

IMPROVING STATISTICAL LITERACY AT UNIVERSITY

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At the University of Canterbury, NZ, the Department of Mathematics and Statistics offers a range of introductory statistics and mathematics courses. Nearly one third of the first year students enrol in our introductory statistics courses. Given this level of interest we could consider our work done: we don't! We have an integrated programme to improve statistical literacy across all the campus. In this presentation we discuss our work in supporting students with very low levels of numeracy via learning skills support, through to supporting postgraduate students with their higher level statistical needs. Rather than running these as separate programmes we have pulled all these levels of support together and have integrated them into the existing university structures. We now offer a university-wide statistical service.

INTRODUCTION

One of the roles of a university is to prepare graduates with skills for their future. An aspect of any graduate's future in society, today and no doubt in the future, is to be statistically literate. We are living in a "data-drenched society", a very apt term described by Steen (1999). It is our responsibility as educators, and as statisticians, to promote, enhance and develop statistical literacy in our community.

We consider statistical literacy to be enabling students to navigate the depths and shoals of the data-driven world. We want our students to have the ability to not only see and read statistical results and data-summaries, but to understand and critique them (Wallman, 1993). Statistical reasoning will be one facet of a student's life that they will carry with them beyond university.

These higher level concepts of statistical literacy, critical thinking and statistical reasoning have appeared in some of the policies and practices at the University of Canterbury (UC). The UC science student graduate profile for an undergraduate science degree refers to the attributes and skills a student will have after their 3-year degree programme. The list of specific attributes includes:

- Demonstrate knowledge of and an ability to apply scientific principles and concepts
- Solve problems through the application of scientific knowledge and methods
- Demonstrate analytical abilities
- Demonstrate the development of skills for lifelong learning
- Understand, evaluate, access and critically review new information
- Demonstrate the ability to think independently
- Demonstrate in-depth knowledge of and skill in his or her majoring subject
- Effectively access and use information relevant to the subject
- Demonstrate numeracy skills
- Work collaboratively on tasks
- Communicate effectively both in written and spoken English

Interestingly, almost all of the items in the list are skills that we consider part of a broader picture of statistical literacy. The overall theme is of a science student from UC being capable of critical thinking and the faculty aims to "provide rewarding educational experiences that develop in graduates capacities for independence and reasoning, critical analysis, effective communication and ethical and social understanding, as well as in-depth knowledge of a field of study".

The need for a broad platform of teaching and learning in statistics has been discussed for some time and is well understood in many countries (for example, see MacGillivray, 2009; Patel et al, 2010). The contribution of our department's statistics teaching into a student's programme of study is very diverse, but it is all directed toward statistical literacy. We provide a range of options from introductory courses, higher level statistics courses, numeracy learning support for targeted

students, and specialized statistical support for postgraduate research students. These individual strands of student centered teaching and learning are all interwoven into an effective and efficient web that enhances student's statistical reasoning and capabilities.

STATISTICS COURSE OFFERINGS

We offer over 20 dedicated statistics courses at UC, with the base being an introductory course, STAT101. This course is offered in three semesters and has in total about 1200 students enrolled each year. Most of these students are first year students and this number represents about 1/3 of the total first year students on campus. The aim of the course is to develop students' critical thinking. The students have a great variety of backgrounds and prior understanding, and almost all are not majoring in statistics. Because of this student variation, and differences in intended programmes of study, we teach the course in a way that caters for individual student's learning (David & Brown, 2012).

Student feedback from the course is very positive and we are encouraged to continue with our blended learning style. We use a combination of large-class lectures, smaller focussed example classes, computer-based tutorials, and dedicated student centred help-classes. We have clear learning objectives and outcomes to ensure content relevancy and, by having regular, low-stakes assessment, we can give timely and useful feedback to the students.

The focus of this introductory course is on data and variation in data. We try to develop student's critical thinking, understanding of statistical concepts and statistical reasoning. This is quite a change from how the course was taught 10 years ago where the emphasis was on tools and methodological steps to conduct analysis. We have discussed the evolution of the course, and offer more details in David and Brown (2012).

The success of this course, and the fact that it is accessible to all students regardless of their major and background knowledge has meant that a number of programmes of study now require STAT101 as a necessary course for their students. This is a wonderful outcome because now more students from UC can access the course and will have had the opportunity to develop their statistical literacy. A 2013 review of the UC undergraduate science degree (BSc) specifically mentioned STAT101, referring to both the quality of teaching and our relationship with other departments, "The STAT101 team were mentioned several times for their strong commitment to service teaching and their high engagement with students, and the Panel commends the team for their work, and the confidence they have instilled in other departments to have this paper as a requirement".

