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An Expanded Approach to Educating Statistical Consultants

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This article describes an expanded approach to the education of statistical consultants that is being implemented at Florida State University. Our program begins with a *preconsulting* course in which students first study general problem-solving techniques. Next these techniques are used in solving applied statistics "textbook" problems. Then problem formulation and research methods are studied. Finally the structure of consulting sessions is considered, along with interpersonal issues that arise in consulting. In the *supervised consulting* course, students work with actual clients in videotaped sessions, attend supervision sessions in which the tapes are reviewed, present case conferences, attend new material sessions, and complete a project. We conclude this article with preliminary evaluation data on the program and observations regarding what we have learned.

KEY WORDS: Videotape; Interpersonal; Supervision; Philosophy.

1. INTRODUCTION

A high percentage of the graduates from master's and doctoral degree programs in statistics enter jobs in which overall success is greatly determined by their effectiveness as statistical consultants. In many conversations we have had with experienced consultants from government and industry and in repeated sessions at professional meetings, there is the recurring theme that students have difficulty making the transition from academia to government or industry. Part of this difficulty stems from the students' lack of appreciation for the realities of consulting practice.

Encouraged by authors such as Cox (1968), who suggested adding a course, "Principles and Practices of Statistical Consulting," to the curriculum to complement apprenticeship training, we began in the early 1970s (as did some other statistics departments) to include training in statistical consulting in our graduate program. Since then, we have gradually added more components from various disciplines to the consulting course to help students bridge the gap between academia and statistical practice. The evolution of our program and practical issues encountered along the way are described in detail in Zahn (1982a,b).

Looking at the entire picture of educating students to become effective consultants, we soon realized that we (and the profession as a whole) had neither a standard definition of "effective statistical consultation" nor primary data from

our students' consulting sessions. A breakthrough in our program occurred when we decided to gather primary data on the statistical consulting process by videotaping actual consulting sessions. After spending many hours reviewing these videotapes, we could see that our students had deficiencies in both the statistical and nonstatistical aspects of consulting.

Our program seeks to teach statistical consulting by systematically identifying and presenting statistical and nonstatistical skills in discrete, easily managed learning units (e.g., see Zahn and Boroto 1981). Over the past two years, we have shifted our emphasis from the identification of key components of such a course to the construction of a comprehensive statistical consulting curriculum. This program includes the teaching of many skills identified by others as important to the effective statistical consultant (ASA Committee on Training of Statisticians for Industry, 1980; ASA Committee on Training of Statisticians for Government, 1982; Baskerville 1981; and Boen and Zahn 1982).

2. WHY A SYSTEMATIC TEACHING PROGRAM?

In the 1970s our supervised consulting course was a blend of an internship (observer-apprentice) model and an on-the-job training model. In the internship model, the students observed consultations conducted by experienced consultants and over time increased their own abilities to conceptualize and solve statistical problems. As student competence developed, the students assumed a greater share of responsibility for the consulting session. In the on-the-job training model, students were scheduled with clients and had a supervisor to turn to for guidance in case of problems. In using these methods in our own program, we have found them to be inadequate in the following ways:

1. The time limits of the program rendered an on-the-job training model ineffective if students were to be adequately trained in more traditional areas of statistics.
2. The internship program did not provide a sufficient breadth of problems with varying characteristics.
3. The internship model allowed the student to observe only a limited range of consulting styles.

The applied master's degree program at Florida State University is a four-semester program in which actual consulting is a requirement. The preconsulting course is offered in the second semester and the supervised consulting course is offered in the third and fourth semesters. Given this short time frame, efficiency has been essential.

In the internship model students are exposed to demonstrations of consulting skills such as problem formulation, resource use, and interviewing and are expected to acquire the proper skills of consulting from the specific demonstrations of techniques. These demonstrations occur unsystematically and discontinuously, depending on the vagaries of

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client flow to the internship setting. If, as is often advocated, students work on one project in depth, that one project may employ a narrow range of skills thereby sacrificing breadth for depth. Furthermore, the timing of the project might not coincide with the academic calendar, requiring the student to leave the project before it is complete. In both the on-the-job and internship models, progress toward becoming an effective statistical consultant depends on entering the program with the requisite consulting skills or identifying and acquiring them without much guidance. Many of these skills are not formally taught in traditional programs.

In our systematic teaching program, a student is exposed to a broad set of typical problems that illustrate specific technical characteristics. In addition, a student is exposed to a wide range of consulting styles, rather than being limited to observation of a few styles (internship) or omitting observation (on-the-job training). Alternative interviewing styles can be illustrated and discussed through the use of videotapes. In Section 4, we present a course that allows students to study and learn various components of a consulting style.

