs. He had designed an experiment and came to me to bestow my blessing on his design. He was studying three different gene enhanced varieties (E++, E+, and E). He planned to place 10 test tubes in the lid of a large coffee can with 10 plants of a single variety assigned to the test tubes in each can, one to each tube. Then two of the test tubes in each can would be assigned one of 5 different levels of greenbug infestation (0, 5, 10, 15, or 20 greenbugs per tube). He had a split-plot experiment with gene level as the whole plot factor and infestation level as a subplot factor. I redesigned the experiment for him so that there would be two varieties of wheat in each coffee can using a balanced incomplete block design. This made both gene levels and infestation levels within coffee can factors, which provided a great increase in power for his most important comparisons. This was my second exposure to messy data as the client changed the design in reps 2 and 3 without consulting me. He changed the design because the higher levels of greenbug infestation were killing all of the plants. This example provides an illustration of what I would call consulting as I was mainly providing advice to the student in the design of his experiment, and later simply providing a statistical analysis of the resulting data.

Many years later, I was involved with KUMC researchers in studying the effects of increased amounts of physical therapy for patients who had suffered a stroke. At the time there was no valid measuring instrument to measure basic activities of daily living (BADLs). The tools that were currently available would have ceilings on the instrument variables that were too small—that is, patients would receive the highest scores possible implying that no further improvement in BADLs was possible. Yet the KUMC researchers believed that additional improvements could be obtained, but there was no available tool to measure such improvements. We developed a new tool called the Stroke Impact Scale based on the results of a pilot study and utilizing many opinions from expert healthcare professionals. Then we used this tool in a clinical trial involving stroke patients to show the advantages that additional physical therapy would have on the BADLs of stroke patients. This example provides an illustration of what I would call collaboration as I was heavily involved with this effort over a period of about three years. This is also a gift that keeps on giving as I did not realize at the time that our Stroke

Impact Scale would be patented; currently, I receive royalty checks twice yearly from researchers throughout the world who are using the scale that we developed.

Two of my clients won awards from professional associations for their ground-breaking research. One was a graduate student who won a best paper award given by the Corn Refiners Association for her paper. The other was for a paper published in *Augmentative and Alternative Communication* which won the Prentke Romich AAC Editors Award. It is exciting when someone wins an award and you were simply doing your job as best as you could.

3.2.2 Non University Consulting

There were three non-university consulting projects where I served as an expert witness: Ping golf clubs, gene transfer patents, and killing fleas.

The golf groove controversy occurred because the U.S. Golf Association banned U-groove clubs based on an experiment conducted by the Association using many professional golfers. The experiment was performed at PGA West in Palm Springs, CA, and the manufacturer of Ping golf clubs filed a suit against the U.S. Golf Association as their Ping clubs had the U-grooves and they were the most popular clubs being used at that point in time. We were able to show that while the U-groove golf clubs were able to put extra spin on a golf ball and allow the ball to stop quicker on a green, it did not allow a golfer to get the ball closer to the hole and hence allow one to have an unfair advantage when it came to scores for rounds of golf.

A gene transfer lawsuit was filed against a different client, claiming that my client had stolen patented gene transfer technology from the plaintiff's company. My client performed an experiment intended to show that the plaintiff's technology did not work. Unfortunately, my client performed such a large experiment that statistical significance was found. However, the difference was clearly not large enough to be of any practical importance. So my testimony was centered about the issue that statistical significance did not imply the observed difference was real or meaningful. We did not use any statistical analyses to prove our point as we simply were prepared to show the judge 72 three-dimensional graphs containing 96 responses each that compared the two technologies in question along with a few spiked samples on each graph.

I can't yet talk about the third case.

One interesting project early in my career was measuring tobacco exposure on overseas flights. The research was sponsored by a consortium of tobacco companies. Their hope was to show that there was very little smoke exposure to passengers in non-smoking sections of airplanes. An experiment was performed by collecting smoke exposure data on flights from the U.S. to Japan and from Japan to Singapore. The test failed because the mostly Asian passengers on the planes did not observe the non-smoking sections of the aircraft and most passengers smoked throughout the plane.

I spent 9-10 years providing statistical support to researchers in the Human Resources Engineering Directorate at the Army Research Labs in Aberdeen, MD. Many of the studies involved crossover designs, but many of the researchers were calling them repeated measures designs, and consequently they were being incorrectly analyzed.

I also spent six years serving on a Human Studies Review Board for the EPA Office of Pesticides. In addition to evaluating many experiments involving insect repellants' effectiveness against mosquitos that might carry the West Nile virus, we looked at lots of experiments and developed the framework for field studies designed to measure workers' exposure to chemicals used in many different kinds of agricultural and industrial practices.

3.3 Stepping Stone 6: Recognizing the Importance of Collaboration to Research Practice (Mike Kutner)

While serving on a Data and Safety Monitoring Board (DSMB) to review an approved and funded NIH multi-center Phase III clinical trial involving four treatment arms, the DSMB members were instructed to review/critique the proposed clinical trial and make recommendations for possible protocol changes.