We offer a complete programme in statistics with higher level (2nd, 3rd and 4th year) courses covering most of the areas typically seen in a university degree programme, including data analysis, probability, inference, Bayesian statistics, computer intensive methods and sampling. Student numbers at these higher levels are considerably lower than in our first year course because there is a reducing number of non-statistics major students enrolled through the levels. Programmes of study tend to become more prescriptive through the levels with diminishing options for non-statistics majors to enrol in a 2nd, 3rd and 4th year statistics course. To maintain our department's goal of raising statistical literacy across UC, given the reducing ability of students to take higher level statistics, we teach statistics units into a variety of courses from other departments. For example, a course in another science subject at 2nd or 3rd year may have a 3-week block of statistics which we would teach. This is another mechanism we use to raise students' statistical literacy. Interestingly, over time, a number of these arrangements with us teaching into other departments' courses have resulted in the department altering their entire programme and now requiring a complete statistics course (taught by us). There are two reasons for these changes to programmes of study: i) over time the science-department appreciates the need for more than just a short statistics block within a course; and ii) over time relationships, and trust, builds between our teaching team and the science department, and the science department have confidence in our ability.

HEADSTART PROGRAMMES

At UC students who are eligible to enrol at a University can chose to participate in a pre-University course in the summer prior to beginning formal study in the academic year. This

programme is called Headstart, a delightful name indicating to the students the benefits of participating.

Our department has been active in delivering the statistics courses in the Headstart programme. This is quite a different course from STAT101. The course is attended by not only those students who will continue on to STAT101, but by a range of different students across all subjects. It is popular with mature students who have an interest in improving their statistical knowledge. The value of this programme in assisting student retention after a large earthquake in 2011 was clear to the University. Students felt supported in the programme and continued with their academic plans and enrolled at UC.

This is a small course with usually less than 20 students and we provide a very supportive learning environment. The first part of the course covers numerical and algebraic skills because most of the students attending are not comfortable with basic mathematics such as working with fractions and rearranging an algebraic expression. In recent years, computers have been introduced so the use of the software package, Excel, can be covered. This software is new to many Headstart students, including those coming from high school. We have found that many school leavers have relied on a graphics calculator to do the statistics for them, without much understanding of what the working actually means.

The feedback from the Headstart course is always favourable and many students change their proposed programmes of study so that in the new academic year they can enrol in STAT101, a very satisfying outcome for us.

UCIC AT UC

This year, Navitas Limited announced the launch of its first university pathway college, UC International College (UCIC) in New Zealand, in association with UC. This partnership creates an independent, but affiliated, college that will recruit and prepare international students for study at UC in future years.

UCIC have acknowledged the importance of statistics to their students by offering the equivalent of STAT101 as one of the first courses to run commencing October 2013. We have taken a proactive approach with this external provider by encouraging some of our teaching staff to be directly involved with the UCIC programme delivery. We are working closely with UCIC to make sure the course material is equivalent and the students have a smooth transition to UC. Our view is that students who successfully complete their courses at UCIC will progress on to second year at UC and higher level study. When they graduate from UC we want them to be statistically literate. Ideally we would hope some of these students will continue study in statistics, although this first cohort is for entry into a Bachelor of Commerce only (later cohorts will include students intending to progress to a BSc).

The UCIC programme is targeted at international students. One of the benefits for us in having a strong connection to the external college is the co-development of support for students where English is a second language. Many students in our current STAT101 class are international students. One characteristic often seen is that they have strong mathematical backgrounds. However, because their English is poor, they do not perform as well as their mathematical background would suggest. This is in part due to the written assessment in the assignments and the exam where a better grasp of the language would help. UCIC is providing additional English support so in future this may be the preferred choice of pathway through the degree programme to enable these students to excel.

UC SKILLS

UC Skills is a recent UC initiative designed to support students' learning. A key feature of UC Skills is the integration of services and functions that have been separate in the past. The initiative draws together into an open learning space resources including services in the library, IT, and support for learning numeracy and literacy. UC Skills is a single portal entry through which students can gain learning support. The group offers on-line facilities, a mixture of study spaces for working individually or in groups, access to digital resources, traditional library collections and services, and access to learning support services both in a physical and virtual realm.

