PANEL SESSION: TEACHING STATISTICS – MATHEMATICAL OR PRACTICAL MODEL

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Introduction

This paper discusses two models of the process of teaching statistics, the mathematical and the practical, in the context of tertiary level service courses. By "service courses" I mean courses given for purposes other than the training of students to become professional statisticians – courses with names such as Statistics for Psychology, Quantitative Methods in Forestry, and so on. Their market is students who may need to analyse data, or understand and criticize someone else's analysis of data, in some other area of study. They offer their students a key to numeracy, and thus full competence in their academic speciality. To the statistical profession they are ultimately the main form of PR (Public Relations activity). As things are, unfortunately, much of this PR is negative.

The mathematics associated with statistical theory is often blamed for this negative PR. While this may be partly true, I submit that the mathematical model of teaching must bear a large part of the blame for putting students off statistics.

The Mathematical Model Described

The mathematical model of statistics teaching takes its name from the approach almost universally used by university mathematics teachers. This may be styled simply as "teaching by theory and an opportunity for students to engage in a dialogue with teachers about the content of lectures." In practice, students are usually not well prepared for such dialogue, as they have comprehended but little of the lecture material. Further, most tutorials are taught by postgraduate students who have little experience of, and no training for, teaching. Consequently, many tutorials closely resemble lectures – with the tutor giving information and the students writing it down. The tone tends to be formal, and the students passive.

The most important medium of instruction is the problem sheet – a weekly list of problems to be attempted by students. It is important because it defines the course in operational terms for the student, and is the focus of most of the attention the student devotes to the course. Further, the examination at the end of the course is but a "super" problem sheet attempted under exacting conditions. Its emphasis is on ability to "do examples". Some questions may ask for exposition of theory, but usually these are set-pieces requiring recall of lecture material – known as "bookwork".

Rationale

The rationale or underlying educational theory supporting the mathematical model is seldom discussed. Perhaps it is thought that explication of the model is unnecessary. The following "water supply" examples, but for a better description it is useful to consider the roles of the lecture, the tutorial and the problem sheet in the mathematical model.

The lecturer is a source of knowledge and wisdom and an organizer of mathematical ideas. In 50-minute stretches of continuous monologue, writing and sketching he reveals a pattern he has imposed on mathematical topics. The subject matter is theory and illustrative examples. He may also give a rationale – a running commentary explaining why the present topics are worthy of study. In service courses in statistics providing a rationale is difficult: there is a tension between getting through a list of statistical topics and relating these topics to possible applications.

The lecturer's monologue proceeds at a conversational pace, which seems to assume that the students are following and understanding. Yet this is rarely the case. The students are kept busy taking down the notes the lecturer writes on the blackboard, also at a fast pace. The joke that information passes from the lecturer's to the students' notes without passing through the minds of either party is sometimes not far from the truth. And the lecturer and the students know this.

Tutorials, in Australian universities, are small-group teaching sessions which supplement lectures. Usually there is one tutorial per week, and either 3 or 4 lectures. In theory, tutorials provide theory, though a caricature, may not be too inaccurate.

Knowledge is fed by gravity from a central reservoir (the lecturer) directly to individual containers (students), and indirectly via holding tanks (tutors). In the containers a permeable barrier separates the open delivery compartment from an inner compartment, so that the knowledge evaporates and percolates at the same time. That part of it which reaches the inner compartment is said to be learned. Problem sheets are provided as tools for puncturing the barrier.

In this theory there are three explanations for student failure. First, excess evaporation. The student has through lack of effort failed to become acquainted with enough of the knowledge provided. Second, inefficient percolation. Though the student may have worked, his learning strategies are inadequate. Third, lack of space in the inner compartment. The student lacks the requisite intelligence. Similarly, there are three explanations for student success.

Corollaries of this theory are that

- student learning is essentially a passive process
- student learning happens on an individual basis
- knowledge flows in one direction, and
- teaching strategies are irrelevant to outcomes of the process.

Popularity

The mathematical model remains popular in statistics service courses for two reasons. One reason is tradition, or inertia. Most statistics teachers are mathematically trained and tend to use the only model of teaching with which they are acquainted.

The other is that teachers see the mathematical model as efficient. It enables them to "cover" a wide variety of techniques – to provide an all-purpose statistical tool kit. The use of mathematics-style "examples" avoids the risk of becoming bogged in "dirty" data or problems which are poorly defined or open ended. Time is not "wasted" on defining, collecting and recording, on reframing questions or redesigning experiments.

But this efficiency pertains only to delivery, not to absorption of knowledge. With students unaccustomed to mathematics teaching evaporation rates can be alarming.

Further, it does not pertain to retrieval of knowledge for later use. Many students who succeed in statistics service courses are unable in later years to match a standard technique to a data-analysis problem arising in some other area of study. Typically, such students have survived their statistics courses by matching problem sheet questions with archetypal examples from texts or lecture notes. Though they find using this technique is difficult, they prefer it to the impossible task of understanding the lecture material. While this method is useful training for statistics examinations it fails with "real-world" problems, which rarely come supplied with exactly that information necessary for their solution, neatly laid out.

The Practical Model

Problems requiring the use of statistical techniques arise in many fields of study. Using the practical model means aiming to teach statistics by addressing such problems in the contexts in which they arise. At present this model is not widely used. In proposing it as an alternative, this paper hopes to encourage experimentation in statistics teaching.

Beginnings

The idea of a practical model is not new. C.R. Rao (1970) describes its use with B.Stat. students at the Indian Statistical Institute in 1960. "The first problem set to the class was how to anticipate the Registrar General and predict the population [of India] in 1961 in advance of the census". Later, "students were sent to a maternity hospital to obtain information on the sex of successive children born, during certain periods of the day over a number of months." These practical exercises gave rise to consideration of theoretical models. Rao called this an "interdisciplinary approach". Statistics teachers using the practical model will inevitably have to venture across boundaries into other disciplines.

Rao (1974) states this in strong terms in a paper on statistics teaching at the secondary school level:

> *In my opinion statistics should not be taught as a separate discipline . . . We have to develop special methods of teaching, which provide opportunities to impart knowledge of statistical methods while guiding a student to think through a real problem in some discipline. Early experience in determining what information is relevant to solve a given problem, collection of data which contain the desired information, critical review of data and, processing of information will be of great value to an individual whether he becomes a scientist or a technologist or an executive.*

Rationale

A student of statistics in a service course would find such experience "of great value" because he/she would

- make mistakes, and thereby learn, in many more ways than are possible under the mathematical model,

- see statistical techniques working in natural contexts,

- collaborate regularly with other students during class time and, most importantly,

- be active in the learning process.

Difficulties

Various administrative and teaching arrangements for a course on the practical model are possible. They would all, however, cost some effort, both administrative and teaching, to set up and run.

The trade-off between the extensive "coverage" of the mathematical model and the useful experience of the practical model must be considered.

Strategies (in Conclusion)

A wholesale change to the practical model could involve abandoning the lecture-tutorial-problem sheet superstructure of the mathematical model in favour of co-operatively taught practical problem-solving sessions – but it is hard to imagine such a change occurring suddenly. What may be possible is incremental change through small, experimental departures from the mathematical model. The revolution in data processing technology is bringing its own changes. I commend to you the challenge of harnessing this technology in the service of courses designed on the practical model.

References

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