We found that there are some skills that internship or on-the-job training programs rarely address. For example, how does one learn to formulate a problem in statistical terms? If one is an observer-apprentice to an experienced consultant, the implicit steps and thought processes of the experienced consultant occur rapidly with no time-out to reveal the reasoning process. At yet another level, pragmatic issues arise, such as which questioning style is most likely to elicit relevant information from a client. We noticed that teaching these skills using either the internship method or the on-the-job training method produced inconsistent results.

Although there exists no logical reason that a skilled internship supervisor could not systematically address all of these issues, in practice the internship structure and emphasis is reactive and dependent upon the issues that arise during a specific session. Thus the number and types of problems discussed will vary according to the nature and length of the internship.

The above considerations have led us to develop a program consisting of two components: (a) a preconsulting course to systematically teach preselected concepts, skills, and techniques for statistical consulting and (b) a supervised consulting course for practicing and extending the methods previously taught.

3. TOWARD A STATISTICAL CONSULTING PHILOSOPHY

Every consultant operates from a philosophy of consulting, however implicit that philosophy might be. Acceptance of our philosophy is not necessary to implement the methodology we outline. In this section we describe our philosophy as explicitly as we can. We have included it in this article to encourage reflection and dialogue. We recognize that our philosophy is neither the only one nor the "right" one. We offer it in the belief that scholarship has as its basis the thoughtful consideration of many and often opposing views.

While viewing consulting sessions on videotapes, we were surprised by the complex interpersonal aspects of statistical

consulting and by the demands placed on consultants that went beyond statistical knowledge. We observed that many of the difficulties that arose in consulting sessions stemmed from a failure of the consultant and the client to establish a common set of goals for consulting. Likewise, when we viewed consultants who we felt were successful in providing assistance to clients, we noticed that they always had a clear idea of the purpose and limits of their consulting and were able to communicate their ideas effectively. What we have learned in talking to other consultants and from viewing hundreds of videotapes is that the greatest barriers to effective statistical consulting arise from the conflicts produced by consultant attitudes, expectations, and goals, rather than from client or project deficiencies. We will present three examples to illustrate how such conflicts may occur.

First, while viewing videotapes, we noticed that consultants often assumed a role that might be characterized as Gatekeeper of the Scientific Method, a position that generally collided with the wishes and expectations of the client. We found that when consultants implied or insisted that they were the sole possessors of the standards by which to judge the quality and utility of the study, clients appeared reluctant and sometimes openly resistant to adopting the consultants' suggestions. Typically, consultants would attribute this resistance to the clients' unwillingness to be scientific. Psychologists have reliably produced comparable resistance in laboratory studies on persuasion and refer to the phenomenon as psychological reactance. Psychological reactance is a consequence of the authoritarian role assumed by the consultant: it is not due to ideological differences between the consultant and client nor is it reflective of some personal characteristics of the client.

Second, academic statistical consultants often have as their goal the gathering of ideas and data sets to enhance their own research and publication programs. If this is a primary goal of the consultant, then consultants and clients may find themselves working at cross-purposes. Consultants will show little enthusiasm and attention toward routine client problems, and since their lack of interest will usually not be verbalized, an undercurrent of strain and discord will emerge in their interactions with clients. If these conditions predominate in a session, clients are unlikely to consider the consultants' suggestions in the future. Likewise, consultants who believe that they are seeing a disproportionate number of unresponsive clients are likely to develop a cynical approach to consulting. Both consequences are detrimental to the practice of statistical consulting.

Third, statistical consultants often emphasize the service aspect of consulting and point to the economic necessity of pleasing the client. Service goals have sometimes been misconstrued as blind acquiescence to the client's every request. The statistical consultant would thus function as the "shoe clerk" described by Bross (1974). In our experience, clients are neither served nor pleased by an acquiescing consultant since it may appear to the client that the integrity of the consultation has been compromised and that the consultant cannot be relied on as a strong partner. A consultant must be able to say "No," that is, to recognize when the research interests of the client are best served by identifying impractical requests and by proposing realistic alternatives.

We believe that the conflicts between consultants and clients described in these examples would be reduced by a common statement of purpose for and definition of statistical consulting. Therefore we define statistical consulting as *any interpersonal interaction that has the goal of increasing the utility of information disseminated within and among disciplines that use statistics*. Although many goals for statistical consulting have emerged in our discussions with others in the field, we believe that supporting disciplines in improving the quality and utility of information disseminated is basic to the nature of statistical consulting.

