Batanero, C. (Ed.), Training Researchers in the Use of Statistics, 325-338.

Printed in Granada, Spain.

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THE TEACHING/LEARNING PROCESS IN UNIVERSITY STATISTICAL CONSULTING LABS IN THE UNITED STATES

The main focus of this paper is on how statistics students are trained in consultancy skills, as well as on how faculty in charge of university statistical consulting units perceive the consultant's role in training researchers. An electronic survey of 106 USA departments was conducted. Results indicate a wide range of practices in how students consult and how they are trained in consulting skills, but much greater consistency in the belief that such training is essential to a statistician's education and about the problems faced by both student consultants and student clients. The consulting service was seen as a useful way for researchers to learn because they would be working on a problem or data set of interest to them. Respondents discussed the importance of collaboration, particularly as a goal for consulting relationships that would benefit both parties, with reciprocal teaching and learning.

1. INTRODUCTION

Consultancy is an integral part of a statistician's life, whether in academe, government, or industry. Such consultation may involve brief interactions to respond to very specific questions or long term associations as team members on on-going projects. If we agree that:

> *"the function of statistics is to solve real problems (across all subjects from agriculture, through medicine to zoology)"* (Barnett, 1993, p.285),

then it follows that a statistician must be able to effectively communicate with researchers and practitioners and be conversant in their functional areas. Consultancy skills should therefore be an important aspect of statistical training. Such skills can be developed on the job (Ruberg, 1998), through statistical consulting courses (Khamis & Mann, 1994; Rangecroft & Wallace, 1998; van Belle, 1982), or via student consulting services in college or university statistics labs (Calvin, 1982; Halavin & Mathiason, 1994; Meyers-Tate, 1999).

Not only do statisticians need to understand enough about their colleagues' disciplines to be effective consultants, but also researchers should have enough appreciation of statistical concepts so that the association may be more productive. Bentley, Schneider, and Bentley (1998) showed how an introductory course in the combined area of archaeology and statistical reasoning allowed

> "*statistics students to learn the basics of consulting*" and *"humanities students to learn the benefits of a statistical perspective"* (Bentley, Schneider and Bentley,1998, p.347).

They provided a paradigm of how a course could be used to train both future consultants and consultees. In detailing how a pharmaceutical company trains statisticians to be truly effective team members, Ruberg (1998) stated that:

> "S*uch training impacts other scientists with whom the statistician inte*racts" (Ruberg, 1998, p.365).

He went on to say that while opportunities such as conferences exist for the statistician to become fluent in pharmaceutical issues, much of the learning comes from working with clinical scientists or on project teams. Likewise, much of the statistical training for clinical scientists comes from the interaction with statisticians.

Many universities in the United States, particularly those with doctoral programs in statistics, have statistical consulting laboratories or centres. Similar units also exist in other departments such as educational psychology. It is reasonable to assume that they provide a useful service for faculty, staff, and students as well as function as a training ground for students in both statistical applications and consultancy. The need for such services and training extends even to small liberal arts colleges without graduate programs (Herring & Jersky, 1995). Regardless of how they function, such units are also a forum for interaction between statistician and researcher and therefore should be a fertile ground for learning on both sides.

One aspect that characterises some articles dealing with statistical consulting labs is the explication of what is done or what has occurred in a specific university or department. In essence, these are case studies of particular centres or labs that provide, implicitly or explicitly, a model for others to follow (see e.g., Meyers-Tate, 1999). Authors often propose a paradigm for how consulting labs can be used to train statistical consultants, provide guidelines for the interaction between consultant and client, or for what the client needs to do for a successful interaction. In their often cited book, Boen and Zahn (1982; reprinted 1997) state that:

> "*It is well known, perfectly understandable, and widely accepted that colleges and universities do not fully prepare their graduates for 'success on the job' as judged by non-academic employers*" (Zahnm 1982, p. xi).