- The primary outcome of interest was the prevention of bone fractures in falls within a high risk elderly population. Since a clinical trial using falls with bone fractures as the primary end-point would require an extremely large number of subjects, a proxy measure, bone density, was proposed as the primary end-point.

- An outside statistical consultant provided the power/sample size estimation for the trial. A one-way analysis of variance on the primary outcome measure, average change in bone density, after 24 months of treatment for subjects in each of the four randomized treatment arms (a placebo arm, a low dose and a high dose of an old drug arm, and a high dose new drug arm) was stated as the primary statistical analysis plan. For the old low and high dose drug treatment arms the investigators provided pilot data on the average change in bone density over time for high risk elderly subjects. However, the investigators did not provide any pilot data on the change in bone density over 24 months for either the placebo arm or the new drug treatment arm.

- The research team **assumed** that there would be no average change in bone density for subjects in the placebo arm over 24 months and that the new drug arm would result in an average change in bone density over 24 months somewhere in between the old low dose drug arm and the old high dose drug arm. They arbitrarily set the average change in bone density for the new drug arm to be halfway between the average change in the old low dose drug arm and the average change in the old high dose drug arm. Maximum tolerated dose levels were determined for the old and new high dose drug arms based on earlier Phase I studies.

- The statistical power argument was based on using standard one-way analysis of variance power calculation procedures to estimate the sample sizes necessary per arm to obtain overall power >80% with an overall Type I error rate of 5%.

Problems: The power calculations were based on detecting average differences among the three actual drug treatment arms only, excluding the placebo arm altogether. In addition, no consideration for multiple or pairwise comparisons was provided. The power/sample size estimates were not based on proper prior pilot data and it was quite likely that the trial was underpowered. Unfortunately, the study section that reviewed and evaluated this proposed trial failed to detect these design deficiencies and recommended

funding the trial. There was no way to fix the power/sample size deficiencies without having pilot data or existing data from the literature for these changes in bone density over 24 months for the placebo arm and more importantly for the new drug arm. Therefore, I had no other choice than to recommend that the proposed clinical trial not be funded.

Note: Other members of the DSMB were uncomfortable with the use of bone density as a good proxy measure for bone fractures. The NIH Director who had appointed me to the DSMB couldn't thank me enough for pointing out the deficiencies in the power/sample size estimation results.

3.4 Stepping Stone 7: Collaborating to Improve your Own Practice (Doug Zahn)

Surround yourself with one or two compassionately ruthless persons with whom you have synergistic relationships. Then collaborate with these persons to mutually improve each other's practices. Pick individuals who are sources of good data about your practice and whom you are confident have your best interest at heart. These are people who will not simply agree with you to "keep the peace." Be sure that they look at the world through different lenses. This must be present if you are to add value to each other.

To base your team's quality improvement efforts on high quality data, video your role plays or actual interactions. Learn to analyze video data. Many of us have ridiculed clients who have come with only anecdotal data seeking to improve a process. What would the reaction of these clients be if they knew how rarely we use anything other than anecdotal data to improve our own practice of statistics? Remember that the data you will be seeing for the first time on a video of yourself consulting will be data that your clients already have seen. Wouldn't you like to see it also?

Develop both technical skills and relational skills. Both are as essential to your success as a professional as is looking both left and right is to your survival when you are crossing a busy street.

Video is essential for developing your relational skills. It will reveal how you interact with your clients. You will have a chance to discover your attitudes and emotions that are triggered in various situations. Once you discover that you have counter-productive attitudes and emotions (and we all do!), you will be able to develop a strategy to become more aware of them earlier and to learn to manage them more effectively.

Consultation, collaboration, and leadership must be (and can be) learned. Design realistic role-plays for improvement, carry out and video them, and search for opportunities to improve. Make a change in how you did some aspect of the role-play and repeat the process—just like we would coach clients who wish to improve any process they are managing.

4. Leadership

The online Oxford Dictionaries define leadership ("leadership, n.1") as follows:

> The action of leading a group of people or an organization.

Leadership follows from collaboration in that one cannot truly lead a group that does not wish to follow; a leader in our context is a servant to whom others choose to listen. This further involves the recognition that the work that one has done has not been completed in isolation, and the lessons learned through experience can influence and benefit others who are in similar positions.

Our authors describe three stepping stones of leadership: taking the lead in research, taking the lead among statisticians, and leading the way for statisticians in research. Ron Snee first describes a situation in which a statistician experienced in a specific research area (with the help of her influential supervisor, also a statistician) became the recognized leader of a research project in addition to being a valuable team member. Frank Harrell follows with a discussion of the importance of leading other statisticians to become collaborators themselves through education (both in and out of the classroom) and through advocacy with other researchers on their behalf. Mike Kutner ends with an example of a statistician leading the way for other statisticians in a research-oriented environment.