We view client satisfaction and scientific rigor as compatible. Effective consulting can occur between consultants and clients who have multiple motives for doing their studies (e.g., promotion, graduation, increased profits) since these motives are, over time, consistent with scientific rigor. Rather than being exclusive, we view our goal as encompassing other goals that do not directly conflict with it and are held subordinate to it. If the primary goal of consulting is to increase the quality of information disseminated, then other goals (such as the goal of using consultations to generate research ideas or the goal of providing service) will be attainable as its natural consequence.

To design a statistical consulting training program that would achieve our goal and embody our philosophy, we found it necessary to delve into the interpersonal complexity of statistical consulting, including the philosophical and attitudinal barriers of consultants. We incorporated into the course our point of view about consulting that portrays the consultant's job as including such nontraditional tasks as inspiring the client to recommit his or her energies to strive for the potential benefits of a project, rather than to compromise to meet immediate exigencies. This point of view is reflected in the curriculum both explicitly in classroom discussions and implicitly in the choice and sequence of interpersonal skills to be taught.

4. THE PRECONSULTING COURSE

Our goal in the preconsulting course is to teach effective statistical consulting skills as efficiently as possible. We assume that entering students are competent in several basic areas including elementary statistics (a good list of skills can be found in ASA Committee on Training of Statisticians for Industry, 1980), the use of one or two computer statistics packages, the creation of simple data files, and the interpretation of computer output. Since clarity in explaining statistical ideas is emphasized, we expect students to have adequate oral and written communication skills.

4.1 Segments of a Consulting Session

Based on our observations of many videotaped consulting sessions, we noticed that all sessions could be divided into five segments. In a consulting session, the consultant must first interact with the client in such a way that the client understands that the consultant is there to provide a service (rather than to judge and evaluate) and to facilitate the emergence of a cooperative working relationship. The consultant must be able to identify the needs of the client and communicate an understanding of those needs effectively.

A second task facing the statistical consultant is managing the consulting session. The consultant must decide when the problem has been identified and formulated sufficiently to move on to other tasks, such as problem solution and summary discussions.

Third, the consultant must translate the client's questions into a form that can be addressed using statistical tools.

Next the consultant must devise solutions to the formulated statistical problem. This applied statistics problem solving consists of working with the client to develop a plan of action that is appropriate to the statistical problem, given the characteristics of the client, the consultant, and the problem to be solved.

The last segment includes general problem-solving skills similar to those described by Polya (1957, 1962). The material taught is based largely on Wickelgren (1974), which is in the spirit of Polya's books but not restricted to solving mathematical problems.

Thus the preconsulting course is divided into five sections:

1. General problem solving
2. Applied statistics problem solving
3. Problem formulation
4. Session management
5. Interpersonal relations

The chronological order in which these occur in a consulting session is often the reverse of the ordering shown here. Our experience suggests that this teaching order works better. Sections 1, 2, and 3 relate naturally to the rest of the courses taken by a graduate student in statistics, whereas sections 4 and 5 are quite different and are often met with more skepticism if taught first. Furthermore, teaching sections 1–3 first offers ample opportunity to demonstrate the importance of sections 4 and 5. In the next subsection, we describe how we teach the five sections of the preconsulting course.

4.2 Teaching Activities

General problem solving. We begin the course by teaching general problem solving. First, basic terms in problem solving (e.g., givens, operations, goals, problem state, solution, action tree, etc.) are defined, and then each of several problem-solving methods (inference, classification of action sequences, state evaluation and hill climbing, subgoals, contradiction, working backwards, solving a simpler problem, solving a more general problem) is presented. Nonstatistical and statistical examples are included for each method. After the entire group of methods has been presented, the class discusses the relative merits of each, focusing on characteristics of problems that make specific techniques especially useful. The class then practices jointly on a set of problems. This segment of the course is tested by a homework assignment in which the students are asked to identify the elements of a set of problems (goals, givens, operations, etc.) and to solve them. They also write down their thoughts and the problem-solving methods used while solving the problem. This information is used in subsequent class discussions to expose the students to differences in the ways people think about the same problem.

Applied statistics problem solving. The second segment of the course is applied statistics problem solving. In this segment, the general problem-solving methods are applied to the specific question, What is appropriate advice to give or actions to recommend to the client?

We point out the differences between the formal problems with which the general problem-solving methods were illustrated and the applied statistics problems. Some of these differences are

1. The goals of most applied problems are not as well-defined as those of a formal problem.
2. Alternate solutions exist at different levels of client and consultant expertise.
3. Constraints on the resources of the consultant and the client play a large role in determining the practical solutions.
4. It is often more difficult to decide when a solution has been reached.

