Teaching Introductory Statistics at Tertiary Level : A Shift in Emphasis

Peter Martin - Ballarat, Australia

1. Beyond the chalkboard

The teaching of statistics at the tertiary level has traditionally taken the form of a "chalk-and-talk" or "stand-and-deliver" approach. Such an approach assumes that provided the material is all delivered to the air, a piece of paper, overhead transparency or chalkboard, then transfer to the student will take place and understanding and interest will occur within the recipient. The implied behaviourist model of learning suggests that knowledge is transmitted from the lecturer to the student and is constructed in a framework quite separate from the learner. Ellerton and Clements (1990) argue that in such circumstances the students will see the teacher and the textbook writer as being the controllers of their mathematical destinies.

Current thinking with regard to communication and mathematical learning, combined with recent political trends and technological developments, is casting very serious doubts upon the effectiveness of the traditional lecture method of instruction. Adler and Rodman (1988) reported a study conducted by Paul Cameron who found that only 20% of students were actually paying attention to his lectures and, of these, he found 12% were actively listening. The process of communication between people is very complex, and at any level there is a large number of variables which may affect the message that a sender wishes to communicate to a receiver. In situations where students are expected to take a passive role in learning it is highly probable that most are not taking part at all.

Throughout the 1980s government policies and decisions at both state and commonwealth levels have sought to increase senior secondary school retention rates. One of the obvious effects of these increases in retention rates in Australian secondary schools has been the change in the range of ability levels of students in years 11 and 12. Given that more of these students are now entering the tertiary sector, what are we doing to provide for such an increasing range of ability levels?

The 1989 Discipline Review of Teacher Education in Mathematics and Science (Department of Employment, Education and Training) emphasised the need for increasing the overall numeracy of the Australian people, in particular, skills associated with data analysis or statistics.

> "Statistical data analysis forms the basis of advertising, and of environmental, economic and social forecasting and policy development. Ultimately, it affects the lives of all Australians individually and collectively." (Vol 1, p8)

The assumption here is that we can expect an increasing number of students studying statistics. Many of these students will probably study the minimum required in some service course. Again the question needs to be asked: How will the traditional "stand-and-deliver" method of lecturing measure up?

Leontiev (1981) distinguishes between actions and operations in his discussion on activity theory, describing operations as automated strategies performed without intellectual effort - a technical means to an end. The seemingly endless formulae that we serve up to students of statistics would fit easily into the category above as defined by Leontiev, who goes on to say that the usual fate of operations is that sooner or later they become the function of a machine (Leontiev, 1981).

It is often said that we are currently living in an Information Age, or as Davis and Hersh (1986) suggest, we are "drowning in digits". The rapid technological achievements of the past ten years or so have given us an impressive array of computers, software packages and calculators that are readily available. Simple calculations through to complex statistical analyses are virtually at our fingertips. So, just how necessary is it for us to continue deriving and teaching our statistical formulae?

Here there is a comparison to be made with the emphasis given to the teaching of the algorithms of addition, multiplication, subtraction and division in the primary schools. Research has shown that people very rarely use the pencil and paper techniques taught at school. Instead they tend to use estimation, or calculators (Hope, 1987).

People wishing to analyse data today no longer have to calculate correlation coefficients or F-values, etc. These statistics, and many more, are readily available from software packages and calculators. What is required, however, is an understanding of the meanings of these statistics and their relevance to the data. There needs to be a shift in emphasis away from the development of operations as described by Leontiev, towards the provision of increased experience of statistical activity (Crawford, 1990).

2. Active learning

Many researchers now believe that knowledge is *actively constructed* by the learner. This occurs as the learner *reflects* on an interaction with both the social and physical environments. Educators, government bodies, business and industry groups, are now all calling for a shift in curriculum experience towards more active participation in learning for students.

At the 1986 International Conference on Teaching Statistics a number of speakers (Roberts, Speed, Glencross) presented useful ideas that could easily be incorporated into an activity-based approach to the teaching of statistics at the tertiary level.

Roberts (1986) argues that in order to become "intelligent consumers of statistics" the subject itself must be seen by the students as doing something useful for them. Roberts suggests that this is best attained by using student-generated data on a modest scale. This issue of ownership in education has recently been recognised as crucial. "If courses enable students to feel that they own their learning then they will accord greater value to what they have learnt, and are likely to be able to use it effectively" (Ellerton and Clements, 1989).

Glencross (1986) mentions that Skemp and Dienes remind us that in order for a person to learn a new mathematical concept they must meet it in a number of different situations made available through a suitable collection of examples.

