USING STUDENTS' WRITINGS TO ASSESS THEIR COGNITIVE AND AFFECTIVE DEVELOPMENT IN AN ELEMENTARY ECONOMIC STATISTICS COURSE

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Comments on statistical articles in the popular press by first-year economics students studying statistics in Australia and South-East Asia are analysed. Three common weaknesses are described—lack of appreciation of journalistic style, disregarding statistical variation, and incorrect percentage statements. Differences between the groups are described and implications for teaching such courses are discussed.

This paper examines results from part of a first-year, one-semester, compulsory introductory statistics course taught in 1997 and taken by about 150 Adelaide and 300 Sepang students. Students at the Sepang Institute of Technology in peninsular Malaysia may study the first two years of an Economics degree from the University of Adelaide at Sepang, and then move to Adelaide to complete their course. There were two lecturers and four tutors in Adelaide and one lecturer and about four tutors in Sepang. I was one of the Adelaide tutors. The lecturer in charge, based in Adelaide, prepared all the handouts, assignments, and examinations, which were identical for both groups. All formally assessed marking was done by the Adelaide staff.

Data about students' cultural backgrounds are not collected, but personal experience suggests that the Adelaide group was fairly representative of a culturally diverse city, supplemented by 10–15% of visiting students, mainly from South-East Asia. The Sepang group were almost all Chinese, and about half had major difficulty with written English.

Each week students were required to attend two one-hour lectures, where the content of the course was addressed, and one small-group one-hour tutorial, where work done following from the lectures was discussed. Compliance by Adelaide students was not high. Formal assessment comprised one two-hour examination, a test of computing skills, and four class exercises spread throughout the semester. The second of these, quoted below, was analysed for this paper and was worth 5% of the total course assessment.

> Find an example of the presentation and use of statistics in a newspaper, magazine, journal or similar. Hand in a copy, suitably referenced to show the source of the extract, and discuss the following:
> - What information was the writer trying to convey?
> - How well did the writer convey the information?
> - Were there any short-comings in the presentation?

- What other methods of presentation would be preferable or useful?

Your answer should be short, no longer than 2 pages, typed (double spaced in 12 point characters). Marks will be allocated as follows:

- choosing a suitable article   1 mark
- commenting on the article   3 marks
- overall style and presentation of the project   1 mark
  (eg source stated, typed etc)

Assignment details were provided in Week 1, in good time for completion by Week 7, just after a two-week. By this time lectures had covered descriptive statistics, standard parameters, probability, the normal distribution, sampling distributions, and estimation and confidence intervals of statistical parameters. In the Week 4 tutorial ways of approaching the assignment were discussed, based on a newspaper article containing pie charts and pictographs. Almost all students chose suitable articles (with text written for lay readers and supported by tables and/or graphs) which could have yielded thoughtful essays based on the statistical ideas already presented in the course. For consistency I marked all essays from both groups, using a detailed structure based on the stated criteria.

This paper aims to describe what students' formal statistical writings (as opposed to statistical calculations) can reveal about their understanding of and attitude towards basic statistical ideas. Such an approach has clear limitations because there is no opportunity to follow up responses individually, and because students tend to write what they believe is wanted. Truran (1997) discussed this problem with respect to the answering of examination questions, but here there were fewer time constraints, less opportunities to use rote-memorised phrases, and more to use free expression than in computational answers.

For some researchers, e.g., Morgan (1996), such analysis is invalid because it is based on a transmission view of the nature of communication. Personal interviews or group discussions (Nicholson, in press) can certainly provide much additional information. So while the method used here has limitations for identifying what has been learned well, is very effective for identifying some of what has been learned poorly, especially when one's concern is with appreciating what misconstructions are possible within a group of students. The source of the misconstruction may still not be clear—

perhaps a textbook, teacher, or other "expert", or inherent in the complexity of the idea. Cognitively the source is important, pedagogically it is less so.