In this segment students begin observing the consultations of experienced consultants.

Problem formulation. The third segment of the course is on problem formulation and the scientific method. The focus is on translating a problem from the client's formulation into a statistical formulation. We illustrate how to translate the client's research ideas into specific statistical terms (e.g., What does the client mean by "related to" or "look at differences"?) using several real consulting problems and discuss several examples demonstrating why many statistical problems are formulated in terms of means, proportions, or correlations. Discussion of problem formulation and the kinds of conclusions that are possible from an experiment leads naturally to a discussion of research design and scientific methods. Some basic terminology (experimental unit, confounding, replication, etc.) is reintroduced and illustrated with good or poor experimental designs.

Feinstein (1970) argued eloquently for this segment:

The preparation for work as a consultant thus contains antipodal contrasts in the education of clinicians and statisticians. A clinician is taught to identify and formulate patients' problems in a carefully structured manner; but he is then left to develop diverse tactics of "judgment" for managing the outlined problems. A statistician is taught a carefully organized set of mathematical structures for managing an outlined problem; but he is left to develop diverse judgmental methods for identifying and formulating the problem. The clinician may emerge able to express the right questions but unable to find the answers; the statistician may emerge with the right answers but unable to select the questions. (p. 902)

Kimball (1957) refers to errors of the third kind as those in which a consultant gives the right answer to the wrong problem. The intent of this part of the course is to teach the student to formulate the problem so that the consultant answers the right question.

The material on problem formulation is evaluated by using a written simulation. The students are given the barest background to a real problem (actually the information form required from the client before the first consultation at the Florida State University Statistical Consulting Center) and are asked to begin formulating the problem. They are also required to list information they need and questions they would like answered about the consulting project. The eval-

uation then proceeds in a sequential manner, with more information being given to the students, who then attempt to formulate the problem again, and so on. This simulates an actual consulting session but removes most of the interpersonal elements so that the students can concentrate on problem formulation and "asking the right questions." The material on research design is evaluated by asking the students to critique and improve several designs on a homework set.

Session management. In the fourth segment of the course, session management is discussed. We identify the order in which consulting activities occur and how to proceed or backtrack. This segment introduces another consulting activity, called "summary discussions" by Zahn and Isenberg (1983), during which implementation of the chosen solution is discussed. The students' performance on this segment is evaluated by asking them to view videotapes of consulting sessions and identify and classify the consulting activities that have been discussed up to this point in the course.

Interpersonal relations. The last segment of the course provides a combined didactic and experiential learning unit (Tyler, Kalafat, Boroto and Hartman 1978) on interpersonal relations in a statistical consultation. The didactic component addresses the necessity of attending to nonstatistical aspects of a statistical consultation. The didactic component also presents some tools used to recognize characteristic problems of a consultation and strategies for effectively handling such problems. The experiential component includes making and viewing videotapes, role playing, and participating in exercises designed to produce a psychological experience likely to be encountered in a consultation, for example, interpersonal anxiety or evaluation apprehension (Zahn and Boroto 1981). The issues covered, although obvious to an experienced consultant, are not obvious to the novice.

The first task in this part of the course is to convince the apprentice consultants, through the use of videotapes of consulting sessions of experienced consultants, that nonstatistical aspects of the session can determine the ultimate efficacy of a consulting hour (see Fig. 1). We demonstrate that the attitudes and biases of both the client and the consultant have a powerful effect on the consultation's direction and ultimate outcome. A videotape that students view initially in this section of the course shows a graduate student client who was sent by her major professor to create an experimental design for hypothesis testing. The client, however, was ill-equipped either to conceptualize or implement the project. The client's basic aim was to fulfill the demands of the major professor. The consultant, on the other hand, was insulted that he was expected to provide pat answers to difficult questions in such a way that the client might satisfy degree requirements without mastering the rudiments of research design and basic statistics. Parts of the videotaped interaction were sadly comical. It should be pointed out, however, that this was a real consultation with an experienced statistical consultant.

Next a communication model is presented that focuses on identifying the motives and intentions of both the client and the consultant at any point in time in a consulting ses-



Figure 1. Videotapes are discussed.

sion. The student has numerous opportunities to observe how consulting sessions become ineffective when the client's and the consultant's intentions or personal and professional goals conflict.