They therefore wrote their book based on their combined experiences in order to help fill that gap. Given the need for training in the non-statistical aspects of consultancy and in how to interact with researchers from diverse fields, as well as the many recommendations about what should or could be done, what is being done in college and university statistics consulting units? To what extent and in what ways are students trained in consultancy skills? What are consultants' perceptions of their role in training researchers from other fields? Are any guidelines provided for clients? In order to answer these and other questions about consultancy units, a survey of faculty in select university statistics labs within the United States was conducted. For this study, the main interest was in situations that employed student consultants.

2. PROCEDURES

The original sampling frame for this study was constructed by a number of electronic searches. Several search engines were used to search for statistical consulting labs, centres, units, or services. Then a few web pages with links to statistics and

mathematics departments were used to search for information about statistics consulting services. The final working list consisted of 248 potential university contacts. If no information was apparent from the web site, an e-mail was sent requesting if there was a statistical consulting unit or a consulting course in the department. The initial list was reduced based on replies that only faculty consulted or that a consulting unit no longer existed.

A closer inspection of 85 web pages for departments who did not respond to this request indicated that only seven were likely candidates for this survey. The rest did not appear to have student consultants, and most included academic grants and contract services, computer support labs, or departmental faculty who provided consulting services.

The remaining contact persons were then sent a pre-notification by e-mail about participating in the survey as well as a request for another contact for statistical consulting services within their university. In addition, they were asked if a consulting course was taught either by their department or elsewhere in their university. Changes were again made to the sample frame based on replies with new potential contacts and additional responses that no such service was available. This left a final usable sample of 106 contacts. This group was sent a second e-mail notification that included the URL for a questionnaire.

The questionnaire, along with an informed consent form approved by Virginia Tech's Institutional Review Board, was located at the web page http://www.nvgc.vt.edu/gbelli/StatLabSurvey. Responses to the questionnaire went directly to an Access database file. To insure anonymity, the responses were received without any identification of the respondent or any way to track from which computer the response came. Closed numerical responses were transferred to an SPSS version 10 data file for processing. Open-ended responses were formatted and printed out for content analysis.

Due to the nature of the items, only descriptive statistics were used on the numerical data: Medians, modes, frequencies, and percents. For a few items that asked respondents to "check all that apply," a multiple response procedure was used. This enabled computing the percentages based on the total sample size as well as on the total number of checkmarks. Open-ended responses were content analysed and organised into sets. In this way, common themes emerged and could be summarised. Individual quotes are used in the discussion if they capture the essence of a set of comments.

3. DESCRIPTION OF THE SAMPLE

A total of 43 questionnaires were returned (a 41% response rate). Although a number of items were general in nature, many were specific to student consultants and student clients. It is likely that at least part of the non-response was due to individuals seeing the items about students and not reading further. Another, more detailed, review of the final 106 web pages revealed at least 15 where this may have been the case. Web page content about consulting services varies dramatically, from less than a page with only cursory information to detailed hyper-linked pages that may include sample projects, forms for clients, and lists of both services provided and names of providers. It is often difficult to tell if faculty, hired consulting staff, or students are doing the consulting. Web pages with similar sounding mission statements can represent

dramatically different consulting units in terms of size and type of services provided. Many responded immediately to initial e-mail requests while others never replied.

While some simply provided the requested information, a number were quite enthusiastic about the need for information about students in consulting services. Certainly some departments included in the sampling frame did not have students consulting and, just as certainly, others that did so were missed. This is due to the way the sample was constructed and the imperfect information available. The non-response adds to the problem. However, even though it is impossible to tell definitively, the diversity of responses seem to reflect the diversity about statistical consulting that is evident in university web pages. While the responding sample is neither large nor random, the responses are informative.

About half of the respondents were directors of consulting units (53%) and almost one quarter were managers or supervisors, several of whom also seem to function as student mentors. The rest of the respondent profile included four consultants, two faculties who teach a consulting course, and two department heads. One respondent said they do not have a lab per se, and two provided no information. Although only four individuals listed consulting as their only role, a number of others listed consulting along with other roles such as focusing on coaching student consultants or teaching a consulting course. Three individuals said they did not use students as consultants.