4.1 Stepping Stone 8: Taking the Lead in Research (Ron Snee)

An example of leadership relates to the role of a statistician at GE Global Research whom we will refer to as "Mary" (Snee and Hoerl 2012). Early in Mary's career, she worked on robust design for many chemistry-related projects. After a few years, a new acquisition was made which was also chemistry based, and a project to enhance the effectiveness of chemical applications using predictive models was defined. In large part, the project was launched because of Mary's initiative and ideas.

When the project was formally chartered, there was some debate as to who should lead the project, given that it was cross-disciplinary. Some proposed that a chemist or engineer should lead the project. When Mary's manager suggested Mary as project leader, there was some surprise from other managers. The primary concern was that Mary was a statistician, and in their minds statisticians didn't lead chemistry or engineering projects. This became somewhat of a test case as to whether that statement should be true or not. After much discussion, the parties involved finally agreed that Mary had all the competencies needed to lead the project, despite the fact that it had major chemistry and engineering aspects.

Ultimately, under Mary's leadership the team was able to solve many of the technical challenges, and delivered the system to the business. Mary subsequently moved on to lead an even larger and more diverse project to incorporate new probabilistic concepts into the design of aircraft engines' sub-assemblies. Based in large part on these successes, she was promoted to Quality Leader, leading the Lean Six Sigma initiative at GE Global Research's four global sites, and then expanded her role to also lead the Innovation initiative at Global Research and chair the Reliability Council across the General Electric Company. More recently, Mary was promoted to Chief Scientist, the highest level in the technical career path at GE Global Research.

In this story we see two examples of leadership: Mary, and Mary's boss, who saw to it that Mary's leadership skills were recognized and properly utilized.

4.2 Stepping Stone 9: Taking the Lead Among Statisticians (Frank Harrell)

My definition of a leader is a servant who gets listened to. You can be a leader in administrative roles, motivated by a desire to positively influence the science or business.

Leadership, in terms of leading other statisticians, involves teaching and mentoring them how to be great collaborators, sharing statistical horror stories to avoid, educating them about old methods that still work and new methods whose importance they may have missed. It also involves in a major way going to bat for junior statisticians when collaborators or customers try to intimidate them into doing the wrong thing, such as engaging in non-reproducible research, or do not give the young statistician respect or credit. Another key aspect of leadership is helping to create the next generation of statisticians through teaching and designing curricula, paying special attention to having graduate students learn methods needed by current research and business needs while learning methods likely to be applicable to unforeseen analytical and design challenges. A leader can also use her experiences by sharing collected horror stories and success stories at key decision points.

4.3 Stepping Stone 10: Leading the Way for Statisticians in Research (Mike Kutner)

Early on in my career I had the honor and privilege of serving as the Chief Biostatistician for Emory's General Clinical Research Center (GCRC), one of the twelve originally funded clinical research centers. GCRCs were at that time not allowed to use GCRC funds to support biostatisticians or to pay for statistical analysis software packages from these NIH/GCRC grants. I was therefore initially paid from the Director's own NIH grants. However, GCRC units could apply for a CLINFO supplemental grant. CLINFO is a software system developed by Rand Corporation under a contract from NIH to perform data management and statistical analyses for clinical investigators. A CLINFO supplemental grant included the software system, a server, PCs to place in a computer lab room and a full-time CLINFO manager (for a discussion of CLINFO, see Groner et al, 1976). As a result, I wrote an NIH CLINFO supplemental grant that was approved and awarded to Emory's GCRC. I then recruited a full-time master's level CLINFO manager with a dual degree in computer science and biostatistics. In the meantime, the GCRC Director and I successfully lobbied the NIH to allow GCRC units to support biostatisticians on their GCRC grants and also allow them to allocate funds to support standard statistical software packages. As a result of these efforts, I was the first of many biostatisticians in the country to be supported off a GCRC grant, and Emory was the first of many GCRC units that was allowed to have their GCRC grant pay for a comprehensive statistical software package such as BMDP.

Note: I was supported by Emory's GCRC grant at 50% effort for 20+ years. Furthermore, I served on Emory's five member GCRC Executive Committee because the Director considered me, their biostatistician, to be the most key member of his leadership team. I will always cherish this wonderful collegial relationship. I also helped form the GCRC's statistician users group and was elected as its inaugural President. This group has met annually at the Joint Statistical Meetings since the early 1980s. Finally, the Clinical and Translational Science Award (CTSA) grants have now replaced the GCRC grants.

5. Concluding Thoughts

These ten stepping stones provide insight as to how statisticians move through their careers, the types of problems they work on, and the impact they can have. As statisticians move from consulting to collaboration to leadership, the problems become more complex and the impact grows. Effective consulting, collaboration, and leadership are about helping people and organizations be successful.

This requires building relationships, working first with individual clients and later with client teams, and ultimately providing leadership for clients, client organizations, and the profession. The ten stepping stones provide a useful model to continually check your career against as you search for better ways to serve your clients and your profession.

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