Finally, students participate in a series of role plays to practice dealing with problems that occur with high frequency in consulting interactions. Topics of these scenes include situations in which the client questions the consultant's expertise, makes many demands, wants to develop a passive-dependent relationship, presents an amorphous problem for which a specific answer is expected, or demands a solution requiring far more statistical expertise than the client (or, perhaps, the consultant) has. The opportunity to play the client's role increases students' empathy with clients. Playing the consultant provides an opportunity to explore various problem-solving techniques at both a strategic and verbal level.

The interpersonal component of the course is evaluated on several levels. Prior to the dissemination of any content, students view a videotape of a statistical consultation session. Two- to three-minute segments of the tape are identified; for each segment, students respond to a general question, What has taken place in this segment? and several more specific questions such as: What are the tasks confronting the consultant at this point? At this point in the session, what are the goals of the consultant and the client? Which are congruent? Which are incongruent?

At the conclusion of the interpersonal section, students view a different videotape and respond to similar questions. The answers to these questions are evaluated in terms of the concepts presented in the interpersonal section of the course. In addition to this pre- and postevaluation, roles played in scenes within the section are immediately evaluated and feedback is given.

5. THE SUPERVISED CONSULTING COURSE

The supervised consulting course is a repeatable, semester-long course in which the students do actual consulting and extend and sharpen the skills learned in the preconsulting course. The students schedule two hours of consulting per week and are required to videotape all consulting sessions. The course has three additional types of meetings per week: Supervision, Case Conference, and New Material sessions.

In the Supervision sessions, segments of the videotaped consulting sessions are reviewed by the instructor and two or three students, including the consultant. A student selects specific sections of a tape based on his or her questions about the session. If there are not specific segments of the tape to be studied, the student is asked to replay four short segments of the tape: the beginning, the end, a spot where the session was going well, and a spot where the session was going poorly. This is sufficient to generate useful discussion. Given the limited time available, it is usually necessary to pick among several potential issues to consider. The students in the course are expected to offer constructive comments on the videotape segments. The discomfort that videotapes evoke is initially quite strong. The instructor has the responsibility of creating and maintaining an environment in which comments are given and received in a supportive manner.

The Case Conferences provide a forum for the discussion of difficult or unusual statistical problems. The student whose consulting problem will be discussed distributes a summary of it to each member of the class one day in advance. The class then meets to discuss the problem, with the presenting student acting as moderator and guiding discussion toward solution of the problem. In addition to receiving suggestions, the student gets practice in writing about and sum-

marizing statistical problems and in running a technical group discussion.

The New Material sessions are reserved for discussions or presentations of new material relating to any segment of the course, from applied statistical procedures not covered in other courses to interpersonal relationship material. By presenting one or two topics to the class, the students gain experience in explaining statistical procedures and also practice in identifying and exploring sources of material on statistical procedures.

Finally each student is required to complete a project consisting of an extensive report on the statistical and non-statistical aspects of his or her interaction with one client.

Both courses are graded on a satisfactory–unsatisfactory basis, incorporating a summary assessment of the student's performance in all parts of the course.

6. ISSUES IN IMPLEMENTING OUR PROGRAM

6.1 Organization of Consulting Activities

The anxiety that students naturally experience as they begin consulting can be reduced by standardizing policies and procedures to minimize uncertainty and confusion. Features that aid students (and consulting faculty) include

1. A clear policy statement that tells clients what services we do and do not provide. The statement eliminates many misunderstandings before an initial meeting.

2. A Client Information Form submitted by every new client at least 24 hours before the initial appointment. The form helps the client clarify the problem and assistance needed and allows the consultant to prepare for the session. Frequently student consultants encounter statistical problems that require a quick introduction to some unfamiliar statistical topic.

3. A Release Form submitted with the Client Information Form in which the client agrees to permit videotaping and to fill out an evaluation of the session. The release informs and protects the rights of the client.

4. A file containing standardized information on clients from previous semesters. This file reduces the confusion that can result when client problems span semesters.

5. A designated consulting room with the videotaping equipment in place and conveniently accessible. A consultant, with minimal advance preparation, needs only to press one button just before admitting the client, thus eliminating needless distraction of both participants.