Over half of the consulting units were housed in statistics departments (56%), with the remainder spread over a number of departments. These included six in mathematics departments and a few in joint departments such as mathematics and statistics or biostatistics and statistics. Additional departmental affiliations were Applied Statistics & Operations Research, Educational Psychology, Forest Science, and an Oncology department. One centre was housed in Learning Resources and Technology, another in the Computer Center, and one had no departmental affiliation. Over half the respondents said that statistical or research consultation was provided elsewhere in their university (58%), however in many cases that represented internal departmental "experts" who provided statistical consultation within their own department. A biostatistics department was mentioned the most (seven times), followed by education (five times).

With respect to the number of faculty lines allocated to consulting units, 12 said they had less than one full time equivalent (FTE), 11 had between one and two FTE, and nine had between 2.5 and 3.5 FTE. The rest responded in terms of hours per week or number of students allocated to the lab or said they had none. The consulting units also varied in terms of hours of operation. Four were open less than 10 hours per week, 15 between 10 and 30 hours, and another 14 either 35 or 40 hours. The remainder provided a variety of answers, such as by appointment only, by e-mail, all the time and no official hours.

4. THE CONSULTING LAB AND STUDENT CONSULTANTS

The first set of questions asked respondents to rank five reasons in terms of their importance for maintaining their consulting lab. Two reasons with a modal importance rating of one and median ratings of two were: (1) to provide statistical assistance to faculty and (2) to serve as a training ground for student consultants (see Table 1).

They were rated as most important reasons for maintaining consulting units by 47% and 44% of the respondents, respectively. Providing statistical assistance to students had both a median and modal rank of two, but was rated first by only 24% of the

respondents. Although two-thirds said that at least some of their services are fee based, particularly for clients who are external to the university, it is interesting that only 7% of the respondents felt that a primary reason for the statistical consulting service was to produce revenue or to serve external clients. Beyond the items listed, the following types of reasons were given for maintaining a lab. (Items are summary combinations of several responses):

1. Keeping faculty up to date by working on real problems, thereby enhancing classroom examples;
2. Initiating collaborative links across campus thereby promoting interdisciplinary research;
3. Provide statistical assistance to administration and staff;
4. Provide financial support to students.

Table 1. Reasons for Maintaining a Statistical Consulting Lab or Service

	Median rank	Mode	% rating item 1st	% rating item 2nd
Providing statistical assistance to faculty clients	2.0	1.0	46.5	27.9
Serving as training ground for student consultants	2.0	1.0	44.2	14.0
Providing statistical assistance to student clients	2.0	2.0	23.3	48.8
Providing statistical assistance to clients external to the university	4.0	4.0	7.0	14.0
Generating revenue for the department or college	5.0	5.0	7.0	4.7

When asked to describe who provides consulting services, faculty were listed by 74% of the respondents and graduate students by 67%, with each representing roughly one-third of all the responses (see Table 2).

About 40% said students consulted as a requirement in either a consulting course (23%) or a statistics course (16%). One-quarter hired non-student consultants and 12% used undergraduates. The most common services, provided by over four-fifths of the consulting units, are: (1) interpreting statistical results (95%), (2) implementing statistical analyses (88%), (3) problem formulation/translating hypotheses into statistical terms (88%), (4) sample size determination (88%), (5) planning statistical analyses (83%), and (6) research design (83%).

Each of these represented about 10% of 341 checkmarks on a list of 14 possible services. The two least performed services dealt with consultations on measurement theory, scale construction (13%) and providing short courses or workshops (5%).

