

## Improving Statistical Literacy: Discussion

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First, I want to thank the organizer. Gwyneth Boodoo, and the speakers for three very thought-provoking presentations. I find it rather daunting to try to make useful comments on such a vast amount of material in 15 minutes. The problem with such an assignment is that while it's easy to say something, it's hard to say anything very meaningful. I'll have to limit myself to just a few issues among the many that have been raised.

First, let's look at what was and was not considered in these papers. The title of the session is "Improving statistical literacy: Classroom, community and consulting issues. Consulting issues were taken up by Pat Busk. The other two papers dealt with classroom issues; Sharon Weinberg with teaching statistics to mathematically unsophisticated students, and Miriam Grosf with teaching statistics in community colleges. The papers don't deal with statistics education for mathematically sophisticated students, except as that education is relevant to consulting. Nor are we dealing with grade school or high school statistics education, or with education in the general community beyond what is obtained in formal college courses. So I'll restrict my comments to the same areas as the papers.

However, we can't ignore grade school and high school developments, because they have implications for the topics we're discussing. The Center for Statistical Education of the ASA is putting a good deal of effort into the promotion of statistical literacy in early education. To the extent that this effort is successful, both the topics we teach at the college level and the methods by which they are taught should gradually change. The implications for consulting are somewhat weaker, but presumably we won't have as many clients who come in with no knowledge of statistics – in the survey reported by Pat Busk, almost half the respondents estimated that more than 10% of their -clients fell into this category. What these developments

mean is that we have a moving target – at least we hope so – and we'll have to continually adjust both the methods and the content of our courses. And that means we'll need constant feedback from and about our students.

There are three main themes on which I'll focus in this discussion:

1. Feedback
2. Diversity
3. Conflicting goals.

I won't take them up in order, rather they'll come up at various points throughout the discussion.

Miriam Grosf and Hyman Sardy's paper deals with two-year colleges, and was the only one that explicitly raised the diversity issue. First, let me say that I was really surprised to learn that 44% of all undergraduates are enrolled in two-year colleges – I would have guessed a far lower proportion. The diversity of backgrounds and goals of students seems to be greater in the two-year than in the four-year colleges, but the issue of diversity is important in four-year schools as well. I agree with the authors that one-size-fits-all courses don't meet the needs of students in either the two- or four-year colleges. On the other hand, it isn't easy to decide what mix of courses is appropriate, and there has been a long debate over the advisability of offering elementary-level courses within mathematics or statistics departments versus offering them within subject-matter departments. Furthermore, the current budget problems in many places make it harder to offer a variety of courses. I won't get into those issues here, but they are important, and the paper suggests that it may be more crucial to work on them at two-year than at four-year colleges, since most of the two-year schools at present seem to have only one beginning course.

Pat Busk's paper gives us some background statistical information, on consultants and their perceptions of their clients. The survey sampled members of the Caucus for Women in Statistics – primarily women – and members of the Special Interest Group – Educational Statisticians of the

American Educational Research Association many of whom received most of their statistical education outside of statistics and mathematics. So the population differs in unknown ways from the population of consultants in general, which would be a very hard population to define in any case. The fact that the different types of consultants within the sample didn't differ significantly gives some support to the generality of the survey findings. The response rate of 70% is not ideal but is good for this type of survey.

Many of the consultants felt that they would have been helped by having consulting experience while in graduate school. A number of schools do provide such experience in a formal way, as pointed out in the article, including UC Berkeley, where I was the faculty supervisor of our student-participation Statistical Consulting Service for many years. I'll describe our service very briefly and discuss some of the issues that have arisen.

We have a free drop-in consulting service run by the Department of Statistics, available to anyone in or outside the University. The front-line consultants are students who sign up for a course. The course is optional, and students can take it as often as they wish. As part of their course activity, each student is available two hours a week on a drop-in basis. The students receive both course credit and a small payment for participation. The service is visited by from 150-200 clients a year.

Each student writes a report on each client seen during a consulting week and these reports are distributed to all members of the class before a weekly two-hour class meeting. In the meetings, we go over the problems, decide what further information we need from the clients, and discuss possible solutions. Occasionally we ask clients to come to class sessions and discuss their problems, and occasionally we have other outside speakers on consulting issues.

I've asked the students what they gain from the course, and there is one dominant answer. In their other courses, problems come with preassigned labels: e.g., if they are in a course in linear models, they know they are supposed to use a linear model, etc. In consulting sessions, they are often called upon to work with the client

to provide such structure, both if the data are already collected, and even more so if the study is still in the planning stage. As anyone who consults knows, formulating the problem in an appropriate and tractable way is the most important part of the process, and the part that is very difficult to incorporate into traditional courses.

Besides increasing the statistical literacy of the consultants, the program helps to increase the statistical literacy of clients. In addition to getting feedback from consultants, we periodically obtain feedback from clients. Among many things we've learned in this way, I'll mention one: It's very easy for clients, especially statistically unsophisticated ones, to misunderstand the statistical advice offered. So it's very important to end each session by reviewing the advice given, to be sure both the advice and the reasons for it are well understood by the client.

Some type of consulting experience in graduate school is a good idea – the consultants who take the class feel that way, and the consultants in Pat Busk's survey do also. The problem is, how much and what kind? One thing most of our Berkeley students don't get is intensive long-term experience with a single project. Indeed, some of our faculty feel that is the only worthwhile kind of consulting. I think both the short-term and long-term types are worthwhile, since they teach different things. The problem is that time spent in consulting settings is time not spent in formal course work – and consultants in Pat Busk's study did note that their coursework was the most helpful aspect of their educational background. We have to consider not only what would be desirable, but what would have to be given up. Conflicting goals is a real issue here. A good consultant should know a lot of theory, methodology, something about the subject matter, have communication skills and skills in dealing with people, etc. But how do we obtain a good balance?

