Where statistics teaching can go wrong

Shelton Peiris
School of Mathematics and Statistics
The University of Sydney

shelton@maths.usyd.edu.au

Eric J. Beh
School of Computing and Mathematics
University of Western Sydney

e.beh@uws.edu.au

Statistics is an abstract subject and getting students motivated is, with the exception of a handful of students, a very challenging task. At present there is a growing demand in the research of Statistics teaching mainly aimed at addressing this difficulty. This paper addresses some associated problems and possible solutions to enthusiastic and dedicated teachers.

Introduction

Teaching is increasingly being recognised as a complex and multifaceted product of many known and unknown variables. The influence of many unknown variables makes teaching and learning statistics a very sour experience for many teachers and learners, especially for students. Although there has been growing attention to try and overcome this problem, especially on the teaching and learning aspects of statistics education (Chance 2000; Sowey 1998; 2001; Peiris 2002a,b), many students still find statistics courses both challenging and unappealing. This is mainly due to the negative and unappreciable methods of teaching statistics that are currently being adopted by some individual teachers at universities. Drawing on Ramsden (1992), the paper argues for an approach to teaching and learning statistics in ways that are linked to students' experiences of the world is more tractable to many students (see also, Peiris and Peseta (2004)).

This note reports a number of problems and possible solutions on statistics teaching based on the authors' long-term experience in higher education in many countries around the world. With that view in mind the next section considers three classical approaches on statistics teaching and Section 3 reports a number of potential and/or dangerous problems at the higher education sector and provides solutions to overcome some of these difficulties in teaching.

Classical approaches

Many elementary statistics courses cover the following topics: random experiments, data collection and summarising data in tables and diagrams, frequency distributions and typical shapes, mean and variance, introductory probability, basic probability rules and applications, some important discrete and continuous distributions, the binomial and normal distributions, sampling theory, the t distribution, statistical inference, goodness of fit tests and correlation and regression.

One problem of the classical approach is concerned with the adoption, and dependence, of a prescribed text by senior teachers that covers these topics, supplemented with examples and recommend it as a throughout the semester/year. It is recognised that most of the textbooks discussing topics of introductory level statistics are derived from class notes of a select group of educators and, in general, these books may not satisfy the requirements of another teacher, in particular the style, the presentation of material and examples. In this case students start throwing the (text)book away (or at least selling it to fellow students) and follow the style of their teacher. Certainly, the material provided by the teacher should always be considered the first port of call for students learning the topics being taught. On the other hand many textbooks do not satisfy students' individual learning needs. A good survey of this problem can be found in Chatfield (1995), Rossman (1996) and Sowey (1998).

Another problem that arises from considering the classical approach to teaching statistics at intermediate or senior level is known as 'Statistics driven by the Theory' (see, Peiris and Peseta 2004). In this approach teachers attempt to explain the statistical concepts through mathematics, which of course, may be very unappealing to many average students. However it seems that this approach is appreciated by those students who are mathematically literate at an advanced level. In junior courses, this theory driven approach is not suitable and the traditional teaching methods can not be used at all. As a result the teaching of statistics is

often done without resorting to formal mathematical descriptions of the topics. This is especially so for statistics courses offered as a service subject for undergraduate programs. A sign that this trend is becoming increasing more obvious is the abundant publication of introductory textbooks that provide very little mathematical descriptions of key statistical concepts.

Following a pre-arranged method of teaching is another difficulty arising from the classical approach in teaching, especially in statistics at the junior level. Despite there being a set syllabus for a course that is taught, it is not always advisable to follow this pre-arranged method or methods of teaching. It is important to allow some flexibility in the delivery of the material to take into account the different analytic ability of the new cohort of students – their skills and knowledge of mathematics and statistics can vary from year to year. Therefore, the teachers must adopt and develop their own teaching style (rather than relying or depending, on a textbook, or other, approach) that is gained from past experience. Only then, can a teacher begin to motivate students and educate them on the while taking into account the varying ability of the students. This helps both 'the teacher' and 'the learner' to enjoy the teaching and learning experience.

Some problems in teaching Statistics today

It is clear that there is a need to strengthen research into statistics education since statistics is becoming more and more relevant in many the workforce that are involved in decision making processes while minimising the uncertainty in the options that are available to them. To reflect this growing demand in the vocational sector, many disciplines, especially the sciences and business, at universities around the world require their students to be literate in the key and fundamental issues of statistics – but not its mathematical aspects.

Anecdotal evidence suggests that many students do not develop the ability or interest in statistics learning during their university education. One reason for this is that seems to be 'the stereotype approach' of some traditional teachers who do not wish to listen to students and/or share their experience with other colleagues in the same discipline. The majority of those 'type' teachers do not provide an opportunity for 'weaker' or 'developing' students to gain confidence, knowledge and/or skills in statistics. This, of course, has had a long term effect on the profession, and, in particular for the existence of 'Statistics' as a discipline at many higher education institutions. On the other hand, the majority of newly appointed teachers do not undertake to develop their teaching skills since many higher education institutions continue to prefer to support 'good research achievements' (R) than on 'excellent classroom teaching' (T). In many cases the ratio of R:T seems to be 90:10 rather than 60:40. Although the selection and promotion criteria clearly state that good classroom teaching abilities are essential for appointment/promotion, it is harder for a teacher to demonstrate his/her skills as an effective educator to a selection panel than it is to demonstrate research output or ones role in a community activity. Unless we find ways to resolve this problem and recognise the importance of teaching, teaching will continue to lead to unreceptive reactions by the many university students learning statistics.

