INTRODUCTORY STATISTICS: CRITICAL EVALUATION AND CLEAR COMMUNICATION

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For many students their first course in statistics is their only course in statistics. The objectives of such a service course are extensive and often this attempt to produce instant statisticians leaves the majority of students with little more than a mysterious bag of tricks. At Ballarat we have run practical based introductory statistics courses for some years and observed an improvement in students understanding of the various statistical techniques. Most students studying a service course in statistics need to be able to critically read and evaluate research and to write reports which communicate results of the statistical analysis of data. Since 1997, we have planned tutorials throughout the course which emphasis this applied objective. These tutorials involve more reading, more writing and less arithmetic. This presentation will include examples of the tutorial tasks set and a summary of the results including interviews with student focus groups.

THE PAST

Throughout the world, first courses in applied statistics commonly covered the same topics. These were presentation of data, descriptive statistics, elementary probability, an introduction to inference and hypothesis testing usually as far as one way ANOVA, and perhaps correlation and regression. Despite dealing with a fairly common core curriculum there was great variety in emphasis, teaching methods and approaches to learning.

At the University of Ballarat we have been engaged in a process of Action Research. As a result our service courses in statistics have altered. While the topics have been essentially the same, there have been radical changes in the way we do things.

The key objectives of our courses have always been for students to be able to understand the appropriate use of statistics.

- DO statistics.
- write reports which communicate statistical results.

It is the balance between these objectives which has shifted.

MOTIVATION FOR CHANGE

Until the 1990s the focus in service courses in statistics was the ‘doing of statistics’. Following formulae, performing calculations and learning short cuts for calculations formed the major focus of teaching because this took so much time. Kaput

(1996) reminds us that the real breakthrough of decentralised and personalised microcomputer-based computing has only been widely available for less than one decade. This facility has brought change to the classroom. In the area of statistics access to computer packages has meant that large sets of raw data can be analysed in quite short amounts of time. Standard deviations and regression coefficients can be correctly evaluated at the press of a button instead of as the result of tedious calculations in which students commonly made errors. Fast, correct calculating power has freed teachers and students to concentrate on understanding the principles and concepts of statistics. No longer are students rewarded for obtaining a correct figure without knowing why it had been calculated or what the result means in the context of the question or scenario.

The availability of affordable statistical calculators and relatively user friendly computer packages presented an opportunity to change our teaching practices. Firstly we worked on increasing students' understanding of statistics by introducing statistics practicals. In these classes we carried out the whole process of introducing a problem or scenario, setting hypotheses, conducting an experiment or collecting data and then using a computer package to facilitate the rapid processing of the data (Martin, Roberts and Pierce, 1994). In these 'hands on' practicals students knew both how and why the data was being collected, and started to interpret the results in context. They recognised outliers, discovered that real data is not 'clean', and gained an intuitive feel for the sort of results that made sense of their observations (Roberts, Martin, and Pierce, 1994). Easy, fast access to exploratory data analysis also meant that students no longer avoided or resented the need to check underlying assumptions associated with the choice of statistical techniques. Student surveys and interviews at the end of these units (usually in first year) and again prior to graduation indicated that these students felt greater confidence in their use of statistics than did those from previous years. Staff feedback, however, still reflected a concern that students' communication of statistical information was poor. Furthermore, leading and probing questioning of students suggested that many of them had a better understanding of statistics than was apparent from their written responses. Understanding and doing statistics had little value without clear communication.

A review of relevant literature reinforced the view that more emphasis should be placed on teaching students to both understand and then communicate statistical ideas and results. Both teachers of statistics and potential employers had listed an extensive range of skills which they would like service statistics courses to impart. Garfield (1995, p.27),

for example, put forward the view that students should be “adequately prepared to use statistical thinking and reasoning, to collect and analyse data, to write up and communicate the results of solving real statistical problems”. Kettenring (1995) claimed that industry needs statisticians who can work in teams and communicate effectively, while Bailar (1995) indicated that it is important for students to be able to use their statistics to deal with the major problems of the world. Radke-Sharpe (1991, p.292) stressed the value of writing skills in statistics, claiming that “the interpretation and analysis and the communication of results are equally important”.

