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TEACHERS OF STATISTICS: NEEDS AND IMPEDIMENTS

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Abstract

If someone is to teach mathematics, there is a reasonable likelihood that they will have attended courses not only in mathematics itself, but also on how to teach mathematics. In contrast, relatively few teachers of statistics have received adequate training in the statistical equivalents of these areas. For a variety of reasons, some of which are outlined, this state of affairs is persisting. Possible remedies are discussed, and some specific examples of steps that have been taken to improve the situation considered.

The nature of the task

Statistics teaching has many in-built challenges. Statistics itself is not a fixed entity. It is a discipline encompassing an increasing range of approaches and perspectives to obtaining, to handling and to interpreting data. Its recent developments have been accompanied by dramatic changes in the technology that is available for carrying out these activities. Teachers are expected to provide general statistical literacy for all students and specialist training for some, and to produce understanding and skills that will continue to develop as statistics itself develops. Perhaps most important is the need to provide specialists and non-specialists with the means of communicating with each other, so that they may interact effectively and exploit their different areas of expertise.

The ubiquitous nature and scope of statistics means that teachers face the task of teaching statistics to all-comers, across a wide spectrum of applied areas about which they themselves have no specialist insights. Indeed, it is possible for a mathematics teacher, using an example of relevance to biology, say, to find that the students know more about the context of the question than he or she does. Cross-curriculum approaches could alleviate the problem, but are relatively rare at secondary school level where teachers are locked into a rigid timetable.

Teaching a student the necessary mechanical procedures to draw a graph, or to work out an average, is relatively easy compared to the task that faces a teacher of statistics who must teach that student *when and how to use* that

graph or that average. Teachers of statistics need help in finding out how best to achieve the desired quality of learning despite being constrained by overcrowded syllabuses, and assessment programmes, that press them to emphasise the mechanical processes. Mike Shaughnessy (1996) alluded to the need for research into instructional strategies. Likewise, Kath Hart (1996) felt the need for research to ensure that guidance given to teachers was robust and reliable.

The difficulty is that this type of understanding is less tangible, more sophisticated, and qualitatively different from the computational facility that is conventionally developed in the early stages within mathematics curricula. Bradstreet (1996) recommends that statistical reasoning should be taught before statistical computation; that we should provide a *working* understanding of statistical techniques without first teaching them as computational exercises. However, this is not necessarily easy for teachers to do, especially if they themselves are insecure with statistical reasoning. Indeed, if they have had statistical training as non-specialists, they will typically have had very little time to be otherwise. As Bradstreet says - 'How much can one achieve in a mere twenty hours?'

The students

The students are often resistant to the idea that they need to study statistics, and may react with resentment and other signs of lack of motivation. Often, too, they are suffering from acute or chronic anxiety at the prospect of having to take a course in statistics to which they feel unequal.

Teachers' backgrounds

Statistics teachers often lack adequate training in statistics, and almost certainly lack training in how to teach it. One of the things that emerged from the 1988 International Statistics Institute (ISI) Round-table conference on *Training Teachers to Teach Statistics* (Hawkins, 1990) was that it is just as urgent for us to find ways to teach *teachers* statistical methodology as it is for us to find ways for them to teach their students. In fact, the same pedagogic insights and developments may be useful for both groups. This is something that has been exploited to good effect in the cascade models of teacher training adopted by the Quantitative Literacy Project, for example.

However, the distinction (if there is one) may be that *teachers* have had more opportunities than their students to be on the receiving end of bad (teaching) experiences as far as statistics is concerned. For specialists in 'user'-disciplines, the result may be a sort of *statisticaphobia*, a feeling that statistics is mathematics, and hence a lack of confidence in their ability to deal with it. Ironically, there are many mathematicians who also display a

different, but equally debilitating, sort of *statisticaphobia* - not because they fear the mathematical underpinnings, but because they feel that they cannot cope with, and hence communicate or manage, practical applications of statistics.

Teachers vary greatly in the amount and type of *formal* statistical training that they have encountered. It is always dangerous to generalise, but older teachers tend to have had less formal statistical training, especially the 'user'-discipline specialists. For such teachers, the increase in quantitative content and methods in their discipline may have been a later development, one that occurred after they finished their formal subject training.

The degree to which statistics has been *integrated* into their subject will also have varied. We still hear 'horror' stories of service teaching that is too abstract for students who lack the necessary fluency in the language of mathematics, and that appears to ignore, and therefore to be unrelated to, the natural context of the applied discipline concerned. On the other hand, there are still teachers who say that they learnt statistics in the context of their discipline as a series of technique classes, week by week, so much so that they never acquired an overview of the subject. The sort of statistics teaching tied to weekly practical classes in a course in experimental psychology is an example of this type of recipe-driven experience.

