

Training Statisticians to be Consultants

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1. Introduction

Training of students to be consultants should begin with two premises:

- (i) statistics is about data; and
- (ii) every statistician is a consultant.

These premises set the tone for the training of statisticians. The need to gain insight into data should drive the understanding and development of statistics. A statistician should be a problem solver, a numerical Sherlock Holmes, with the desire to work with others in a cooperative spirit. Statistics provides the framework for the difficult task of making decisions when there is uncertainty. Through statistics we have a marvellous opportunity to serve, to learn about our world, and to educate.

In 1979 a report was prepared by the American Statistical Association's Committee on Training of Statisticians for Industry (Snee et al., 1980). It listed the skills needed by industrial consultants, including a broad knowledge of statistics, the ability to listen, to ask questions, to work on multiple projects, to meet deadlines, and to communicate effectively. Two important themes of that report are the need for students to work on real problems and for faculty to have a positive attitude to this work.

A few universities have had long-standing programmes to train students in statistical consulting. Many more programmes have been initiated in recent years. These include formal courses in statistical consulting, client problem seminars, internships with government and industry, and consulting in university based statistical laboratories. It is important to recognise that the training of statistical consultants depends upon an atmosphere created by the faculty in all courses, and on other faculty-student interactions. My comments concern the training of statistics' graduate students.

2. Statistical consulting process

Before reviewing specific training programmes for statistical consultants, we need to understand the consulting process, including the tasks consultants perform. As

part of her doctoral dissertation, Sarah Tung (1989), and Tung and Schuenemeyer (1990), investigated the consulting process. It is no surprise that this process is complicated with many feedback loops, false starts, and other detours. Some of the factors which contribute to this complexity are:

- (i) difficulty in establishing the client's wants and needs;
- (ii) training and experience of the consultant;
- (iii) individual style of the consultant;
- (iv) most problems do not have a unique solution;
- (v) knowledge of the client;
- (vi) resources available to client and consultant; and
- (vii) the state of the problem (no design, data collected, etc.).

During our research, we (Tung and Schuenemeyer) interviewed six experienced consulting statisticians from industry, government, and academia to determine what they do and how they do it. Summaries of some of these videotaped interviews are presented in Tung (1989). Good consultants used the following strategies:

- (i) Be interested in the client and his or her problem. Listen! Put the client at ease. Find out what the client wants. (Occasionally it may be a paper, a dissertation, or a satisfied boss as opposed to a good design or analysis.) You may not be able or wish to satisfy these wants but understanding them will facilitate communication. Ascertain the client's background.
- (ii) Gain insight into the problem area. Draw pictures. Restate the problem in your own words. Use, insofar as possible, the client's terminology. Avoid statistical jargon.
- (iii) Know when to say no. Know your limitations and determine those of the client's experiment. A corollary to this is, "only promise what you are prepared to deliver".
- (iv) Develop a check list.
- (v) Identify the experimental unit. Ask the client what he or she did with a single subject.
- (vi) Encourage the client to plot the data.
- (vii) Propose the simplest model or analysis possible, consistent with the complexity of the problem and other restrictions. The consultant should ensure that the client's objectives are consistent with the experiment.
- (viii) Attempt to make the design robust. Be concerned about (possible) missing data and departures from assumptions.
- (ix) Summarise the results of the meeting. Try to ensure that the client understands your advice. This is difficult to do in a non-threatening way. Decide who will do what and when.

The interviewed consultants stated that helping the client to define the problem, identifying the experimental unit, and ensuring that the client understands the advice, are among the most difficult tasks.

3. Teaching statistical consulting

Having identified some of the important parts of the consulting process, we will examine the tools used to teach consulting and see how they match the components described by experienced consultants. For this discussion, I rely mostly upon my experience at Delaware but will mention other activities. Besides directing the Statistical Laboratory at Delaware and coordinating internship programmes, I have been instrumental in the development of what now is the American Statistical Association Subsection on Statistical Consulting Education. I have also consulted widely with government and industry on a variety of problems.

One must recognise that *statistics is something you DO*. In order to train statistical consultants, we need to have them do consulting in a supervised environment. Among the approaches to this are:

(i) *A Statistical Laboratory*: At the University of Delaware we have such an institution. It was begun in 1984 and consists of a 1/4 time director (in theory), and two advanced graduate students. Each graduate student spends 20 hours per week in the laboratory. We also have an advisory committee of about 15 faculty and staff. These are statisticians and others with statistical expertise. We serve graduate students, faculty, and staff within the university, and some outside clients. Funding comes from the Department of Mathematical Sciences (our home base), the Provost's Office, faculty with grants (a very small amount), and outside clients. Service to the university community is free except for those with grants who are expected to pay.

At the beginning of the semester, I meet with the student consultants to discuss consulting procedures and operating procedures of the laboratory. Students are given consulting check lists, client information forms, and articles and references to material on consulting. I recommend that they read Jim Boen and Doug Zahn's excellent book on the human side of statistical consulting (Boen and Zahn, 1982). In addition, I try to allay the fears that all new consultants have.

The following example illustrates the operation of our Statistical Laboratory. A chemical engineering graduate student calls the secretary for an appointment. If this is her first visit for a particular problem, we request that a brief written problem statement be submitted three days prior to the appointment. (There is not always a high correlation between this document and the problem the client presents, but it helps.) We also request that the faculty advisor accompany a student client on the first visit which I try to attend. During this visit, normally scheduled for an hour, we try to understand the problem. If it is straightforward we may propose a solution. Otherwise, we schedule a second appointment and then investigate the problem. For the first several new client visits, I lead the discussion. After this I let the student take the lead and try to speak only when asked. The role of statistical consulting units has been discussed by Carter, Scheaffer, and Marks (1986).

We evaluate the consulting services in several ways. We give each client an evaluation form and study the completed forms. I also meet weekly (for about an hour) with the graduate student consultants to examine the status of cases, make sure there are no unusual time delays, and provide help as needed. We also videotape a few consulting sessions and review the tapes with the students. We have done this on a limited basis because of space and time constraints. A couple of times we reviewed tapes of consulting sessions with a psychologist in the Department of Psychology. He provided