6.2 Videotaping

Videotaping the student's sessions is an essential part of the course. By providing a complete account of what happens in a session (rather than information via selective recall by one participant), the taping sessions have benefits to the training program that offset the disadvantages of videotaping. These disadvantages include an increase in the level of consultant and client anxiety that occurs as a reaction to the taping and other, more quantitative costs, such as the time needed to adjust the equipment at the beginning of the session, teach videotaping, establish and monitor the security of the system, and maintain the equipment. Though anxiety

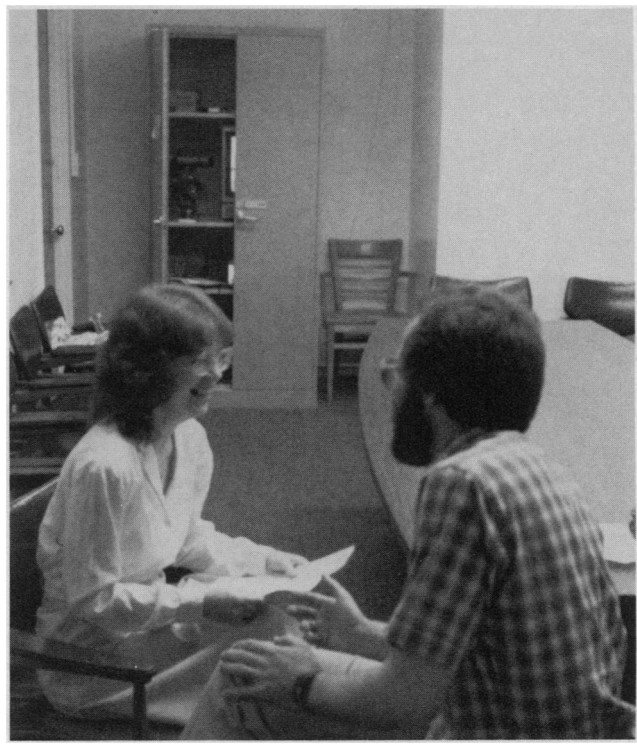


Figure 2. The camera is unobtrusive during the session.

levels may be higher, we have noted that after 5 or 10 minutes in many sessions, the consultant and client appear to pay no attention to the camera. The camera is unobtrusive, having been placed in a cabinet in the corner of the consulting room (see Fig. 2).

Though the camera initially distracts some individuals, we have not made its use elective. We know of only four clients over the past three years who have objected to the videotaping of their sessions. Any adverse effects of videotaping from the client's point of view are outweighed by the more accurate and helpful input the student consultant receives from the faculty supervisor reviewing the tapes. The taping also signals the clients that we take the supervision process seriously.

6.3 Supervision

Supervision sessions have been one of the hardest parts of the program to implement because they require of statistics faculty skills in identifying the interpersonal events on videotapes that interfered with the statistical work being done. These are skills that were new to the statisticians involved in our program and that, we suspect, would be equally new to other statisticians starting such a program.

Supervision is a complex task. While supervising, one is watching a tape of a session with the student consultant and two or three of his or her peers present. The supervisor must identify effective and ineffective parts of the session. This information must be delivered to the apprentice in a constructive manner that clearly communicates the intention to help the apprentice learn how to consult better. We have already noted that it is often useful to have a psychologist or other counseling professional on the team to help us learn to identify critical interpersonal aspects of the sessions and

to teach us effective strategies for dealing with the more common problematic interpersonal situations.

We have noticed a tendency on both the student consultant and supervisor's parts to shy away from potentially uncomfortable discussions of interpersonal material by focusing on familiar and comfortable statistical topics. This must be guarded against. Case conferences are the place for the extended statistical discussions that are necessary in most consulting problems.

The optimal length of time for supervision class sessions is to some degree dependent upon class size. With six people in the class, we recommend having 90 minute supervision sessions. We suggest adding approximately 15 minutes of supervision time for each additional student included in the class. The maximum length of time for sessions should be two hours: students seem to tire and lose interest if the sessions exceed this limit.

6.4 Beginning to Consult

Some students who have completed the preconsulting course are still not sufficiently prepared for their first actual client. Making more extensive use of role playing and pseudoclients (individuals from other departments who present practice sessions) in the preconsulting course and beginning the supervised consulting course by having the supervisor sit in on a student's first few sessions can be implemented as needed.

6.5 Time Constraints

One of the major constraints we have encountered in developing this program is the limited time available in the master's degree curriculum. (We advise doctoral students to take the sequence in their second or third year). Some are very uneasy about consulting with a client, even after practicing in the preconsulting course; no amount of practice will totally eliminate the apprehension associated with this step. Students are uneasy about the amount of statistics they know when they begin to consult in their third semester. We have found, however, that students can make a substantial contribution to the problems of most graduate student clients they see. The videotaped sessions and subsequent supervision help to identify when they are "in over their heads" and then assistance is given by one of the faculty members of the Consulting Center.

