Learning Statistics in First Year by Active Participating Students

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Abstract: *There has been a growing attention, especially in the last fifteen years on the teaching and learning aspects of statistics education (Chance 2000; Sowey 1998; 2001; Peiris 2002a,b). Although the knowledge, training and skills on statistics are welcomed by many employers, the majority of students still find statistics courses both challenging and unappealing. This paper reports on students' experience of learning statistics in a first year unit of study MATH1015: Statistics for Life Sciences at The University of Sydney. Following Reid (1997) who argued that a teacher's approach in a level environment can encourage student learning at a high level, the paper reports on the effects of small-scale curriculum change on students' levels of motivation and engagement with statistics. Drawing on Ramsden (1992), the paper argues for an approach to teaching and learning statistics in ways that are connected to students' experiences of the world.*

Introduction

The unit *Statistics for Life Sciences* at The University of Sydney is one of a number of junior statistics options that students enrolled in the Faculty of Science complete as part of the mathematics component of their course degree program. Students choose this unit on the basis of prerequisite knowledge in mathematics and usually those who have completed 2 units or less at the NSW HSC (or equivalent) are encouraged to pursue it. The *Statistics for Life Sciences* unit is about developing students' basic analytical skills related to statistics problems. Given the range of student interest and ability, together with the fact that many of these students do not intend to continue with any mathematics at the senior level, the challenge is always in how to keep students engaged in the possibilities of statistical literacy. Following Reid (1997), how might we create a learning environment that encourages and supports student learning?

In fact, anecdotal feedback suggests that many students do not develop this ability or interest at all throughout the duration of the semester-long unit, despite the importance of statistical skills and training for employability. One reason may be the continued persistence of what Prosser and Trigwell (1999) call a information transmission/teacher-focused approach to teaching, where the intention is to transfer information from the syllabus to students, with a teaching strategy where the teacher is the focal point. The converse of such an approach is an emphasis on the student as central, where the intention is to change the students' experience of the phenomena of their study. The need to understand how students' approach their learning in statistics seems central to the development of Prosser and Trigwell's (1999) conceptual change/student-focused approach to teaching.

This task has been taken up explicitly by Reid and Petocz (2001). Their focus on understanding the range of ways students' understand or experience their statistical learning is crucial then for informing teachers' curriculum-change interventions and their approaches to teaching. While Reid and Petocz (2001) argue that there are qualitative differences displayed by students' different conceptions of learning statistics to incorporate a deep approach – which are characterised by Ramsden (1992) in the following ways – as relating previous knowledge to new knowledge; as relating together knowledge from different courses and contexts; as relating theoretical/abstract ideas to experience and as the organisation and structure of a coherent conceptions, the main implication we want to draw out here is how we might design our teaching in order to shift whole. This is the learning context that we want to bring first year students into in the *Statistics for Life Sciences* unit.

Teaching and Learning in the *Statistics for Life Sciences* unit

The remainder of the paper describes a number of small-scale curriculum changes designed to engage students actively in their learning in *Statistics for Life Sciences unit*. These changes are best seen as a work-in-progress with ongoing evidence needed to provide evidence of its impact on learning and the sorts of outcomes students themselves describe. Firstly, I (Shelton) outline what I see as the 'classical approach' to teaching statistics and then I describe a new approach I have been using for the last 4 to 5 years based on my long term experience in higher education for more than 20 years.

The Classical Approach

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 with the classical approach is the strict adherence to these topics as written in textbooks. In fact, it has been recognised that most textbooks are derived from the class notes of individual teachers. These textbooks may not satisfy the requirements of other teachers, in particular, through its style and presentation of material. In such cases, students are often guided by the preferred style of the teacher. Similarly, many textbooks do not provide for students' individual learning needs. A good survey of this problem can be found in Chatfield (1995), Rossman (1996) and Sowey (1998). Another problem with the classical approach is a tendency for 'Statistics driven by the Theory'. In this approach teachers explain statistical concepts primarily through mathematics—an appeal to abstraction. This may be suitable for mathematically oriented students but prove more problematic for students with less experience. For example, the concept of Probability is defined and developed using the theory of limits, and asymptotic results are studied including unbiasedness and consistency. There is little opportunity to move away from this type of heavy abstraction unless we critically reflect on the design of our learning environments and students' conceptions of learning statistics. In service units such as *Statistics for Life Sciences*, this theory driven approach seems to limit student engagement with the range of meanings and contexts for learning about the relevance and application of statistical knowledge for problem solving. If we are to take seriously the important place of statistics in the world, then this needs to be made clear to students in a variety of ways in order for them to develop personalised meanings of its purpose.

A new approach

It is clear that the emerging research into statistics education calls for a new approach to teaching and learning. Keeler and Steinhorst (1995) call for the use of small groups in the promotion of active learning. Yilmaz (1996) suggests that the ability to use statistics in context requires connecting problems to real world situations, knowledge of basic statistics concepts and the clear communication of statistical results. Along with Reid and Petocz (2002) conceptions of learning statistics, these aspects need to be accounted for in designing curriculum initiatives. To achieve this, the teacher must be knowledgeable, not only of the subject matter but also with the ideas about statistics students' bring to the classroom. In this way, the teacher can better support students' interest in and curiosity for the subject and show them how learning and understanding are important and useful in their career development.

The concepts of statistics developed below are based on 'randomness' or 'uncertainty'. Before beginning to teach a topic from the program, I take a real world example/application to demonstrate to students an application of this topic. In Table 1 we provide two examples of based on this approach.

Table 1. Examples of the classical and new approach to typical statistical concepts

Topic	Classical approach	New approach
Example 1: Linear regression	Define the correlation coefficient, properties of correlation, estimate the slope and intercept, residual analysis, model checking, prediction/forecasting	Take few examples of bivariate data, plot each data set, convince students various degree of association between variables, define a measure to find this association, explain the use of a suitable model, estimate parameters.
Example 2: Hypothesis testing	Define the null and alternative hypotheses, explain a test statistic, explain the P-value, power of the test, decision making	Consider a problem in the society. For example suppose that the government believes that 65% of the Australian people support their new environment policy. However, the main opposition party believes that this ratio is much below the 65% due to its long term effects of the proposed policy. Clearly there is a dispute between the two groups. How can we solve this dispute?

With the new approach in Example 1, the focus is on engaging students in inquiry. It is about putting data to use rather than students being passive recipients of abstract concepts. In Example 2, there is an attempt to demonstrate that statistics are useful in solving problems—in this case, a political context. The shift is a subtle one but an important one in rethinking the purpose of the unit overall. Students' experience of learning statistics this way has been largely positive. Witness their comments from end of semester feedback:

> Thank you for a great course and your support during this semester. I never thought I would understand statistics. Not only you did make it clear, interesting but it has been fun as well.

> Just want to let you know I enjoyed your Life Sciences Statistics lectures and tutorials last semester. I appreciated the classroom-style teaching and your understanding that many of us were not exactly math whizzes at school and/or, like myself, haven't done math for quite some time. Thank you for your patience and humour!

> The lectures were very clear and easy to understand with many real world examples and applications.

> The course notes were excellent and the pace of the course was perfect to all. The concepts are explained with real world examples which make the subject memorable.

This has been a small but significant change to the design of the *Statistics for Life Sciences* unit. While we note that student retention in the unit has been steadily increasing from 2001-2004, the next step will be to continue the emphasis on students' learning and the ways that a continued research agenda into their experiences can provide further understanding on the design of teaching and learning environments.

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