

## **23. DISCUSSION: HOW TECHNOLOGY IS CHANGING THE TEACHING OF STATISTICS AT THE COLLEGE LEVEL**

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This summary will be organized into four parts: (1) a synopsis of the comments made by participants during the entire group discussions after the paper presentations; (2) a synopsis of a small group discussion on technology and post-secondary education issues; (3) a list of recommendations regarding technology and teaching/learning at the post-secondary education issues that is based on the five papers and discussions; and (4) a list of research recommendations based on the five papers and discussions.

### **SYNOPSIS OF PARTICIPANT COMMENTS**

Several comments following the presentations concerned how difficult it was for students to understand the subtleties involved in correlation coefficients and confidence intervals. Related to this were comments about the importance of assumptions and the concepts of efficiency and power and how much should be discussed in introductory level courses with respect to these topics. There was also a discussion of the role of formulas and the practice of providing formulas only after students have had experience with the concepts via technology or other activities.

The dilemma of whether to use one large dataset for an entire course or several small datasets was discussed. One participant felt that the analysis of real data was not an end in itself, but a way to illustrate and motivate statistical concepts. A disadvantage of using the same dataset throughout a course is that there will be students who may not be interested in the context of that dataset.

There was a discussion regarding the rapid improvements being made in technology, resulting in the fact that the number of people having access to the Internet is growing exponentially. It was mentioned that, worldwide, better interfaces between computers and telephones need to be developed and that language translators need to be developed in order to make Internet resources available in many languages.

Discussions also centered around the use of “black box” systems for teaching and doing data analysis. Several participants expressed mixed feelings about this. One participant said that you can train a monkey to use a black box system, but the monkey cannot make intelligent decisions. On the other hand, many aspects of statistical computing packages are already taught as black boxes without the users knowing where the formulas come from or without even being given the formulas and/or algorithms that produced the computer output. It was also mentioned that black box models need to be readily understandable, especially when used to teach people with no background in statistics. Another participant pointed out that black boxes sometimes work better than people. One participant pointed out that there are not only white and black boxes but intermediate gray ones. The teacher needs to decide what should be white, gray, or black.

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There were also some questions by participants as to what managers need to know in terms of statistics and quality control. In particular, do they need to know hypothesis testing procedures, such as *t*-tests, and how much do they need to know about control charting, capability studies, and trouble-shooting using statistical analyses? There was also some discussion of the advantages and disadvantages of resampling methods.

### WORKING GROUP DISCUSSION

The small group discussion on post-secondary issues took place the last morning of the conference. The six participants all teach or have taught at the university level. Many of the ideas summarized below were unanimous, but several were by consensus and not unanimous. The main goal of the discussion was to make recommendations, although the discussions covered a wide variety of topics.

Before providing recommendations, the group felt that it was important to give a statement of the discussion group's philosophy. This philosophy statement helps explain some of the rationale behind the recommendations, and states:

At present syllabuses tend to be overcrowded and ineffective. We think that syllabuses should be as simple as possible given:

- The purposes of the students for enrolling in statistics courses.
- The available technology.
- The abilities of the students.

The group also discussed ways in which technology can be used. In particular, technology can enable:

- Instructors to rethink content (basic ideas, new ideas).
- Learning to be more active.
- Learning to be more utilitarian.
- Sharing of knowledge (Internet, etc.).

The group's recommendations in terms of teaching and learning were:

- We need to rethink content.
- Curricula need to be developed independent of a particular platform.
- We must develop intelligent partnerships between students and technology.
- The role of probability needs to be examined.

The group's research recommendations were:

- More long-term research programs need to be developed. A few already exist and some examples are given in other parts of these proceedings.
- We need to find out what particular disciplines really use and want taught.

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### RECOMMENDATIONS

As indicated in the beginning of this summary, the recommendations will be broken down into two groups: those that deal with teaching and learning and those that deal with research. Although these recommendations are given here in the context of post-secondary education, many of them are applicable at the primary and secondary levels as well.

