COMMUNICATING THE VALUE OF STATISTICAL THINKING IN RESEARCH

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In recent years much attention has been given to statistical literacy and to stimulating interest in statistical thinking and statistical reasoning. Statistical thinking is important for understanding the world around us and is in all but recognition the cornerstone of evidence-based research. Statistical reasoning is motivated by real-world problems, which in turn promote the use and development of statistical methods of enquiry. It is well known that many researchers from other disciplines find statistics challenging, and some do not appreciate the relevance of statistical enquiry. This paper gives examples of some of the teaching strategies that have been applied within the Lancaster Postgraduate Statistics Centre when teaching students from a range of disciplines and short courses for social and health scientists. Issues concerning course structure and methods of teaching will be discussed and several experimental innovations highlighted.

INTRODUCTION

Quantitative reasoning in an evidence-based society is a key component in public debate as well as government, business and individual decision-making processes and the discipline of statistics plays a key role (Smith, 1996). Risk and uncertainty play a part in everyday life crossing many boundaries and influence society in many ways, including politics, finance, law and order, and health and medicine, but the confused nature of media reporting and the public reaction to it is a cause of concern (Spiegelhalter, 2008). The public perception of statistics has changed little since the quote used by Disraeli, that "there are three kind of lies: lies, damn lies and statistics", was published in the Times in 1895 (Twain, 1924). People do not understand what statisticians do and what statistics are used for, they think that the subject requires a high level of numeracy and are often baffled by the jargon used (Hand, 2009).

The challenge for the 21st century is to overcome these misconceptions, to show that statistics is interesting, that statistical thinking is crucial for making sense of the world around us, and that statistical literacy is a key skill (Walman, 1993). Statistical literacy has been defined as the ability to interpret, critically evaluate, and communicate about statistical information and messages (Gal, 2002). With the dawn of evidence-based medicine in the 1980s and the Cochrane collaboration in the 1990s we have prime examples of how these skills can be coordinated within a structured educational framework for making informed decisions, in this case about the care of individual patients (Sackett et al., 2000). It is disappointing then that this philosophy has not been well adopted as an educational framework in other disciplines, the Campbell collaboration (2008) being the equivalent but less well-known movement in the social sciences, focusing on education, crime and justice, and social welfare.

It is well-known that students and researchers from other disciplines find learning statistics challenging (Garfield, 1995; Garfield & Ben-Zvi, 2007), but this is where the skills-base has to be developed. There have been many initiatives to encourage the development of statistical skills involving school children (Marriott et al. 2009), college and university students (MacGillivray, 2003) and adults (Gal, 2002). Gal (2002) has suggested using motivating examples from the media and newspapers to contextualize statistical thinking, and this can include bad examples (Goldacre, 2008). Another endorsement has been to keep the initial examination of data simple shifting attention away from complicated methods until students get a 'feel' for what they are doing (Chatfield, 1985). We can also learn a lot from our historical counterparts in the nineteenth century in applying statistical reasoning to practical situations of interest and concern (Lancaster, 2010). It is therefore not only a challenge but also a great opportunity for us to try and stimulate a wider interest in statistical thinking. In this paper we present some of the teaching strategies that have been applied at Lancaster Postgraduate Statistics Centre in teaching students from many disciplines and external participants on short courses from the social and health sciences. Issues concerning course structure and methods of teaching are discussed as well as several experimental innovations.

ESTABLISHING A PORTFOLIO OF COURSES

The establishment of the Postgraduate Statistics Centre (PSC) as a Centre of Excellence for Teaching and Learning (CETL) and the funding that came with it (see Lancaster et al. (2009), provided us with a unique opportunity to review our portfolio of courses and to restructure and design new ones where necessary. The PSC is an integral part of the Mathematics and Statistics Department enabling all staff in the Statistics Group to participate in a variety of initiatives, and its success is due to their enthusiasm and commitment to high quality Teaching and Learning (T&L). The following examples provide a flavour of some of the T&L strategies that we have developed.

MSc in Statistics

In 2008 we restructured three smaller statistical MScs into one large MSc programme in Statistics with optional pathways in medical, pharmaceutical and environmental statistics. The students are given guidance in their choices throughout the year and following a pathway is encouraged but it is not rigidly adhered to, giving the students the chance to have a taste of other pathway topics in the courses they choose where practicable. The students are taught a range of transferrable skills including consultancy, communication and employability. The pathways approach has helped with advertising and marketing the strengths of the course, providing a wider range of possible options, and gives both flexibility and focus for potential students unsure of what to study. This course is primarily for students with a good background in mathematics or statistics and equips them to an *advanced* level of statistics training. Focus groups with the students have endorsed this approach and many stay in the department to study for a PhD.