Table 2. Profile of Consultants

	N	% of respondents[a]	% of responses[b]
Faculty on staff	32	74.4%	34.0%
Graduate students, in assistantship or internship	29	67.4%	30.9%
Hired non-student consultants	11	25.6%	11.7%
Students in consulting courses, as requirement	10	23.3%	10.6%
Students in statistics courses, as requirement	7	16.3%	7.4%
Undergraduates, in assistantship or internship	5	11.6%	5.3%

[a] Percent based on number of respondents (n_a=43)

[b] Percent based on total number of items checked across the six options (n_b=94)

Respondents were then asked to check any of eight types of consulting skills for which they provided training to student consultants. Three of the respondents (7%) said they did not provide training for students. According to the rest (see Table 3), the main types of consulting skills training deal with applied statistics problem solving (87%), problem formulation (82%), general problem solving (74%), and oral and written communication (74%). These four items represented from 15% to 17% of the 199 total selections made by 39 respondents. Only 11 people (28%) indicated training in how to teach within a consulting session as a skill that was taught to student consultants, and less than half trained students in session management. These results seem counter-intuitive, given the importance placed on such skills.

Table 3. Consulting Skills Training Provided for Students

	N	% of respondents[a]	% of responses[b]
Applied statistics problem solving (e.g., about appropriate advice to give clients)	34	87.1%	17.1%
Problem formulation (e.g., translating a client's problem formulation to a statistical formulation)	32	82.1%	16.1%
General problem solving	29	74.4%	14.6%
Oral and written communication	29	74.4%	14.6%
Interpersonal relations	25	64.1%	12.6%
Ethical standards in statistical consulting	20	51.3%	10.1%
Session management	19	48.7%	9.5%
How to teach within a consulting session	11	28.2%	5.5%

[a] Percent based on number of respondents answering this question (n_a=39)
[b] Percent based on total number of items checked (n_b=199)

Open-ended responses following this question indicate the extent of variability in statistical consulting in universities. On one end, one respondent said that all of the skills given in Table 3 were provided in a class discussion mode. Another indicated that students take a six-week course in consulting before meeting with clients and that their first client meeting is with an experienced consultant. At the other extreme, one respondent indicated no formal training and that the students learn by assisting regular consultants and through experience. This diversity can be seen in Table 4, which provides a checklist of how respondents said that students learn consulting skills.

Table 4. How Student Consultants Learn Consulting Skills

	N	% of respondents	% of responses
Through informal mentorships	25	59.5%	22.7%
Formally via course work on consulting	23	54.8%	20.9%
Picked up through their own experiences	22	52.4%	20.0%
Through reading materials provided or suggested	19	45.2%	17.3%
Formally via scheduled meetings or workshops	15	35.7%	13.6%
Through other means	6	14.3%	5.5%

[a] Percent based on number of responses with student consultants (n_a=42)
[b] Percent based on total number of items checked (n_b=110)

Over half of the respondents, as well as less than a quarter of the total items checked, indicated that this was done primarily via informal mentorships or formal coursework (only seven indicated both ways) and/or picked up through their own experiences. Less than half credited reading materials or regular meetings and workshops. Additional comments indicated that students pick up these skills by working jointly with faculty consultants and by informal training and observation.

When problematic research or statistical issues arise, the most frequent way they are handled is via consultation with faculty (72%). In very few cases are issues resolved openly at regular staff meetings (12%) or jointly among the consultants (9%). In one case, they use videotapes of the sessions.

With respect to formal technical skills, respondents think that student consultants bring only a moderate level of knowledge to their consulting. Based on a five-point scale from limited knowledge to proficient, four areas achieved a median rank and at least one modal rank of three: applied statistics, statistical software, theoretical statistics, and research methods (see Table 5).

Measurement had the lowest median ratings: two for applied measurement and one for theoretical measurement. Over one-third of the respondents could not rate this area. Overall, though, this seems a reasonable profile for beginning student consultants, some of whom are doing this as part of a course. Given that improvement in statistical and research understand is at least part of the purpose of having students consult, it would be interesting to evaluate their knowledge gain as a result of this practice.