Those who have studied statistics as a specialism in its own right, and who go on to become academics teaching other specialists, may never have experienced the problems associated with teaching non-specialists. They therefore tend to perpetuate the teaching methods that they experienced as students. Few spontaneously seek new ways of teaching, or address the issues associated with course content and structure. For many, there is no reason to change, nor awareness of changes that have taken place elsewhere. Without courses in how to teach, how are such academics going to stumble across different ideas, or be motivated to look for them?

Teachers, like their students, also acquire some of their statistical understanding from informal media sources. As reliable sources of statistical education, these rate low. It is easy to collect examples of bad journalistic use of statistics. We sometimes do this for use in teaching our students. This is fine for teachers who are able to spot the flaws, but it requires more than a modicum of statistical training for people to be sensitive to the sloppy, misleading and frankly incorrect reporting of statistical information, rather than being merely passive assimilators of its style.

Syllabus/curriculum considerations

The place of statistics in the curriculum is ambiguous, and there is not really a consensus of opinion about its nature. Also, as Jane Watson pointed out (1996), the question of who is ultimately responsible for developing statistical literacy is not always a simple one, with teachers assuming rightly

or wrongly that this is being done somewhere else in the students' curriculum, and that there is not time or space for it to feature within their own teaching.

Sometimes statistics is thought of as being of secondary importance compared to the main curriculum disciplines, and there is consequent pressure on its teachers to spend less time on it. Meanwhile, the statistical content of syllabuses continues to expand to accommodate new techniques (often accompanied by additional theory to support these developments).

A national curriculum *can* be a means of bringing about progress - In the UK, 'Statistics for All' could probably not have happened without the National Curriculum, which also motivated some in-service teacher-training. However, as David Vere-Jones (1996) points out, a national curriculum can also be a power to constrain, and even to repress, policies of statistics for all (or beliefs that statistics is an essential part of literacy), if these appear not to be in the best interest of the government. Vere-Jones (1995) also discusses the role that mathematics education (and hence presumably statistical education in some contexts) continues to play in encouraging, or in some cases enforcing, socio-economic divisions in certain contexts and cultures.

Assessment issues

Frankly, examination syllabuses, examination papers and examiners' reports can be misleading for teachers. Marks are given to certain aspects which are then perceived by teachers to be important features of statistics, whereas they may in fact be merely the means of ensuring that weaker candidates do get some marks!

Errors on the part of examiners are not unknown, and the knock-on effect of incorrect examiners' reports on teachers' understanding of statistical principles (and that of their students in subsequent years) can be catastrophic. Moreover, Examination Boards can be very reluctant to admit it when they have made a mistake.

Resources

Access to relevant technology, computer hardware and software is patchy and, on an international basis, is often most lacking in those places where alternative teaching resources are also most stretched, i.e. where it could be most useful. Furthermore, teachers need training in the use of such resources. It is the very *variability* of experiences of statistics and statistical education, resulting from uneven provision of resources (in physical, personal and personnel terms), which is so worrying.

There are many textbooks available - some good, some less so, and some that are frankly bad, either in the general messages conveyed or the inaccuracy of their contents. Reliable reviews are needed, both in terms of the technical correctness of texts and other materials, and their appropriateness for the

level and context, and also from the point of view of their usability. How else are inadequately prepared teachers to sort the wheat from the chaff and enhance their own understanding from 'good' rather than 'bad' sources?

Influences for change

Traditionally in tertiary education, the lecturer was master or mistress of the classroom process. Students took what was offered (or voted with their feet) thereby risking, or in some cases enhancing, the likelihood of passing their exams. There was little effective pressure for change of approach, etc. Thus an in-built conservatism was encouraged. However, as the provision of tertiary level education becomes more competitive and subject to market forces; as lecturers are confronted with a broader range of students, in an educational climate that has given students a louder voice, and a more active part in shaping the educational process; and as peer review evaluates *teaching* as well as *research* performance; lecturers are becoming more open to change. Their classroom doors are opening, and what goes on inside is becoming more public. This is resulting in a raised level of awareness of developments in statistical education, in terms of both teaching content and also teaching methods. This process has started in England, although it is still in its infancy. Future generations of statistics teachers can, however, be expected to be qualifying with at least a *little* more appreciation of how statistics can better be taught than in the past.

In the United Kingdom recently, the 'climate' has become more right for statistical education. Controversies such as the BSE ('Mad Cow Disease') scare have meant that the general public are on the receiving end of more 'statistical sounding' arguments from Press and politicians. The diversity of conclusions being drawn from the same information has generally raised people's awareness of the needs to understand *risk* and to be able to interpret probabilistic statements if they are to make informed life choices.