The approach to textual criticism used here follows three writers, all of whom see interpretation of texts not as the receiving of transmitted ideas, but as a complex activity requiring balance and breadth rather than literal reception. Grice (1975, pp. 45–46) argues that transmission of meaning involves co-operation between creator and interpreter. Usually they rarely meet, so co-operation is achieved by conventions about how both will behave. These are based on four maxims for optimal communication:

- Quantity: say enough, but no more;
- Quality: be as honest and accurate as you can;
- Relation: be relevant;
- Manner: be clear and orderly.

Kelly (unpublished lecture notes, Flinders University of South Australia, 1989) has argued that to achieve these maxims four sets of skills need to be used simultaneously:

- mastery of language system;
- world [i.e., contextual] knowledge;
- ability to think inferentially;
- knowledge of conventions of language use.

So the analysis should indicate students' abilities to make such skilled interpretations, and since they received little formal assistance in developing this skill, it should provide a fair indication of their usual practice. My task, as marker and commentator, is to identify and describe their practice. To do so I use the ideas of *connoisseurship* and *criticism* proposed by Eisner (1985, ch. 6, esp. pp. 104–105). "Connoisseurship … is that art of perception that makes the [appreciation of complexity] possible. Connoisseurship is an appreciative art. Appreciation in this context means not necessarily a liking or preference for what one has encountered, but rather an awareness of its characteristics and values". In criticism "the critic aims at providing a rendering in linguistic terms of what it is that he or she has encountered so that others not possessing his level of connoisseurship can also enter into the work". For Eisner "[g]eneralization is possible because of the belief that the general resides in the particular and because what one learns from a particular one can apply to other situations subsequently encountered. … Artistic approaches to research … attempt to shed light on what is unique in time and space while at the same time conveying insights that exceed the limits of the situation in which they emerge (p. 193)." Such practice is, of course, much the same as the students were applying to their essays.

Some claim that this critical textual analysis is trivial: unworthy of a research report because good pedagogues do it routinely. Some good teachers undoubtedly do. Many lack the time, and in any case it is best done from a background of formal training in mathematics education rarely possessed by tertiary teachers of statistics. The method is efficient and economical, it encourages remedial action, and is of special value for to teachers working in a non-interactive teaching environment, because it looks more at the *teaching* than the *learning* of statistics, in so far as these may legitimately be distinguished. What is more, the findings are rarely mentioned in the relatively limited statistics education literature. It is not a trivial exercise to identify problems and disseminate one's findings.

SOME SPECIFIC EXAMPLES

Given the limited space available, I concentrate mainly on students' statistical interpretations. The first issue was found mainly among the Sepang group (identified below as "S-XX"), the second was common in both groups, the third is an example of how thoughtful work may still use no more than lay knowledge.

Concern about Lack of Graphical Precision

Many students, especially from Sepang, were concerned that the graphs did not provide exact data or simple presentation. For example, one Adelaide student of Chinese origin (A-WD) who chose an article on seasonal youth unemployment illustrated by a line graph commented "the figure which it showed was only an approximate number, it is not the actual number of unemployed youth. … The point (dot) on the graph did not clearly show the number of unemployed youth, the reason for this is that because we (as reader) cannot see the actual amount it is showing straight away. We have to look closely at the graph." Students expected high levels of precision. Thus S-LTX wrote "the height for the area of property departments is actually half a millimetre higher than the height for the area of sales tax. Thus readers may get the idea that the percentage of revenue contributed by both of the sources is the same, without measuring the height of both the areas precisely."

Other students were concerned when two graphs were superimposed, with scales on each side, then the structure was too complex to be of value. Thus S-DZG wrote "the combination of two types of graph that is the stack bars and the line in the same diagram is not suitable. This is mainly because employment by sector and unemployment statistics

do not have a same unit. Therefore, they have to be represented in two different Y-axis. readers may find it troublesome to refer to two Y-axis on both side of the diagram."

