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DISCUSSION

I would like to express my appreciation to the Round Table Committee for inviting me to participate in this discussion. I will discuss below each of the papers.

1. EMPIRICAL RESEARCH ON THE UNDERSTANDING OF ASSOCIATION AND IMPLICATIONS FOR THE TRAINING OF RESEARCHERS

Antonio Estepa and Francisco Sánchez Cobo present a coherent set of findings about the way students perceive association. These results came from an assessment study on how university students understand correlation and regression.

The paper touches upon a number of issues, which I found to be very important in the training of researchers. I am very impressed with their findings and found little to take issue with. My comments will therefore focus on questioning how to remedy the misconceptions on the part of the students.

The learning of statistics must move from passive to active. We face many challenges when teaching an algebra-based introductory statistics course. Among the numerous obstacles is the perception of many students that statistics is boring and pointless. One of our principal goals as teachers is to engage students in the subject and to teach them that statistics is full of ideas and methods that will make them more informed users of the information they encounter every day.

To reduce "statistical anxiety" and nurture an appreciation that statistical thinking and methods can be helpful in solving real problems, we can bring real problems to solve in the classroom. Could it be possible that we use more formulas than needed? With the availability of an ever-increasing technology, like the graphing calculator, we can move to the discovery approach.

With more emphasis on teaching "statistical thinking" students can unlearn the "law of small numbers" and understand that variation exists in all processes.

I always found it surprising how difficult it is for students to distinguish the dependent from the independent variable. Is IQ the independent and income the dependent variable? Could it be possible to consider income the independent and IQ the dependent? Income may permit private tutors and IQ could be improved.

Finding a relationship between variables is an important step toward modelling phenomenon. However, how do relationships arise? Both variables may change with a third variable. One variable may be the cause of the other. The relationship may be the result of chance variation alone. The relationship may be the result of aggregation of several sub-populations. The relationship may be the result of the operational definition of the variables.

I found it very helpful to teach with counterexamples to accelerate the learning process. In the case of association, using the graphing calculator in class permits the students to enter, manipulate, and plot data quickly and conveniently. The graphing calculator minimises hand calculations and eases data plotting situation. It also helps

one verify the derived hand calculations, making a formidable formula much more manageable.

2. IMPORTANT CONSIDERATIONS FOR OPTIMAL COMMUNICATION BETWEEN STATISTICIANS AND MEDICAL RESEARCHERS IN CONSULTING, TEACHING AND COLLABORATIVE RESEARCH- WITH A FOCUS ON THE ANALYSIS OF ORDERED CATEGORICAL DATA

Elizabeth Svensson's paper primarily reflects on the lack of understanding about the relationship between the measurement properties of data and the choice of statistical method of analysis among researchers and statisticians. Beverige, quoting Schiller, suggests that:

> "The slowness and difficulty with which the human race makes discoveries and its blindness to the most obvious facts, if it happens to be unprepared or unwilling to see them, should suffice to show there is something gravely wrong about the logistician's account of discovery" (Beverige, 1961, p. 112).

Tukey (1962) asked himself how can new data analysis be initiated. And his answer was that we should seek out wholly new questions to be answered. Statisticians might assume that they play a natural role in teaching the statistical methods, but researchers from other disciplines have the technologies at hand to collect and store data and have assumed a role in the analysis. Much of the development of new methods is going on outside the traditional statistical literature, and it is no longer sufficient to scan statistical journals to be aware of what is going on.

The easy availability of manuscripts and software on the World Wide Web has already had a major effect. What are some of the risks? The software may not have been tested. An article electronically published may not have been peer-reviewed, and it might contain errors, etc, etc.

I am a strong advocate of changing the basic curriculum in the first courses offered in statistics. Technological change, and both innovation and improvement is often so rapid that if we are trained to run the machinery of today, the value of what we learn will be quite limited. The life cycle of technology is short, but the principles, which permit learning, are long-lived. The focus of teaching has to be on describing the principles of efficient learning. The learning process, however, is not a common sense activity. We need to teach students how questions should be asked as well as the scientific method. We need to teach students how to think within statistics. I propose a following list of topics as we teach them in our Stat. 170

Anne Hawkins, director of the Centre for Statistical Education, at the University of Nottingham, UK once suggested that as statisticians, we have important specialist skills, knowledge and understanding, not all of which may be shared by everyone, and that is what makes us specialists.

However, it is in our interests, as well as being our professional duty, to learn how to communicate the general principles of what we have to offer to as wide an audience as possible. This requires not only a continuing commitment to the study of statistical teaching and learning processes, but also the willingness to implement indicated changes into classroom practice. Specialists in the field of statistical education are beginning to make progress in a variety of ways, but the task that faces them is far from trivial. The problem of how to educate the educators is almost as pressing as the need to produce and research innovations for them to adopt. This is something for which all

members of the statistical profession have the responsibility, not just those who are identified as specialists in statistical education. A professor of statistics who cannot be persuaded that participation in a conference on statistical education has relevance to him or her has indeed failed to grasp the basics!

3. STATISTICAL TRAINING OF RESEARCHERS IN TOTAL QUALITY MANAGEMENT

I enjoyed reading Hirotsu 's article, which provides an overview of a training system for statistical methods in Total Quality Control in Japan. I will not argue that one finds motivated students in the in-company educational system. Instead, my comments will be about the "content" of those courses offered in the educational system.

When teaching at universities, many instructors may not give careful thought to course objectives nor consider their major goal to be that of exposing students to statistical metaphors. This might be because a strict curriculum, perhaps built around a specific traditional text, has been pre-ordained by the department. Unfortunately, for the vast majority of students, the experience of taking a statistics class is a negative one.

In an effort to overcome such problems, I am wondering whether industry should play a more aggressive role in offering assistance to local universities in order to help add a more practical flair to the introductory classes.

The University of Michigan attempts to be a leader in Interdisciplinary teaching approach and offers research opportunities for undergraduates. We offer a class, Stat. 170, where we tie the statistical ideas into an overall approach of scientific inquiry. Much of the teaching in quality is based on system thinking. Maximising a function of several variables, for example, cannot be accomplished variable by variable, so the best team is NOT necessarily the one with the best players. An organisation with excellence in each department may produce an inferior product or service. Some points to consider:

- Descartes admonition: "Sense perception can be sense deception";
- Examples that should cause us to think carefully about comparisons;
- Probability: Interpretation;
- When are surprises not uncommon?
- Paradoxes;
- Concepts of conditioning;
- Relationships;
- Cause and effect versus alternatives;
- The regression effect;
- Systemic biases;
- Size and other selection biases;
- Observer and experimenter bias.

I advocate more explicit discussion of goals, the degree of change I think will require Content, Pedagogy, and Technology.

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