MSc in Applied Social Statistics

The MSc in Applied Social Statistics is for students who are numerate and want to develop good quantitative research skills. The course provides a practical foundation to the theory and application of statistical methods in the social and health sciences and caters for students from any background. The course equips students to an *intermediate* level of statistics as well as providing a strong grounding in research methodology. For 2010 the course has been restructured into optional pathways in crime and forensic statistics, health research and teaching statistics up to pre-university level. This course is designed with professional development in mind and to facilitate part-time study with most modules offered as two day short courses. For those wishing to study to a higher level in stages we also offer an MRes/PhD programme, which follows a similar course structure to the MSc for the first year but with an additional three years for PhD study.

Service teaching and Research Training for PhD students

We currently teach five undergraduate (UG) and five postgraduate (PG) statistics service courses and contribute six courses to Research Training Programmes for PhD students across three Faculties (Science and Technology, Arts and Social Science, Lancaster University Management School). These courses are at an *introductory* level teaching basic statistical skills from within a subject-specific context. In 2007 in collaboration with the Lancaster Environment Centre we carried out a survey to determine what PG students and staff from Environmental Science, Geography and Biology thought about their statistics provision and what they perceived their needs to be. This produced a list of recommendations that we have taken on board in reviewing all our PG service and training courses. It provided us with the evidence that PG students found the course too advanced, and were not necessarily any better at understanding and using statistics than UGs or students on introductory courses. However, they did have a level of maturity which meant that they appreciated their weaknesses and were willing to learn (Allen et al., 2010).

Short courses, masterclasses and workshops for continuing professional development (CPD)

We have a strong history within the department of short course provision dating back to the 1980s. Today many of our MSc modules double up as short courses and are delivered as two, three or five day courses. To provide further training regionally and nationally we run occasional masterclasses and workshops *at all levels*, inviting visiting experts in the field. This is an excellent way of not only supplementing CPD opportunities for external researchers but also enhancing the training of PhD students and staff from across the university.

STIMULATING INTEREST IN STATISTICAL LITERACY

Having established a range of courses that enable students to study at a level relevant for their personal needs and career development, we wanted to focus more specifically on initial motivation, communication and delivery in our introductory courses.

Simple graphs and examples from the media

A very popular course that highlights this approach is the second year 'Measuring Crime' course, run for criminology students. In this introductory ten week course the focus is on using stimulating crime examples from newspapers and simple data visualization to put measurement, basic numeracy and statistics into context (Humphreys & Francis, 2009). There is very little statistical content in the course but the underpinning research interests of the lecturers bring the course alive in terms of case studies using real data and research methodology, demonstrating their expertise in the field and giving the course authenticity. We currently have a mini project running in which we are developing examples for use in other contexts (Tishkovskaya & Lancaster, 2010).

In another example, taking an approach commonly used with medical students and applying it to science students, we used scenarios to stimulate problem-based learning on a research training programme (Jaki & Autin, 2009). The feedback suggested that the students appreciated the entire course being motivated through examples, ie., 'learning by doing' and the annotated bibliography that was provided, although this was unfamiliar territory for them. The course provoked students with differing levels of prior knowledge and subject interests to work together as a group, which emulates work in real life.

Team teaching

Team teaching is an approach that we have used in a course for research students in the social sciences. In this ten week course on 'Social Data Analysis' a social scientist from politics and a statistician teach together, have debates and discussions with each other and demonstrate to the students how such partnerships can benefit research: *"Watching instructors debate using different methodological approaches allows students to see the advantages of different disciplines..."* (student feedback, 2008). Some guidelines for team teaching include teaching with someone you get on well with, carefully planning the lectures and that it is not necessary to take this approach in every lesson. In a similar respect, it is useful to have special guest speakers from the field to bring together taught elements of methodology. For example, after learning about the principles of measurement, graphical representation in time, person and place and study design in epidemiology, statistics MSc students found it very illuminating to have a guest presentation on breast cancer epidemiology that utilized the various techniques they had learned in presenting the current evidence.