Table 5. Beginning Student Consultants Level of Technical Knowledge

	Median	Percent[a]					
		1	2	3	4	5	DN
Applied statistics	3	4.7	11.6	32.6	32.6	14.0	4.7
Statistical software	3	4.7	20.9	37.2	23.3	7.0	7.0
Theoretical statistics	3	16.3	16.3	32.6	14.0	11.6	9.3
Research methods	3	14.0	25.6	25.6	14.0	4.7	16.3
Applied measurement	2	27.9	14.6	14.0	7.0	2.3	34.9
Theoretical measurement	1	34.9	16.3	4.7	9.3	0.0	34.9

[a] Responses from 1 = basic coursework or limited to 5 = advanced coursework or proficient.
DN = don't know.

5. DEALING WITH CLIENTS

Considering the clients who come to consulting sessions, 44% of the respondents provide guidelines for clients before they interact with a consultant and 23% have time limits on the number of sessions clients may have.

The type of guidelines vary from formal written policies, information in a brochure and on the web, or new client questionnaires to signed contracts or waiver forms. In a number of cases, the main specification was that only consultation and no data analysis was provided.

Limits on the number of consulting sessions were placed in only a very few instances. A couple of web pages made reference to the client guide available from the Statistical Consulting and Research Group at Northern Arizona University. Over two pages long, this guide is available at the following URL:

http://odin.math.nau.edu/~scrc/client_guide.html. It contains answers to such questions as: "How much statistics do I need to know?" and "What will my first session be like?"

Over two-thirds (67%) have some type of fee for services. The most common seem to be for clients who are external to the university, for funded projects, or for routine tasks of data entry, program writing, and data analysis. Some additional responses were that work on grant preparation for faculty was free if a faculty consultant is included in the grant; that there was a sliding scale differentiating among industrial projects, funded campus projects, and unfounded projects, where the first three hours were gratis. In only four instances were all clients charged.

Almost half the respondents (47%) said that consultants are selected based on a match between client need and consultant skill, while 30% do it on a first come, first serve basis. Additional clarification on this item indicated instances where a combination of these two is used, where the client picks the consultant, or where the students volunteer after the applications are read. One Consulting Center director indicated that clients are matched to student consultants according to appropriate background if the student is in a consulting class or if the director takes the client call, but that students in the Consulting Center get clients depending on availability.

As shown in Table 6, most clients approach consultants after the data are collected (reactive), particularly so for student clients (64%). About one quarter of both student and faculty clients are said to be proactive, engaging a consultant early on in the research process. Only 14% of both faculty and external clients are felt to be true collaborators, where the client and consultant work as a team throughout project. It should be noted, however, that one quarter of the respondents either didn't know about or did not have external clients.

Table 6. Client Characteristics by Type of Client

	Student clients	Faculty clients	External clients
Reactive	62.8%	58.1%	46.5%
Proactive	25.6%	25.6%	14.0%
Collaborative	4.7%	14.0%	14.0%
Don't know or N/A	7.0%	2.3%	25.6%

The next set of items asked for a rating of student clients. The profile of the perceptions of areas with most to least expertise for student clients (Table 7) and student consultants (Table 5) does not match.

Table 7. Typical Student Client Level of Technical Knowledge

	Median	Percent[a]					
		1	2	3	4	5	DN
Research methods	3	14.0	32.6	30.2	18.6	0.0	4.7
Statistics application	2	27.9	34.9	18.6	14.0	2.3	2.3
Statistical software	2	37.2	34.9	7.0	7.0	7.0	7.0
Measurement application	1	44.2	18.6	7.0	4.7	0.0	25.6
Statistics theory	1	72.1	11.6	2.3	0.0	4.7	9.3
Measurement theory	1	60.5	4.7	4.7	2.3	2.3	25.6

[a] Responses based on a 5-point scale from 1 = limited to 5 = extensive. DN = don't know.