This concept of an open learning space is in response to identified student needs: student feedback was that they want to learn when they have time, often outside the usual University opening times and they want flexible spaces that suit their preferred learning styles. Students' learning is supported by considering their entire university learning experience, rather than focussing only on their time in the lecture theatre, lab or tutorial room.

The physical and virtual space has been designed to attract students and accommodate their needs. At UC we want students to make a smooth transition into tertiary education, and it is important that students "feel as if they belong and are part of the learning community" (Krause, 2006). UC Skills provide physical space on campus that is student-friendly. The virtual space provides flexible access to many of its services beyond the walls of the buildings, when and where students need that access and support.

Our group has been instrumental in integrating part of the learning support package (basic use of Excel, statistics and numeracy) to the range of options on offer. We use a blended learning approach with students choosing among face-to-face workshops and classroom based tutorials, and accessing on-line material such as video recordings, on-line quizzes and other electronic materials to supplement tutorials.

In New Zealand there is open access to universities. Students under 20 years old need a "University Entrance" qualification, while students over the age of 20 can enrol without any qualification. In our experience this open access means that some students find the level of numeracy expected of them is more than they had anticipated. UC Skills gives students the opportunity to identify and then "plug" those gaps in a timely manner and in a way that suits them and is non-threatening. Our involvement in the UC Skills programme means that we are accessing a wider group of students than we would see in STAT101, and we hope, increasing the statistical literacy of students who attend.

POSTGRADUATE STUDENT STATISTICAL ADVICE

One final strand of our web of enhancement to student's statistical literacy is statistical support to postgraduate students (mostly PhD students). We set up a statistics consulting unit in mid-2011. A campus-wide survey was conducted at the end of 2011 to identify the need across campus for this type of service. At this level student learning needs appear different from what we see at the other levels discussed above, with students often arriving with a data set they have collected and wanting quick-fix methodology advice (e.g., what linear model do I use, how do I use R, SPSS, SAS, and what does this computer output mean?).

Our approach has been to step back from these questions, and focus the students' attention on developing their own statistical literacy by running statistical seminars on the most commonly raised topics and augmenting them with computer labs in R and SPSS. These labs provide the participants with immediate hands-on experience that help consolidate their seminar learning. The topics we have covered in seminars and labs have been: Understanding and Interpreting Statistical Results, Experimental Design, ANOVA, Generalised Linear Models, and Mixed Effect Models. The seminars proved to be very popular, with 20-60 participants per session (the number of lab places was limited to 20).

We also run one-on-one private consultations to postgraduate students and staff. The duration of a typical consultation is set at 1 hour, a time-length that seems to be adequate. Follow-up is often needed either via another personal consultation or via e-mail. The students (or staff) are usually asked to describe their problem and send any relevant materials in advance, which is especially useful if their question concerns some method specific to their field and not widely used.

The response from students, and staff, including the students' supervisors, to the statistics consulting unit has been overwhelmingly positive. Without this service many postgraduate students and staff were literally swimming, and sinking, in their pools of data. The most rewarding aspect of the new unit has been the willingness of both students and staff to improve their own statistical practice.

SUMMARY

We offer a broad but student-centred service to UC to improve statistical literacy. This includes provision of a teaching programme of introductory statistics, and higher level courses,

statistics courses in preparation to University programmes (Headstart), statistics components in an external provider's alternative pathway into UC, statistics in the supported physical and virtual learning spaces of UC Skills, and statistical support for postgraduate students. These multiple threads of statistics teaching and learning weave together to form a web for developing and enhancing statistical literacy at UC. As part of our department's strategy we have chosen and facilitated our team's involvement in all these aspects of statistical literacy support across campus, and see our role as being far broader than simply teaching statistics courses. This strategic direction is new, it is something that has come about in the last 5 years, but the enthusiasm and gratitude from the UC community confirms that it was a sensible path to follow.

In a perfect statistical world we would have data on some measure of graduating student's statistical literacy before our strategic change, and compare these with data collected since our strategy-change. In this real world, we don't have this data-evidence, so we can not specifically say that graduates that exit UC now are more literate now than 5 years ago. However, we have confidence that we are responding to the changing world where the data-ocean is getting deeper and wider (Monovich 2011), when we hear reports from employers of the quality of our graduates. Our response to the changing world has been to not just teach more statistics courses but to think how to reach all UC students.

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