Disregarding of Statistical Variation

Many students had difficulties in understanding what might reasonably be deduced from a sample statistic. For example, one student (A-LI) examined an analysis of Australian teenage smoking habits and observed that "The major flaw in this article is that it is entirely based solely on *estimated* statistics. Though the statistics are given some credence since they were sample by the Australian Bureau of Statistics."

More seriously, many students failed to recognise the inherent variability of sample parameters, or of population parameters from year to year. Thus S-UZT looked at data giving percentage pass-rates for children in peninsular Malaysia for two consecutive years. The article claimed that there had been an improvement in all states. Although S-UZT made sensible critical comments, he totally disregarded the facts that the percentage differences were small, some were falls, and some variation is to be expected from year to year.

Thoughtful, but Untechnical Responses

The following example from a thoughtful response highlights the issue of not using taught skills in a different way. A-QN, from a poultry industry family, wrote: "The table does not give the reader the number of birds in each flock. … Do the 'high' and 'low' figures represent the number of eggs laid by a hen or a flock? … The article also does not tell us if the strain of hen used is the same in each flock. …" All of these comments are apposite, probably partly because the student had "ownership" of their material (e.g., Boaler, 1993). But this should not prevent us from noting that this student has also not applied relevant taught technical skills to his comments. This assignment met many of Boaler's criteria for ownership; QN was one who made the most of this opportunity, but although his essay was good, its omissions suggest that ownership is not enough. I would argue that one function of education is to teach students how to approach problems in which they have little interest.

DISCUSSION

Researchers have examined students' interpretation of graphical presentation (e.g., Moritz and Watson, 1997) and also technical difficulties they have in presenting graphical statistics (e.g., Li and Shen, 1992). Pitcher (1989) and Watson (1992) have provided

examples of how a simple statistical summary may be used as a basis for deep analysis. Haack (1979) has argued that statistics should be taught as a language and N. and E. Smeeton (1984; 1985) have proposed ways of integrating statistics with the teaching of English. These ideas seem rarely to have been taken up, even though there is great interest in activity-based statistics teaching which requires written statistical reports. A search of *Teaching Statistics* and *Journal of Statistics Education* suggests that there has been little specific concern with how students read popular statistical reports, even though it is probably the most general statistical skill required by non-specialists.

This paper has described two difficulties which students encounter when reading such reports. The first is a failure to apply principles taught in class to critical writing. Students disregard the Quality maxim of the Grice/Kelly model by not using all of their mastery of the statistical language system. Since many did apply principles learned about non-deceptive graphical presentation, they did realise that they were expected to link principles to their written critiques. Perhaps they had learned about graphical deception in the past, and hence found it easier to apply, but this possibility needs to be tested.

The second difficulty, which was found more within the Chinese culture, was a concern for a very high level of graphical precision at the expense of communicating the big picture. Tang and Biggs (1996, pp. 169–170) have argued that Hong Kong Chinese students are not concerned with self-expression and communication when writing for assessment, even though they will do so in other situations, and suggest that this is partly due to their limited command of English. While many Sepang students had poor English, they tried hard to communicate their ideas, and were often successful, albeit in stilted prose. Many criticised (often in strong terms) genuine errors in graphical presentation and often provided improved versions. But they seem to have been unaware of the special conventions of language use applicable to the popular press. It is likely that deterministic teaching in the past has inhibited them from appreciating that journalists need to present the big picture and will use a more flexible language system than formal textbooks. Many Sepang students saw this as deliberate dishonesty. Similarly, they saw inaccuracies such as scales not starting at 0, not as faults arising from ignorance or carelessness, but as deliberate attempts to deceive. So for many of these students Grice's co-operative relationship between writer and reader was notably missing. This understanding and acceptance of differing literary *genres* has not been discussed by Watkins and Biggs (1996), but is clearly significant in this context and is a good example of the need to ensure that both cognitive and affective issues are addressed in the teaching of statistics.

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