Student clients are rated as having only moderate to rather limited knowledge, with research methods the only category having a median rank as high as three. As might be expected, the least knowledge is seen in theoretical aspects of both statistics and measurement and in applied measurement. As before, though, over a quarter of the respondents didn't know about knowledge in measurement.

6. PERCEIVED ROLE OF THE STATISTICAL CONSULTANT IN TRAINING RESEARCHERS

In response to an open-ended question about the consultant's role in training researchers in other fields, the most prevalent answer dealt with various aspects of helping them develop quantitative thinking and the importance of the scientific method. This role was seen as being important, and one individual described it succinctly as a way to "*improve the overall quality of scientific research."*

Although only one respondent said that the *"aim should be to help the researcher become more self-sufficient,"* this concept was implicit in a number of comments. People learn from mistakes, but *"this won't happen unless consultants can diplomatically bring these mistakes to the researcher's attention."* This goal is not only for the client's benefit, however, as seen from the continuation of this statement: "*So training one's clients is critical, especially if you wish to have an on-going relationship."*

Five individuals wrote at length about the client and the importance of "*having them take an adequate amount of coursework in statistics."* This relates, in part, to the lack of time to do extensive teaching in a consulting session, particularly for short-term interactions. Educating clients to be proactive and consult early on research and questionnaire design was seen as an important role for the consultant, probably as a reaction to the number of reactive clients who approach a consultant after data are collected,. Such behaviour would not only enhance the final product, but would help clients *"identify the most effective and efficient approach to the problem at hand and to jointly develop implementable plans*."

Another theme that emerged was that of the consultant as an educator, as someone who had an important role to play because of the utility of learning by doing. The consultant was seen as having "*the unique opportunity of teaching clients with an example that is already of importance to the client*." Some of the respondents offered lists of general types of assistance that a statistical consultant could provide to clients. These included helping them solve research problems, assisting in designing and conducting research studies, providing practical advice on collecting, analysing data, and interpreting data, as well as providing references, suggesting courses, and instructing on specific procedures. The term *"collaborative mentoring*" was used. This seems quite descriptive about the perceived nature of the interaction as a mutual teaching and learning situation.

There were a couple of discordant views. One respondent felt the role of the consultant should be limited to assisting when asked and another that there was no role beyond *"some guidance to the researchers when their designs are poor."* This latter individual, however, felt that this was a rare occurrence. But these were not the prevalent views in this sample.

One individual summarised the role of the consultant quite well: *"Statisticians certainly have a part to play in the education of researchers about experimental design,*

choice of response variables, and analysis and interpretation of analysis. However, the role of the statistician, and the ability of the statistician to do these jobs well, is limited by the desire and ability of the client. Some clients are very willing to learn a lot and they are motivated to do so. Others are not motivated and want only a brief response. As a consultant, we need to be responsive to those desires. On the other hand, we have to be ready to take every opportunity to help train researchers. By being proactive in this area, by providing training opportunities (short courses, workshops, seminars) and by being willing to invest a little more effort than a client might expect, we can demonstrate our desire to help researchers learn the tools they need to work."

7. TEACHING CONSULTING SKILLS

Nearly all of the respondents thought that it was important to teach statistical consulting skills (93%), but only 74% said that a formal statistics consulting course was offered (67% in the respondent's department and 7% elsewhere). However, an open-ended question that allowed respondents to comment on any aspect of teaching consulting skills produced only 15 responses. While no claim can be made for their representativeness, the comments are interesting and therefore will be discussed.

Several individuals laid out two essential aspects for teaching consulting skills. First, the experience must be problem based with real examples, small group discussions, and model sessions. Second, there needs to be opportunity to practice because experience is critical. Consulting skills are "*hard to teach*" but "*important to learn*," therefore students need "*lots of chances to interact with people from different disciplines with different types of problems."*

Three individuals stressed the importance of providing statistics students with consulting skills, and one provided a graphic metaphor: "*Not teaching these skills is like sending someone out to play professional tennis, possessing only a racquet, tennis balls, and several courses on the physics of bodies in motion."*

One respondent thought that having a consulting course depended on the size of the program, with smaller programs able to teach these skills individually through hands-on experience but that larger departments needed the formalised structure of a course. The latter would provide all students with the opportunity to perform in a consulting situation as well as *"help formalise faculty involvement with student consultants*." Another cited the importance of "*some training in general consulting skills like listening, attention to timeliness and physical constraints, friendliness, respect for all people,* etc." But, also added that "*statisticians might not be able to teach these well in all cases. May need someone besides a statistician to teach these skills effectively*."