The paper by Sharon Weinberg is quite different, dealing with suggestions for teaching statistics to mathematically unsophisticated students. It's useful to distinguish between two related but distinct questions: What should we teach and how should we teach it? She suggests

that the "what" should be insight and conceptual understanding, rather than computation and a collection of specific techniques

On the "what", we may once again run into conflicting goals. Sometimes subject-matter departments want their students to learn about a great many techniques within a single course so that they'll be able to read and understand the literature in their fields. Many statisticians feel that a beginning course that has to cover multiple regression, factorial designs and analysis of variance, perhaps even some multivariate statistics, can't achieve the goal of conceptual understanding and results in a cookbook type of knowledge. How do we reconcile these conflicting goals and expectations?

As for the "how" of teaching, Sharon derives methods from principles of effective teaching and discusses specific methods that she has found to foster conceptual clarity. The specific points she elaborates are:

- (a) Linking topics and ideas; providing a general framework
- (c) Reintroducing topics in a spiraling manner
- (d) Stressing the utility of statistics for the solution of real world problems.

On the "how", I agree that all of the approaches suggested in the paper can help as general guidelines, but the only way to know what specific techniques work is to get feedback from students. As an example, I'll mention one specific point on which I have some disagreement. The paper states: "Whenever possible, examples should be clipped from newspapers and the popular press to illustrate the applicability to everyday life of the statistics being taught in class... ." I did a good deal of this one semester, and in my evaluations was criticized for going off on tangents too often. At least some of the students wanted more concentration on the subject matter. Of course, we do run into the problem of diversity here – not all students felt that way. But it is possible to overdo these examples, at least for some students. Again, conflicting goals. If we do more of one thing, it means doing less of something else.

Of the three themes – diversity, conflicting goals, and feedback, I want to concentrate now on feedback. Once we've set our goals, we have to get evidence on how effective we are in reaching them. There are three ways in which we can get such evidence.

1. First of all, we have surveys, both surveys of the type reported on today, in which we find out what is actually being done and how various groups feel about it, and surveys such as the National Assessment of Educational Progress that directly measure what students know.
2. Then, we have evaluations from students, that tell us what students think of various aspects of our practices. What do they like? What do they think helps them learn? We can't be sure that if students think something helps them learn it really does make them learn better, but in the absence of other information to the contrary, it seems wise to take such student comments at face value.
3. Finally, there are formal experiments. We'll never be able to carry out experiments on all aspects of teaching practice, especially since both content and methods will have to change over time, but there certainly has been and will continue to be a great deal of experimentation with respect to major aspects of instruction.

I'd like to end by mentioning a project that many of you may know about, an exciting new approach to obtaining information that will help us increase statistical literacy as well as the effectiveness of education in general. The project is called the Harvard Assessment Seminars, was initiated in 1986 by then-President Derek Bok of Harvard, is an ongoing study, and is directed by Richard Light, Professor of Education at Harvard. So far two reports have been issued: First Report in 1990 and Second Report in 1992.

The participants have included over 100 faculty members from 24 colleges and universities and about 60 students. All the types of research I mentioned have been used – surveys, student evaluations of their educational experiences, and experiments – and the results are being organized and presented systematically in the reports. The reports have a great deal of very concrete, useful information, and are

available free of charge by writing to Professor Richard J. Light, School of Education, Harvard University, Cambridge, MA 02138.

I'll mention just a few of the fascinating and sometimes surprising findings, relating them to the themes of feedback, diversity, and conflicting goals.

A. Feedback: The very fact that the project is yielding such interesting information attests to the value of feedback of the kinds described. In addition, one of the suggestions for improving teaching, called the one-minute paper, involves regular feedback from students. At the end of each class, each student is asked to write down brief answers to two questions:

(1) What is the big point you learned in class today?

(2) What is the main, unanswered question you leave class with today?

Most of the professors who have used this approach feel it has helped the educational process in a number of ways.

Furthermore, when students were asked for features of the courses they have found most effective, the most frequently mentioned point was quick and detailed feedback. They suggested, for example, that homework and examination solutions be handed out immediately after they hand in the homework or examinations, when they are concentrating on the problems.

B. Conflicting goals: At the same time, students also like to get feedback on their work, correct it, and hand it in again. But if solutions are handed out immediately, as suggested in Point 1 above, the benefit of this activity would be severely compromised. Which approach would be more effective? Or is a combination appropriate?

C. Diversity: The participating schools are almost all very prestigious with highly-selected student bodies, so one unanswered question is the extent to which the results of the project will generalize to other institutions. Furthermore, within the studies themselves, some striking gender differences have emerged, some of which may have implications for teaching practices. One interesting finding is that women are much more likely to study alone than men, and yet

women and men who study in groups feel they have learned more in the courses. In addition, there is some experimental evidence that assignment of subjects to study groups results in better learning. These results suggest that it may be particularly important in teaching women to encourage studying in groups.

In conclusion, many of the issues that arise seem to cluster around the three general themes:

1. Feedback. Continual feedback of all kinds is necessary to improve statistical literacy.
2. Diversity. Different kinds of students need different approaches – how should we/can we discover and allow for this?
3. Conflicting goals. More of one practice means less of another – how should we resolve the conflicts?