The sources of these recommendations will be given in parentheses after each recommendation. When the phrase “large group discussion” is used it refers to the discussions that took place at the conference after each of the individual presentations. Also, the word technology is used throughout these discussions to mean more than calculators and computers. It can include, but is not limited to, such diverse technologies as paper-and-pencil (see the paper by Jones), radios, videos, and compact discs.

#### Recommendations on teaching and learning

1. It is important to always think about the customers being served (usually the students and their present or future employers) when designing curricula both in terms of topics taught and the use of technology. The teacher, the students, or both, may use technology. (Sources: All of the papers in this Section and the large and small group discussions.)

2. The actual topics taught and depth of instruction must be rethought in light of the available technology. In particular the role of probability needs to be examined carefully. (Sources: All of the papers in this Section and the large and small group discussions.)

3. Curricula developers should try to develop the materials that use computers or calculators to be independent of a particular platform or calculator. They must also take into account that students and teachers often will not have access to the latest technology. (Sources: Jones, Rossman, Starkings, and the large and small group discussions.)

4. Curricula developers should take into account that at the post-secondary level students within a class often have a wide variability in background in terms of probability, statistics, and technology. (Sources: All of the papers in this Section and the large and small group discussions.)

5. Intelligent partnerships between students and technology need to be developed. In particular, students need to understand that just because a piece of technology gives them an answer, the answer may not be correct, for a variety of reasons. (Sources: All of the papers in this Section and the large and small group discussions)

6. Teacher training in post-secondary institutions needs to incorporate the use of new technologies both initially and subsequently (e.g., offering in-service workshops and courses for teachers). In areas where repair service is not readily available, repair methods should also be taught. (Sources: Starkings and the large group discussions.)

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7. The distinction between statistical significance and practical significance must be emphasized, especially when technology is being used as a black box. (Sources: Rossman and Wood.)

8. More researchers should make their data readily available on the World Wide Web. (Source: Snell.)

9. The ISI and other organizations (both statistical and nonstatistical) should play a prominent role in helping developing countries and poorer areas within other countries gain greater access to technology. (Source: The large group discussions.)

#### **Research recommendations**

1. More long-term research projects need to be developed. These may be in terms of particular curricula, on how students learn particular topics in the presence of technology, or on how to best teach particular topics in the presence of technology. (Sources: All of the papers in this Section and the large and small group discussions.)

2. Funding needs to become more available for long-term research projects. (Source: The large group discussions.)

3. For uses of technology that seem to work well, it needs to be determined why they work well. (Source: The large group discussions.)

4. Research should be conducted on how to develop intelligent partnerships between the user and technology. These partnerships are in the context of statistics teaching and learning and in the context of data analysis in the workplace. (Sources: All of the papers in this Section and the large and small group discussions.)

5. More research should be conducted to investigate how the use of various forms of technology can increase students' intuition, knowledge, understanding, and higher-order thinking skills for specific probability and statistics topics, and in general. (Sources: Jones and Rossman and the large group discussions)

6. More and better methods of assessment need to be developed to measure all aspects (both in the cognitive and affective domains) of probability and statistics learning and teaching in the presence of technology. (Sources: Jones, Rossman, Starkings, and the large group discussions.)

7. Research should be conducted to determine for specific topics, as to how and when paper-and-pencil technology, calculators, larger scale computing devices, and other technology should be used by students. (Sources: Jones, Rossman, Wood, and the large group discussions.)

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8. Research should be conducted to determine if, when real data are used, students prefer one large dataset as the basis for a course or several different datasets. (Sources: Rossman and the large group discussions.)

9. More research should be conducted to determine what students learn when doing simulations. (Source: Rossman and the large group discussions.)

10. It is important to find out what statistical knowledge various disciplines use and what topics and technology they want taught. (Sources: Wood and the small group discussion.)

11. "Solar-powered" graphing calculators with statistical capabilities need to be developed for use in areas where electricity and/or batteries are not readily available. (Source: Starkings.)