At Ballarat University College we aim to teach our first year students in groups of less than 30, with each group having a similar academic interest, e.g. education, business, nursing, etc. This enables us to design courses which will be of relevance to the students rather than a general course with no specific application to their area of interest. The class size and teaching style takes into account the academic history of the majority of our students and in particular their predominantly weak mathematics backgrounds. It is important for materials to be locally developed with the need of the specific students in mind as these are more likely to be culturally sensitive and use appropriate language and notation (Ellerton and Clements, 1989).

A programme involving students in suitable statistical activities will require those students to measure and collect their own data. It will necessitate group discussion in planning and problem solving. Such a programme would be a more accurate model of what they can expect to experience in the "real world". There will be a need for concrete aids, for example populations to sample from and dice of various shapes. Preferably, there should be access to appropriate computing facilities both for simulations and statistical analysis of data. In planning such a programme it is important to keep these things in mind:

Class size: If the class is small, collecting data within the class may not yield sufficiently large samples to meet the assumptions of some inference tests, e.g. Chi-square, z-tests. If a class is very large then the logistics of the data collection must be well planned or too much time will be wasted.

Technical skills: Are the students able, for example, to draw statistical graphs, use statistical functions on the calculator, use computer statistical packages? Are the students able to read a mathematics/statistics textbook?

Strategic skills: Do the students know when to use their various technical skills? Which statistical concepts have they already grasped?

Organisation: Do the students know how to proceed with the investigation? What equipment, time, and space will be required for exploratory work in class?

It is also important to give students the experiences of working together in groups, gathering their own data for analysis and using concrete aids such as dice, home-made populations such as described by Glencross (1986), *before* introducing computers for simulation activities. If students are introduced to computer simulation too early, then they tend to regard it as some sort of magical "black-box" exercise. They will see the computer simulation as being quite divorced from reality, and therefore fail to appreciate the power and usefulness of this facility.

3. Lecturing and group work

Lecturing, backed up by tutorials or problem classes, has been seen as an efficient method of delivering the content of a large syllabus in a short amount of time. Even those who recognise that students would learn more from an interactive approach are worried that it would take too long and that they would not cover the required syllabus in the limited time available. Ruthven (1989) trialled an exploratory approach with British senior secondary students where this same pressure to cover a syllabus for examinations applied. He found that careful planning was the key to maintaining the rate of learning required:

> "Essentially this entailed spending much of the class contact time on exploration and codification of new ideas, with the majority of consolidation carried out in private study time - an established and important feature of study at this level. Equally homework was set regularly and marked to ensure effective feedback, but students were encouraged to refer first to texts and printed solution sheets, rather than expecting every aspect of homework to be gone over in class." (p457)

The ability of our students to read mathematical/statistical textbooks must be considered. This will particularly be a problem for those who "dropped" mathematics some years before. Time needs to be devoted to helping students with the required language and reading technique. In addition much care should be taken in the choice of text or selected references. If students are able to read the texts for themselves then class time may be spent in gaining some hands-on understanding of the subject. Ruthven also mentions the problem of some students being reluctant to "engage in exploratory styles of working". To help overcome this problem Ruthven suggests several pedagogic skills he believes are necessary:

> "... giving students the opportunity to think for themselves, but providing appropriate stimulus or support where necessary; helping groups to work constructively together, and individuals to participate effectively in groups; gathering ideas from students and identifying critical issues for clarification at the later codification stage." (p457)

We introduced hands-on simulations, group work, student-generated data, a higher level of student involvement and discussion in class, but all of this was within the structure and order of the usual course outline. Therefore, the order of learning and questions addressed were imposed on the student. If students are to gain interest and understanding then perhaps we must allow them to pose more of their own questions in the areas of study that are of interest and relevance to them. Speed (1986) impresses on us the importance of learning to ask the right questions before starting to collect or analyse data. Framing the questions may be just as important a learning exercise as obtaining data and "doing" everything to it that you can think of.

Emphasis in any activity-based programme should be placed upon getting the students to work cooperatively in small groups of four or five. Opportunities should be made available for preliminary discussions, as well as for reflection upon the results obtained. Also, it is important for everybody to share their methods and their findings because, as Crawford (1990) states, "in any group activity different actions may be taken to reach the same goal, or, the same observable activity may meet different needs and enable students to meet different goals". We all need reminding that often there is more than one way of completing many statistical investigations. By sharing problem solving strategies in statistical activities we may gain a fuller understanding of what our students know and do not know. Only then are we in a position to be able to guide them effectively towards becoming what Roberts refers to as "intelligent consumers of statistics".

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