Future Directions for the Teaching and Learning of Statistics at the Tertiary Level

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1. Introduction
At the tertiary level the last 40 years have seen significant advances in theoretical aspects of the Statistics discipline. Universities have been outstanding at producing scholars with a strong theoretical background. However, questions are increasingly being asked as to whether this has been somewhat at the expense of appropriate training of users of Statistics.

More recently, advances in Information Technology (IT) have resulted in a much more data-based society, a trend that we can expect to continue at an accelerating rate in the foreseeable future. The IT revolution has already had a very real impact on the Statistics discipline including the training of both professional statisticians and users of Statistics, and will continue to result in profound changes both in course content and in course delivery. Major research directions have also evolved during the last ten years, directly as a result of advances in IT. Now is the time to be thinking about requirements for the future training of statisticians, taking account of what their needs will be, what methodologies will be available, and how best this training might be done, in the next 5 to 10 years, let alone two decades. At the same time, we need to view the totality of changes, and our responses to them, as an evolving process which, on the one hand, recognizes that changes cannot take place faster than society can absorb them and which, on the other hand (from our own ‘selfish’ viewpoint) we shall seek to manage in maintaining Statistics as a recognized discipline. To help in achieving this, there is a vital role for Continuous Quality Improvement (or CQI, see Hogg 1999) of the teaching and learning process.

It might have been expected that with the impact of IT leading to a much more data-based society, the Statistics discipline would have experienced a dramatic increase in demand for its graduates and for more basic training (or service) courses in Statistics. Since this has not happened, at least to any notable extent, one may ask why not? The failure of the profession to train its graduates to communicate effectively, and the failure of the profession itself to have the discipline accepted as a truly professional activity, might be regarded as an indication of the lack of recognition of the importance of communication skills (both written and oral) by the discipline.

Other professions have introduced, had accepted, and indeed had recognised in the public arena, professional certification or accreditation. Only in the last few years has this commenced in Statistics (e.g. the Royal Statistical Society and the Statistical Society of Australia Inc.). If the discipline hopes to gain the recognition required to exist into the future, this direction must be pursued by relevant national and international Societies and Associations. Certification or accreditation also provides another goal to which Statistics graduates can aspire.

Given the foregoing context, this paper is concerned with the contention that satisfying the needs of society as well as meeting the needs of the profession are the basic determinants that will drive the future teaching and training of statisticians at the tertiary level.

2. Concerns for the Future
During the last decade there has been significant concern expressed about the future of the discipline. Recent American Statistical Association presidential addresses by Hunter (1994), Iman
(1995) and Kettenring (1997a) all relate, in one way or another, to the future of the Statistics profession. Similar concern is also reflected in addresses to the Royal Statistical Society by Bartholomew (1995) and Smith (1996), while Cox (1997) has concerns relating to the risk of the fragmentation of the Statistics discipline.

From a teaching and learning perspective, Iman (1994) and Kettenring (1997c) have discussed threats to the future of ‘stand alone’ Statistics departments. Moore (1997), (1999) raises many issues of concern in statistical education, and together with Higgins (1999) and Hogg (1999) consider changes which should be implemented to enable students to receive training which is both up-to-date and relevant to society’s needs. There is a recognized need to interact with other closely related disciplines (Kettenring 1997b, Friedman 1997) but this must be in such a way as not to lose our identity.

3. Statistics as an Evolving Discipline

Historically Statistics had its foundations in Mathematics and was considered as probabilistic inference based on mathematics. Up until the late 1960’s, lack of suitable computing hardware and software resulted in Statistics courses being very much of a theoretical nature. As noted by Nicholls (1999),

‘.... the early 1960’s tables of logarithms and slide rules were the tools used for calculation. This was followed by mechanical calculators, programming using punched cards, DOS based PC’s, software requiring the writing of code, to the current menu driven software packages of today. Four years ago the World Wide Web was virtually unknown; four years on it is providing for network based statistical analyses.’

This dramatic change in technology has resulted in a transformation from the production of graduate statisticians in the 1960’s and 1970’s with strong mathematically based theoretical backgrounds but with little practical experience to graduates today who have had the opportunity to be exposed to realistic data analyses. Indeed, from the point of view of the training of both professional statisticians and periodic users of Statistics, the pendulum is in danger of swinging the other way, particularly for the latter group. With the ease of use of menu-driven statistical packages now available, the periodic user can carry out technically difficult analyses with little understanding of what is being done. From a training point of view, whereas students were once given the theory but didn’t have the computing facilities to apply it in practice, they now have the computing resources to undertake technically difficult analyses without the formal theoretical background to understand what’s been done, at a technical level. Achieving an appropriate balance between the theory and application will be a major challenge into the future.