Using consultancy and collaborative research

Another approach taken within the PSC to stimulate interest in statistics is to provide a consultancy service for staff and PhD students across the university. This enables one to one sessions by pre-arranged appointment to go over problems and facilitates more in depth discussion. Advice is given on a range of topics from basic statistical methods, study design and software packages to more advanced statistical methods. We also use this medium to train our own statistical PhD students in statistical consultancy skills. If the problem is felt to be beyond the capabilities or inclination of the person seeking advice, usually determined after several appointments, then a research collaboration can be negotiated. Alternatively the statistician could become a joint PhD supervisor of the student, which ensures that responsibility has been taken by the statistician to provide statistical advice and help when needed by the student. This has been very successful in capability building, and usually takes the student to a level of knowledge beyond that which they would have achieved without this support. It also demonstrates and promotes the merits of multidisciplinary collaboration for future grant applications. Over the last year we have been asked to give talks on study design and writing statistics support into grants at several research training events.

EXPERIMENTING WITH TECHNOLOGY

There are now many different technologies that can be applied to enhance or augment teaching and learning. Whilst they may be successfully applied in most lecturing situations they do need careful evaluation as there is the possibility of both detraction from subject matter and protraction of lecture length.

Web-based distance-learning and e-learning

The development of distance-learning courses is very time-consuming and needs adequate resources for the development of good self-explanatory learning materials and a clear target market. To date the PSC has developed one distance-learning course in Genomics which was funded as a mini teaching project. The course has a special password protected website from where the course materials can be downloaded together with video recordings of the lectures. A special one day workshop is also held on site during the year to consolidate the concepts. The course was independently reviewed by a biologist and subsequent changes made before its launch this year. A new mini project is currently evaluating the new course against running a hybrid course.

As part of an external grant funded teaching project we have been able to develop over several years a set of e-learning materials to supplement our short course programme. The materials are available free of charge after registration and can be used by staff to supplement their lectures or students to extend their learning. The audiovisual technology used to create these materials is straightforward to implement and they serve a useful purpose as material for review and reflection after the course has ended.

Personal response systems and computer-based assessment tests

Personal response systems are a way of making learning fun and are usually used with large UG classes. We have tested their use on a smaller group of students taking our MSc in Statistics 'Principles of Epidemiology' course, as a means of checking the students' knowledge as well as providing short practical examples during lectures. In smaller classes there is a tendency for some students to feel slightly intimidated as the rest of the class waits for the slower responders but with reassurance this can be overcome. In general the handsets are well received as a teaching aid. The implementation and feedback from the teaching experiment has been summarized elsewhere (Titman & Lancaster, 2010).

Computer based assessment tests are another way of facilitating learning. In the MSc courses that use them they count for 10% of the final mark. The tests are created using Question Mark Perception software, last for approximately 40-60 minutes and ask less than 10 questions on average. We have found that students can treat these tests as they would their main exam and so some reassurance is necessary to ensure that they understand the questions will be similar to those seen in class and to avoid inordinate amounts of time spent on revision. A bank of questions are currently being developed for use in UG service teaching.

Podcasting and other resources

There are many useful resources available to stimulate self-directed learning and for use by staff to enhance their teaching practice. We are building up a library of resources containing a range of DVDs, Computer Aided Learning programmes and videos, as well as the e-learning courses described above that can be used by students or staff as part of a practical session. For staff in particular web-based resources such as useful web links for stimulating T&L, podcasts and presentations of seminars on T&L, and details of teaching projects and pedagogical publications are available on the PSC website (www.maths.lancs.ac.uk/psc). Podcasting is a relatively new concept within the PSC and we are using it increasingly to capture seminar presentations and to record lectures for reflection and review (Jaki, 2009). We have also just begun a mini project to set up a dataset archive to aid in teaching different statistical methods that we hope in time will become a public depository with well defined searching criteria (Hoti et al., 2010).

CONCLUSION

In conclusion, we have seen that there is a real need and opportunity to promote quantitative reasoning in the general population, and we must target this early through the

education system. It is important to engage with students at the level at which they feel most comfortable, to put problems into their own subject-specific context and to provide motivating examples from real life. This approach promotes interest in the subject and facilitates questioning when there are misunderstandings. The use of appropriate technology, learning resources and software will also help stimulate learning. The provision of statistic courses at a variety of levels (e.g., introductory, intermediate, advanced) gives students the freedom to begin to develop statistical literacy skills at their own pace, with the added motivation of having real problems to solve. Once their appetite has been cultivated then they may be enticed to think and reason more deeply and study intermediate methods pertinent to a more sophisticated analysis. This may be the level at which many researchers wish to remain, but by this time they should have gained sufficient skills to use simple statistical modeling approaches and also the confidence to discuss their work with a statistician when they need to collaborate. The more adventurous having developed a reasonable mathematical and statistical foundation, can go on to study more advanced and complex techniques such as those found in a typical MSc in Statistics syllabus, and coming from a non-mathematical and statistical background to attain this level of competency is to be highly commended.

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