In the midst of all the very positive comments, two negative aspects were brought forth. First, the incredible amount of effort a consulting course entails, and that *"teaching such a course takes a very skilled instructor and one with years of experience."* Second, although consulting is important for the students, *"university funds students to be TA's and help with classroom teaching and grading"* but "*is stingy at funding students to serve as assistants to consulting projects."*

8. PROBLEMS STUDENTS ENCOUNTER IN STATISTICAL CONSULTING

Unlike the previous question, nearly everyone answered this one on what is the most common problem that students encounter in statistical consulting. With respect to *student consultants*, a series of responses all dealt with different aspects of problems with interpersonal and management skills. In particular, things like knowing how to listen, establishing clear communications, asking enough questions to truly understand the client's problem, negotiating a reasonable time-frame, knowing how to effectively run a consulting session.

Another problem is "*determining the difference between consulting with someone and doing it for them,"* even though sometimes that is more expedient. Given that student consultants are still learning, they sometimes *"lack confidence in their statistical skills" and "are afraid to make a mistake."* They are not able to tell a client that they don't know the answer; that they need time to think about it. This is where lots of practice, particularly in supervised settings helps. Sometimes, however, they are deficient in the statistical or methodological knowledge needed to help a client. But this can, to some extent, be alleviated by judicious matching of client and consultant, by having formal meetings to discuss difficult cases, or by pairing a novice consultant with an experienced one.

The one difficulty most often mentioned was problem formulation. Respondents mentioned the fact that student consultants have a hard time *"abstracting the real problem from the story that the researcher tells."* They have problems interacting with clients due to not "*understanding enough about the problem from the perspective of the other discipline to give good statistical advice*." Even if they have the proper knowledge, they may not be able to figure out "*how the client's problem relates to the methods they are familiar with*." Another difficult, but related, situation for student consultants has to do with not knowing how to deal with clients who "*have no clear idea regarding their research objectives*" or "*come in with one introductory course in stats and want help carrying out sophisticated analyses*." Because a substantial amount of the assistance provided is reactive in nature, the student consultant is often faced with difficulties from two perspectives. One, trying to make sense of data from a flawed design, and two, having to deal with how to tell a client that most of their research questions are not answerable given the data they collected.

A few respondents provided information about the problems faced by the *student client*. They cited things like misunderstanding the method or analysis presented to them, not being able to communicate effectively, and "*lack of initiative during the meetings*." Although some student clients with little background want guidance in complex analyses, others seem to have the opposite problem. Some are advised by consultants to *"run designs with difficult issues that are well beyond their capability to understand and resolve*." Both situations are frustrating and very likely lead to poor research.

9. DISCUSSION

It appears that there is great diversity in how students gain statistical consulting skills in the United States. A few models emerged from this study: (1) a formal consulting centre or lab where students consult with some form of supervision, (2) a consulting course where students may work in groups or function as individual consultants on a given project, and (3) participating in consulting sessions with a faculty consultant as mentor or role model. In some cases statistics students receive specific

training in consulting skills, while in others they are expected to learn by observing an experienced consultant. Consulting courses may also differ in terms of the content covered and the activities involved (Belli, 2001). At one extreme, the students in the course effectively served as the consulting lab. At the other extreme, they worked in small groups on real or model problems. But, for all the apparent diversity, there seems to be overwhelming consistency in the acceptance that consulting skills are an important part of a statistical education. Some people consider these to be nothing more than a strong statistical background that enables a consultant to resolve a client's problem. Given this view, teaching statistical skills revolves around exposing the student to a range of problems from various disciplines so they can develop their experience. In contrast, what seems to be a majority opinion at least for this sample, is that this is only half the lesson. While statistical and methodological knowledge is certainly important, it is not effective if the consultant cannot adequately communicate it or cannot manage a consulting session properly. In such cases, effective teaching can not occur as part of the interaction. Likewise, a researcher who does not know how to work collaboratively with a statistician, and only utilises one at the end stages for analysis is not able to benefit fully.