4. The Impact of Information Technology

The single phenomenon with the biggest impact on both research and teaching in Statistics has unquestionably been the development and ready availability of IT hardware (and software). As a result of these developments previously computationally intractable areas of research have become possible. Examples include nonparametric curve estimation, resampling methods, modelling and analysis of financial data, neural networks, wavelets, data visualization, data base management and data mining. As Nicholls (1999) states

‘While new research areas have developed as a result of technological advances, it is unfortunate that statistics researchers (other than a few individuals in each case) have not pursued a number of these and worked in with other disciplines such as computer science (eg data base management and data mining).’
This concern is also recognized by Friedman (1997) and Kettenring (1997b). While there is no question that statisticians must collaborate and be involved in other disciplines, including IT related areas, it must be in such a way that they are there as ‘equal partners’. In many disciplines the statistician is seen as ‘the person who analyzed the data’ rather than as a significant contributor.

From the point of view of teaching and learning, while there have been enormous benefits, particularly in terms of the sophistication of analyses that can be undertaken by students as a result of user-friendly software, there are also downsides. For example, time is now spent introducing students to appropriate hardware and software, with a consequent reduction in time available for actually teaching Statistics. What then should be removed from syllabi? This issue is addressed at by Moore (1997) and by the discussants to that paper.

The conflict of depth versus breadth (of course and unit content) in the training of applied statisticians will always exist in a discipline that is ever evolving. The increasing influence on statistical theory and practice of developments in IT will serve only to make matters more difficult. This alone provides compelling evidence in favour of introducing the process of CQI proposed by Hogg (1999), to continually review course content and delivery to meet the demands of society.

Whilst technology should serve course content (and its pedagogy), it is particularly true of Statistics that technology has changed course/unit content, and made possible new forms of effective learning. As more tertiary institutions come ‘on-line’ with video conference links (and associated facilities) and courses are made available through the Internet, it would make good sense for units offered between universities to be rationalized, particularly at those levels (e.g. senior undergraduate and graduate levels) where class sizes tend to be small and as a result courses expensive to deliver.

5. Communication

The recent special section in The American Statistician (Vol 53, 1, 1999) titled ‘Undergraduate Statistics Education: What Should Change’ identifies communication as a major problem for the profession (also see Nicholls 1999 pp. 906-909). There are two aspects to this problem:

(i) The failure of the profession to communicate the relevance and importance of Statistics to non-statisticians. This is evident in many universities, where Statistics departments are continually under the threat of amalgamation with other departments and are not seen as true ‘stand alone’ academic disciplines. Statisticians are often regarded as either mathematicians or users of mathematics’, rather than as people possessing distinctively different and important skills. With the dramatic changes that have taken place in our discipline in recent years it is imperative that we communicate what we have to contribute and establish the discipline (in the minds of non-statisticians) as a truly recognizable and essential profession. Professional statistical societies have a leading role to play here, here in the development of accreditation or certification processes, together with continuing professional development programs for its members. Schemes such as these will certainly help to lift the profile of the profession and this will flow through to the student body. One challenge is to determine what the ISI can do in this regard, indeed, what should the ISI do?

(ii) The teaching and learning process at the tertiary level generally fails to teach Statistics students how to communicate with others, particularly with non-statisticians. This is a major failing in our current training of students, regardless of whether they are being trained as academicians, professional statisticians or users of Statistics. The subject is replete with jargon and concepts that are comprehensible to statisticians but are generally incomprehensible to others. The existence of the jargon and concepts must be accepted as a fact of life. What mustn’t be accepted is that the only way to communicate with non-statisticians is using the same language and ideas. We must train our students to find plain language and vivid, apposite imagery to convey vital statistical information.
6. Conclusion
Tertiary teaching programs in Statistics are aimed at three groups, potential academics, potential professional statisticians, and those who want to have an awareness of Statistics and to make some limited use of Statistics. If Statistics is to survive “two decades” into the next Millenium, two things must occur. Firstly, everyone involved in providing these programs will need to be attuned to the dynamic and evolving nature of both the discipline and its pedagogy, and particularly to the way information technology is driving the changes. Continuous Quality Improvement will have to become a way of life. Secondly, we shall have to learn how to communicate to others the vital role that Statistics plays in all aspects of life.

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8. References
Holden - Day. San Francisco.