The first step in the teaching of any discipline is that there should be an optimal transmission of knowledge between the teacher and his/her student. This is not an easy task for a subject like statistics. To achieve this, the teacher must be knowledgeable not only the subject matter but also being able to adapt to a student's basic analytic skills and capabilities. For example, even in an elementary statistics course students are expected to have a desired level of mathematics. However, students without that background must be encouraged to achieve the level of mathematics within a couple of weeks of the semester – this is a problem in itself since these students often bear the characteristics of 'maths-phobia' that has been instilled in them during their secondary education. If these issues, in particular overcoming a student's 'math-phobia' can be addressed then the teacher can encourage a student's interest and curiosity of the subject and convince them their learning and understanding are important and useful in career development.

The concepts of statistics are developed based on 'randomness' or 'uncertainty'. Before beginning to teach a topic from the program it is advantageous to consider a real world example/application. Such an example illustrates to students the importance and role of statistics in terms of social, political, and commercial sectors. A good place to start is to provide an example that has recently appeared in the media, or government, print.

It is recognised that another important point of teaching is to develop the problem solving skills and strategies to motivate students. One method of doing this is to divide each class into small discussion groups in order to teach these problem solving strategies more efficiently. This student-centred approach provides students with the opportunity to apply knowledge gained from the demonstration of the topics and receive feedback on their comprehension of the concepts. It is also helpful for students to clarify any doubts related to the topic. This practice has been very successfully adopted over the past few years at the University of Sydney and the University of Western Sydney. Once students have mastered the fundamental concepts it is then important to slowly build on these foundations to a point where they have a clearer and deeper understanding of the material. A preliminary investigation of these skills can be monitored by providing relevant and thought provoking assessment components that provide the student with the opportunity to gain a more global understanding of the concepts and their application to real life situations.

Another challenge at a large university is working with diverse groups of students. They have different expectations and backgrounds. Therefore it makes sense to take this diversity into account when designing a course and planning a class. Always be prepared to modify your program/approach as necessary. Technology also can be of very useful to students to gain experience in data analysis. Now it is known that it is impossible to prepare students

adequately without allowing them an opportunity to acquire computer based skills. There is clear evidence that more effective learning can result when computer applications are used appropriately. As current students are confident with computers, this can support to motivate students. For example, in the Time Series Analysis course at the University of Sydney almost every student attends each Computer laboratory session: more regularly than any other session.

Sometimes, in some courses, irrespective of whether it is statistics or another discipline, some teachers feel that in order to pass more students they reduce the level of content, or scale upwards so that those who may originally fail appear to satisfy the requirements for the course. It is evident that passing the junior level students by lowering the respective passing cut-off mark had done significant damage to the curriculum of the subsequent years. For example, there are still undergraduate students who would argue that 2/5 + 3/7 = 5/12. Enthusiastic teachers must use more time to help weaker students to encourage their learning, or arrange alternative ways of trying to educate students on the fundamental principals of mathematics and statistics. One may provide additional consultation times and advertise them regularly in lectures and tutorials. Additional educational resources may be made available to the student. For example, first year students who have problems understanding material taught in mathematics and statistics subjects at the University of Western Sydney are often directed to the Learning Skills Unit, a university body whose (partial) objective is to help students overcome any difficulties associated with the study of these disciplines.

In Section 4, we summarize five important points that may be helpful for further developing the skills of dedicated statistics teacher. In fact, by keeping these points in mind, a teacher from any discipline may find them useful.

A five point summary

In order for a teacher of statistics to provide a sound education of the topics to students, we advise the following steps be followed:

i. Advertise your program clearly at the beginning of the teaching semester. Inform the students of the assessment components that need to be successfully completed and the contribution of these components towards the final grade.
ii. Cheerfully communicate with students. Be a conscientious and motivated teacher. Improve your teaching methods and skills to best suit to students.
iii. At the start of a course, or in its early weeks, try to meet as many of the students as possible and find out about their background knowledge and expectation. In large class teaching, this can be done by selecting several random groups of students (at least one group each day, after each lecture, during the first 2–3 weeks of the semester).
iv. Make teaching statistics a shared process by interacting, and understanding, your students' concerns with the topics.
v. Try to gauge your students' fear, boredom, confusion and unhappiness. Non-verbal communication can often provide a glimpse into students progress, especially for those who are struggling with the material. Encourage them to see you and discuss any difficulties they may have.

References

Chance, B. (2000) Components of statistical thinking and implications for instruction and assessment. *Proceedings of the American Educational Research Association*.

Chatfield, C. (1995) *Problem Solving: A Statistician's Guide*. Chapman and Hall.

Peiris, M.S. (2002a) Teaching Mathematical Statistic, Scholarly Inquiry in *Flexible Science Teaching and Learning*, UniServe Science, 85-86.

Peiris, M.S. (2002b) A way of teaching statistics: An approach to flexible learning, *CAL-laborate*, **9**, 13-15.

Peiris, S. and Peseta, T. (2004) Learning Statistics in First Year by Active Participating Students, *Scholarly Inquiry into Science Teaching and Learning*, UniServe Science, 76-79.

Ramsden, P. (1992) *Learning to Teach in Higher Education*. London & NY: Routledge.

Rossman, A. (1996) *Workshop Statistics: Discovery with Data*. Springer. (Companion Web site: http://stats.dickinson.edu/math/Rossman/wshome.html).

Sowey, E. (1998) Statistics teaching and the textbook - An uneasy alliance. *Proceedings of the Fifth International Conference on Teaching Statistics*, Singapore.

Sowey, E. (2001) Striking demonstrations in teaching statistics. *Journal of Statistics Education*, **9**(1).