We encourage longer-term students to repeat the supervised consulting because there are so many things to be learned as one is starting to consult. By beginning to train students in the interpersonal aspects of consulting, we have substantially increased the number of topics to be taught. One semester is often not sufficient to firmly establish the newly acquired skills. Under stress a person tends to revert to long-established habits, rather than use newly learned skills.

Experience suggests that it could take as much as three or four years of supervision to replace long-standing habits. Thus we must be realistic in our expectations about how much progress students can make in these areas while in statistics graduate programs. Our aim is to help them *identify* major habits or viewpoints that interfere with the effective-

ness of their consulting. We then offer some alternatives to their habitual response and, at the very least, help them to see, after-the-fact on videotapes, how these alternatives could be used.

6.6 Generalists versus Specialists

In our program students are exposed to a general selection of problems from a variety of disciplines. We choose to expose our students to many disciplines during their training since they do not know where they will specialize later. The course structure described here could be equally useful in a program that exposes students in depth to a few areas of application.

6.7 Videotape Equipment

The initial capital equipment for the consulting program in 1980 consisted of a Hitachi color camera, a Sony Betamax video recorder, a programmable remote control, a Sony color monitor, a set of four quartz lamps, a tripod and tripod dolly, camera adaptor, 40 videotapes, and security equipment. Our total outlay was \$6,400. Since 1980, the cost of video equipment has dropped considerably. Today one can purchase an acceptable color video system consisting of a camera, recorder, and monitor for less than \$3,000 retail.

6.8 Curriculum Issue

An important question that we considered while developing our curriculum was how to make room for the consulting courses in the master's and doctoral degree programs. Our decision was to have students take two fewer elective or statistical "tool-type" courses (e.g., sample surveys, non-parametrics, applied multivariate analysis, and applied time series analysis). We reasoned that students who have taken basic mathematical statistics, probability, and other courses would be able to increase their knowledge of comparable statistical methods and applications in the supervised consulting course or through individual study. The consulting courses offer students the added opportunity of practicing what they have learned in their formal curriculum and applying this knowledge to "real-world" problems.

The concepts taught in this course will continue to be important even as statistical computer programs increase in their usefulness and popularity. The trend toward the use of computers will actually increase opportunities for "user-friendly" and "interactive" statisticians to assist clients in operating and interpreting sophisticated computer software.

6.9 Faculty

We recommend that faculty who plan to develop and implement a program similar to ours be willing to learn and teach topics such as interpersonal relations. They must be willing to deal directly with anxiety in students and faculty who are videotaped. Furthermore, colleagues may be skeptical of the course's value and appropriateness in a statistics curriculum. We have found that most statistics professionals respond favorably to the theme of the course: the improvement of the utility of statistical information disseminated in other fields.

To create our program, we assembled an interdisciplinary team consisting of three statisticians and statistical consultants (McCulloch, Meeter, and Zahn), an instructional design expert with statistical consulting experience (Pollard), and a psychologist (Boroto). We now realize that there are a number of aspects of the psychologist's background that have been critical to the development of our program. In particular, he is a practicing psychotherapist, an active research psychologist in a university setting with substantial statistical training who frequently employs statistical methods in his own research, and a supervisor of apprentice psychotherapists. An essential skill that comes from his supervising experience is the ability to sort through the myriad of potentially interesting topics to discuss when viewing a videotape and identify those most helpful to the student. We recommend that any group of statisticians planning to implement a program such as ours collaborate with a psychologist having skills and experiences comparable to these.

We recognize that the instructor is the key component in this program. We also recognize that the task of training instructors to teach consulting cannot be accomplished by text alone. For a training program for instructors to be successful, it must include a combination of textual and visual material as well as guided experiences in observing and participating in consulting activities.

7. EVALUATION

Evaluation is an integral part of our course development. We view evaluation as a continuous, iterative process that generates data for course improvements and modifications. We routinely incorporate into our instructional plans the ideas suggested by the evaluation data.

There are several forms of evaluation that are used to judge the progress of the student and the effectiveness of the instruction.

The first of these is the Consultant Checklist, a 40-item questionnaire that students use to rate themselves and their classmates on how well they managed their consulting sessions, interacted with their clients, and made statistical recommendations.

Another measure of student effectiveness, the Client Feedback Questionnaire, is a 20-item survey administered by computer to the client immediately after meeting with the consultant. Clients are asked to assess the consultant's understanding of their problem, the amount of interest shown

by the consultant, the appropriateness of the consultant's recommendations, and how feasible it will be for the client to carry them out.