The statistical consultants' role in training researchers in different fields may very well be a function of what the client desires. Although some results here were no surprise; e.g., that too many clients tend to seek help only after data collection and arrive for a consultation with poorly defined questions or questions that don't match the data collected. Certainly these are problems and the consultant must learn how to interact with such clients in a reasonable manner. A far more interesting result, however, is how collaboration was mentioned. In particular, how training clients to come early in the research process could lead to joint determination of process and even collaboration in future projects. This transforms consultancy from a service performed to a valuable working relation that benefits both parties. As Svensson (2001) states about one area:

> *"there is a need for more biostatisticians with an interest in collaborative research, not only for the improvement of the applied research, but also for the development of the biostatistical science"* (p. 33).

The same could be said for any applied area. Indeed, Jollife (2001) states that:

> *"significant progress in any field of application needs the participation of both specialists in the field and of statisticians"* (p. 365).

On the one hand, several respondents mentioned how consulting centres *"were not appreciated by the administration"* and were seen by departments as "*a service rather than a contribution to the research infrastructure."* It is therefore difficult to get funding for them and consulting efforts are not rewarded. These sentiments echoed results from a recent survey of heads of biostatistics services in health care research settings in the United States and Canada (Niland, Odom-Maryon, Lee, & Tilley, 1995). Problems with insufficient institutional funding and lack of co-authorship on manuscripts after substantial input were reported. Several presenters at the August 2000 International Association for Statistical Education Round Table Conference commented that similar problems exist in their countries. Some individuals from this sample, however, indicated how collaborative projects and inclusion in grants resulted "*from routine consultations*" and how the centre is *an "excellent source of research problems"* for classroom use and

"*has led to a number of published articles*." One responded summed up by saying that "*these types of collaborations are highly encouraged by the university and are rewarded at the departmental level."*

Professional consultations are a two-way street, and so should be student to student consults. Both parties must bring something relevant to the table and could be taught to do so. The student clients needs some assistance, but must be willing to do their part in terms of communicating effectively to the consultant and learning the necessary statistical concepts. Likewise, the consultants must work to understand the client's domain enough so that a useful solution may be found. The result should be beneficial to both parties. The consultant gains experience and improves in both statistical and consulting skills. The client gains a solution to a research problem and improves in statistical knowledge. More importantly, both can develop an appreciation of collaboration that they carry with them after they graduate and into their professional careers. This is consistent with Godino, Batanero, and Jaimez's (2001) conception of :

> *"statistical consultancy as a device to co-operatively study data analysis problems"* and that *"consultants need the client's contribution, as much as clients need consultant's knowledge"* (p. 347).

Although this survey had a small number of respondents, mostly from statistics or statistics related departments, they provided useful information about the process and problems in university statistical consulting units. One interesting result was the extent to which things like problem formulation and research design issues were part of typical consultation. While one might expect this from more general *research* consultancy units rather than *statistical* consultancy units, this did not seem to be the case. A follow-up survey will be conducted with colleges of education, in part to determine the extent to which any research consulting services there differ from those in more quantitative departments. A search of web pages to find listings for statistics or research consulting in colleges of education under programs in educational psychology, measurement, statistics, or research methods is already in progress. The final list of web pages will be put on a web page, with links to statistical and research consulting services and statistical consulting courses in USA universities. These results will provide a substantial profile of the consulting services available in USA colleges and universities.

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