Sources of support

Initial training courses in statistical pedagogy remain few and far between, and suffer by being in competition for time with what are perceived to be more main-stream curriculum areas - maths (other than statistics), science, etc. In-service courses are also not easy to find and to access in the UK in the current economic climate, but certainly the 1988 ISI Round-table recommended that the emphasis should be placed at the in-service (rather than at the initial training) level, in what was recognised then as a crisis situation. The format of such courses can vary, and can include distance learning courses like those offered by the Open University and Sheffield Hallam University, teacher moderation exercises, cascade models, etc. Short courses on specific topic areas, or on managing practical project work, are

also frequently requested by teachers and, in the UK, there is *some* provision in response to this.

The Internet can also provide opportunities for distance learning, as well as for interacting and exchanging experiences with colleagues (who may have similar difficulties) via electronic bulletin boards like ISOSTAT, ALLSTAT, and STATED. Some deal more with technical aspects of statistics, others more with pedagogy. The International Association for Statistical Education (IASE) also maintains a National Correspondents Network, aimed at supporting two-way communication between statistical educators.

In addition, IASE works to enhance the teaching and learning of statistics through its annual international conferences and meetings, which it seeks to locate in diverse geographic regions so as to impact on as many different teachers as possible. It also has a commitment to producing books and research reports giving insights into statistical pedagogy.

National statistical organisations can help teachers by providing workshops, seminars and national conferences on relevant subjects. The Royal Statistical Society (RSS) and the American Statistical Association have both been active in this respect. The RSS, for example, has an Associate School scheme through which it provides regular support to statistics teachers, as well as giving them materials for use in the classroom. In collaboration with the University of Nottingham and SPSS(UK) Ltd, it has recently established the RSS Centre for Statistical Education, which serves as a focus for national and international collaboration aimed at enhancing statistical understanding, including undertaking and disseminating research, and supporting teachers, etc. The RSS also provides annual bursaries for teachers following courses in statistical education.

Teachers can benefit not only from contact with other teachers but also with practising statisticians in commerce and industry. The Higher Education Network begun this year at the RSS Centre for Statistical Education, entitled *Matching Education and Assessment with Employment Needs in Statistics* (MEANS), is an initiative aimed at forging useful links and encouraging dialogue between employers and trainers.

There is now an increasing number of publications in the field of statistical education, both traditional (e.g. *Teaching Statistics*) and electronic (e.g. *Journal of Statistics Education*). They contain such materials as reports on pedagogic innovations and research, teaching suggestions, annotated data sets for classroom use, reviews of teaching materials and software, etc.

Hungary, the UK, Hong Kong, Sweden and the USA are among those countries that have held national or regional competitions in statistics at the school level. As well as raising the profile of statistics, these provide the means for some subliminal teacher-training. So too can workshops that are ostensibly aimed at stimulating students, but which also have an agenda for their accompanying teachers. The Royal Statistical Society has been running a successful series of such events during the past year.

Other needs

Statistics teachers' tasks would be made easier if statistics had a better 'Press'. The statistical profession as a whole has a responsibility to be clearer about the image and expectations that it portrays. While it still gives mixed messages about the nature of statistics, and of its practitioners, to the outside world, or allows mixed messages to be given on its behalf, it is not surprising that misconceptions persist. Presidents of the RSS, Peter Moore (1990) and Adrian Smith (1995) have both given important presentations on this subject. Zidek (1988) expressed concern about the dangers of statistics fragmenting into a number of disparate specialist areas. The Director of ISI, Zoltan Kenessey (1995), has also pressed for more integration within statistics.

Teachers need more research. Developments in methods and materials for teaching statistics (including those involving technology) often rely more on impressionistic than on empirical evaluation, making it difficult to establish the discipline of statistical education as a subject for study in its own right. There has been more research in the past few years, but there is a general lack of dissemination and synthesis, and still a great divide between cognitive research and classroom implementation. Until we have clearer empirical answers as to how best, or even how better, to teach statistics, then it is difficult to know where to start when training statistics teachers. This is somewhat reminiscent of Kath Hart's (1996) points about the paucity of mathematics education research although that discipline certainly has a head-start compared to statistical education.

In order to avail themselves of opportunities for training, teachers may need to be released from their other duties. They certainly need the study of statistics and of statistical education to be recognised as worthwhile for teachers. The provision of longer courses that focus on content *and* teaching methodology, and that result in the award of formal qualifications for teachers, would help to raise the status of statistical education. Such courses can also provide research skills and future researchers, with consequent benefit for the discipline of statistical education itself. However, such courses require more substantive, empirical content if they are to be viable.

Finally, statistics teachers need students who have all had better (or no previous) experiences of statistics (and mathematics) courses prior to reaching them than is typically the case. It will take time, and evolution, for this to be achieved on a widespread basis. Somehow, we have to find ways of breaking away from approaches that merely perpetuate 'bad' statistical education, and that in so doing create further generations of teachers and students with the wrong ideas about statistics itself. Statistics is largely the exercise of common sense. Many teachers still need to be convinced of this, however, and until they are their teaching is unlikely to be really appropriate or effective.

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