We use two methods of determining course impact. At the end of the Preconsulting Course and the Supervised Consulting Course, students receive a Course Evaluation Form that requests their feedback on the quality and effectiveness of the instructor and the course activities. Students are also asked for their views on how to improve and reorganize the course.

A second form of program evaluation is a follow-up study of graduates of the statistics department and the consulting program. The purpose of this survey is to determine what consulting activities former students are performing in their jobs and what role the supervised consulting program had in preparing them for actual consulting.

In the follow-up evaluation completed in 1983, master's and doctoral degree graduates who completed the consulting program in 1981 and 1982 were contacted via telephone. Only those currently employed full-time in statistics were included in the survey. Out of 24 former students, 18 met this criterion. Of the 18 identified, 14 of these (78%) were successfully contacted by phone for the survey.

The participants were interviewed by the administrative assistant for the Department of Statistics. Respondents were given a list of consultant characteristics and asked to rate the importance of each characteristic to their consulting activities and to rate the effectiveness of their instruction on each characteristic. At the end of the interview, graduates were asked to describe the purpose and orientation of the consulting course and to say whether it facilitated or inhibited their performance as consultants.

7.1 Results of the 1983 Follow-up Evaluation

The 14 graduates of the program were employed in several types of positions, most notably assistant professors (four) and senior systems analysts (three). Except for three of the graduates in academic positions, all indicated that computer programming was one of their main job tasks. Research, data analysis, model building, and teaching were the other main tasks reported.

When asked to describe the purpose of the consulting course, a majority of graduates said that the course gave them an opportunity to gain experience in actual consulting, learn more about applied statistical problems, and learn how to work with nonstatisticians.

Table 1. Results of Evaluation Survey

Characteristics of consultants	Median importance	Median grade
Communicating effectively with clients	4.85	3.25
Identifying and solving problems	4.71	3.05
Working cooperatively with others	4.57	3.08
Understanding the realities of statistical practice	4.06	3.00
Negotiating responsibility with clients	4.00	2.80
Using computers to solve problems	4.00	2.67
Adapting quickly to new challenges	4.00	2.64
Extending and developing statistical methodology	3.60	2.30
Managing consulting sessions	3.50	2.80
Recognizing interpersonal anxiety	3.25	3.64

Foremost in their recollection of unique aspects of the course was the videotaping experience. Most students noted that videotaping added to their understanding of the non-statistical aspects of consulting. On the negative side, some students recalled a certain amount of disorganization in the course's structure. Their assessment of disorganization is a valid one and corresponds to a period when the course was being developed and undergoing rapid changes.

Graduates were asked to rate the importance of each of ten consultant characteristics to their consulting activities. Respondents were scored on a five-point scale on which 5 indicates that the characteristic was "Essential to their consulting" and 1 indicates that it was "Not important at all." Each of the characteristics was also rated according to how well the consulting courses taught that particular skill. Graduates were asked to rate their instruction by using the standard grading scale of A, B, C, D, and F where A is worth four points and an F counts as zero points. A summary of their responses appears in Table 1.

The three characteristics rated as most important to the graduates' consulting activities were "Identifying and solving problems," "Communicating effectively with clients," and "Working cooperatively with others." The course received a grade of "B" or better on how well it taught each of these skills. The characteristic receiving the highest grade was "Recognizing interpersonal anxiety."

The high grade for "Recognizing interpersonal anxiety" is reassuring, given the emphasis we have placed upon the nonstatistical aspects of consulting. The lowest grade the course received was for "Extending and developing statistical methodology." Many of the statistical problems that students encountered in their consulting required the application of methods quite unfamiliar to them. Students often remarked on their end-of-course evaluation that they would have liked to have had at their disposal a larger "arsenal" of statistical procedures.

8. SUMMARY

In this article we have described a comprehensive consulting curriculum that systematically incorporates the statistical and nonstatistical aspects of statistical consulting. We have discussed the limitations of internship and on-the-job training methods of educating statistical consultants in time-limited university programs and have proposed a broader definition of consulting with a specific goal to be achieved. We have stated our general philosophy of statistical consulting and have contrasted our philosophy with several existing ones. Key parts of our program are

1. A preconsulting course that systematically teaches skills required for consulting not currently taught in statistics programs

2. A supervised consulting course that includes videotaped consulting experiences, sessions involving supervision, case conferences, and presentations of new material

3. An evaluation of competence achieved at each stage in the program

Because of the innovative philosophy and technology of our program, we have made a wide range of recommendations intended to aid others in the implementation of a similar program. Finally we have included the results of our initial evaluation of the effectiveness of the program.

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