CHANGE: NEW APPROACHES

In 1997 and 1998 we have trialed a new version of our service course in statistics that radically shifts the emphasis from calculations and formulae to understanding concepts, interpreting results and reporting both findings and conclusions. In our situation calculations are almost exclusively done using computer packages. The students have access to Minitab, SPSS and Excel, and learn to use whichever package they prefer for a given purpose. The course runs for 13 weeks with a total of 52 contact hours. Each week this consists of:

- one lecture where relevant concepts and assumptions are outlined
- one practical class in a computer lab
- one problem class, working with computer output from the practical class or other sources
- one discussion class as detailed below.

At the discussion class students are presented with a scenario motivated by a ‘real world’ problem, for example a report in a newspaper or magazine. In the early weeks students are exposed to various types of reports which include statistical information and are asked to explain what the writer is trying to communicate (see example 1).

Example 1:

Task A: Choice Supermarket article

Read the first two pages of the Choice article 'What the supermarkets are getting right'. (Reference: Choice September 1996 pages 14 and 15.)

- Explain what they are talking about when they refer to 'reality bars' in tables 1 and 2.
- Why do the bars have different lengths? Perform the calculations yourself for Coles and Festiva IGA to verify the results shown.
- Identify a pair of supermarkets within the same state for which there seems to be a genuine difference in satisfaction levels, and another pair for which there is no difference. Give reasons for your choice. Do not use the examples given in the article.

Task B: AGB McNair Age Poll

Discuss the results from one of the questions asked in this survey.

- Mention the method of polling and the sample size as well as the results.
- Note the statement at the bottom "The error margin that may apply to national questions given this sample size is approx 2%". What is meant by "error margin"? How did they calculate the 2%?
- How big a sample would be needed to reduce this error margin to 1%?

Later students are given background information, data, and computer output (which might include information that is not relevant or inappropriate). The students work in groups. Their task is firstly to study and discuss the problem. Next they select relevant and appropriate statistical output, discuss and interpret these results. They then have to write a report outlining the problem, the method of obtaining data, the results and conclusions (see example 2).

In addition to written answers each student must present a report to the class at least once in the semester. This class presentation is not formally assessed but is a hurdle requirement of the course. Encouragement rather than pressure was seen by the teaching staff as very important. Many students, especially those with mathematics anxieties, were very nervous and it was important that the class network acted as a support to students in such a learning situation. The end of semester exam required written reports based on a scenario and computer output.

Example 2:

It has often been asserted by both health officials and home cooks that plastic cutting boards are more sanitary than wooden ones. An article by Ak, Cliver and Kasper in the Journal of Food Protection (V57, 1994) looked at the accumulation of bacteria on different types of cutting board.

One experiment involved contaminating the surfaces of six samples of each of five types of cutting board with E-coli bacteria and then measuring the percentage remaining after two minutes.

Three wooden surfaces (birch, oak and maple) and two plastics (polypropylene and polyethylene) were used.

A preliminary analysis gave the following output:

(Students were given descriptive statistics, boxplots and ANOVA printouts)

Write a report on the output which includes the following points:

- Identify the independent variable or factor, and the dependent or response variable
- A comment on the results of the preliminary descriptive analysis
- The hypotheses tested in the ANOVA
- The validity of any assumptions for the ANOVA
- The p value and conclusion
- The type of cutting board you would recommend as a result of this experiment.

REFLECTIONS ON CHANGE

As the semester progressed, students became much more confident in their ability to both understand and communicate statistical results. In the final examination, most made reasonable attempts at explaining the results of a statistical problem in a practical context. Two focus group interviews were held with students several weeks after the completion of the first trial of this new course. Many participants commented on the difficulties of learning the new language of statistics, but said that the emphasis on writing and presenting reports helped them to master that language. While they had commenced the course with the common fear of numbers and formulae, they emerged with a more positive attitude:

"I thought I'd hate it to tell you the truth, but it turned out that quite a lot of the stuff was actually relevant!"

As statistics educators we are faced with many challenges. Statistics is taught as a service subject in many disciplines, and these client disciplines require students to be competent in a variety of skills and techniques. The curriculum is often crowded, and we must balance what we can achieve in a limited time. New technologies have given us the opportunity to review both what we teach and how we teach it. We must consider the relative importance of the different objectives of our courses. Now that there no longer needs to be an emphasis on the use of formulae and tedious calculations, we should grasp the chance to spend more time teaching students to understand the context of a problem, to find the relevant information from computer output, and to interpret the results in a report suitable for a non statistically trained audience. There should indeed be more reading, more writing, and less arithmetic in statistics classes.

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