IMPLEMENTING THE CHANGE: TEACHING STATISTICAL THINKING NOT JUST METHODS

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In 2009 we changed the way of teaching our first year statistics course at the University of Canterbury. This paper discusses the changes and presents results from student feedback. The major change in emphasis was to think 'Why? not 'How?' An introductory survey collected student data and the information was used to explore students' backgrounds and perceptions, to give personal context and relevancy. Teaching and learning is now a combination of lectures, on-line tutorials, computer-based testing, written assignments, and a written exam focused on critical thinking. This combination provides varied pathways of study, important for this large course with over 1,000 diverse students. Feedback from the students during and after the course shows they were very receptive and enthusiastic towards the changes.

INTRODUCTION

Over the past 5 or 6 years of involvement with the introductory statistics programme at the University of Canterbury (UC), Christchurch, New Zealand we became increasingly aware that the students were passive, rather than active participants in the course. The traditional course style, which focused on lectures as the primary means of delivery, was difficult for many students, in particular those without a background in mathematics. This was due to the level of computation and abstraction required of the students to understand some material, in particular formal probability, which is not unusual (Moore, 2005). For many, this meant motivation was low. This course was (and still is) a required course for progressing in many disciplines, so it is not freely chosen by the majority of students. The drop-out rate was of the order of 20% (this figure relates to those students who failed to participate in the majority of the assessment items of the course or failed to complete the course whilst remaining on the roll, 2008 data). With the student numbers representing about one quarter of all first year students at UC, and very few (one of the 1000 enrolled in 2008) self-identified as starting university intending to graduate with a BSc in statistics, we considered it was appropriate, and perhaps overdue in light of the reform movement in America (Cobb, 1992; Garfield, 1994, 1995), to review the course and look at bringing it up to date. Due to the vastly improved computing facilities available for use, and through the efforts of the teaching team we were able to make radical changes to the way our introductory course operated in 2009, making the material and methods of delivery and assessment more relevant and interesting to the students enrolled.

Many statistics educators agree that any introductory statistics course should raise students' awareness of data in everyday life and prepare them for a career in today's "age of information" (Rumsey, 2002). This was at the heart of our plans for change. Thus inspired, we visited the University Of Auckland Department Of Statistics to observe their methods of delivery and returned enthusiastic to implement some changes. We undertook a complete review of the introductory statistics programme with input from the University of Canterbury Centre for Teaching and Learning (UCTL) and the whole department statistics team of academics and senior tutors. This process is described in detail in the companion paper (Brown & David, 2009).

The course now operates for students in a primarily self-directed style with student engagement being the focus. The responsibility for learning is with the student (Saville & Zinn, 2005) and we have designed the course to provide a range of opportunities for learning (Moore, 1997). We emphasise the range of learning and assessment opportunities because every student's learning needs differ. We offer advice and support to allow the students to use these learning opportunities to best meet their individual needs.

Three lectures followed by an on-line tutorial related to the material covered, provide the week by week pathway through the course. We host all-day tutor supported tutorials in large computer labs (70 computers). Students are encouraged to help each other and often form small study groups for mutual benefit and support.

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THE STRUCTURE OF THE NEW COURSE: ASSESSMENT

With the support of our departmental IT technicians and the Blackboard learning management system (LMS) we set up a secure environment for computer-based skills tests so that only the Blackboard testing environment and Excel were available to students when they were being assessed. There were three skills tests in total, each worth 10%, with two attempts allowed at each and the better of the two marks counting towards assessment. These skills tests were spread out through the 12 week semester, the first one being in week four. This first test gives the students immediate and timely feedback on their performance to date and sets the tone for this type of assessment on the course. The question data base allows for many possible versions of questions, so students sitting at adjacent computers are presented with different questions or different numerical values within the same question.

The second attempt at each skills test allows students to improve their score (if necessary) by revisiting the tutorials and seeking help. Each skills test runs over the course of a week so there is the opportunity for students to improve on any weakness that they identify before their second attempt. This repeat option addresses mastery, where students can self-identify their understanding at each level and work on improving and achieving competency.

There are three written assignments. The first uses Excel to provide graphing practice and experience in writing a short report based on some aspects of the student data set (collected from the introductory course survey). Two further assignments in the second half of the course are based on hypothesis testing and confidence intervals. Feedback from the first of these two is returned in time to inform and help students improve in the second. These project-style assignments are used to develop the concept of the data cycle (Wild & Pfankuch, 1999). The written assignments enable statistical literacy and critical thinking to be developed in context, and provide a tool to develop and assess written communication skills.

The written final exam, comprising mostly of short answer questions, encourages students to develop communication skills. The traditional final exam is still an essential part of the course for two main reasons. Firstly, the exam provides the summative piece of assessment, and secondly, because it is done in a secure environment it motivates the students to study. Again, the form of the exam encourages students to develop and achieve a logical progression through the material and towards statistical reasoning.

THE STRUCTURE OF THE NEW COURSE: DELIVERY

The first lecture featured a ‘youtube’ clip ‘Statistics–Dream job of the next Decade’ http://www.youtube.com/watch?v=D4FQsYTbLoI, showing Google’s chief economist Val Harian presenting an introduction on why learning and understanding statistics is important in today’s society. This short video showing an independent high profile figure, provides motivation to learn statistics to get ahead of the pack and highlights statistics as the ‘sexy job of the 2010’s’. Lectures for new topics begin with motivational examples, New Zealand based where possible, and real data collected from the students in an introductory survey (the survey is described later). Lectures are interactive as far as possible and the lecturers strive to encourage the students to participate by asking and answering questions. Outline lecture notes are posted on the web for students to bring along and complete during the lecture, and students are expected and encouraged to work through examples as they are covered to gain confidence in their competence and understanding.

We recognize that for some students traditional lectures are important when the material is new, and provide an opportunity to experience the lecturers’ enthusiasm. There are usually 3 or 4 lecturers, each delivering a 3 week block of material. For those students who have come straight from school however, much of the first half of the course is a review of year 13 statistics and so many can go straight to the on-line tutorials and prepare for the skills tests. Lectures are videoed for students who prefer to participate at different times, and for those who want to use lectures for review and consolidation.

The course uses Excel as a teaching and learning tool, and in all lectures examples are worked through using the lecture room’s computer. Notes and hints on how to use Excel are provided for each lecture within the lecture notes or as companion material. Using Excel for its computational functionality and graphing facility (and teaching both in the course) made it possible to move away from extensive computations and towards an understanding of concepts. Also, use of

appropriate Excel functions replaced the use of formulas or tables for generating discrete probabilities and the emphasis changed to interpreting the output in context. This provides a more level playing field in terms of assessment when students coming directly from school may own expensive graphic calculators which can give an unfair advantage over those without.

We use the LMS from the Blackboard Academic Suite (Blackboard Inc), for interactive examples and for supervised online assessment. Blackboard will be replaced from 2010 by the LMS Moodle, the open source course management system (http://moodle.org). All course material (except videos of lectures which can only be viewed on-campus via streaming) is available on and off campus via the internet and students can work on the course when and where they like.

The three lectures per week followed by an on-line tutorial provide the main pathway through the course. All-day supported tutorials in large computer labs on the days following the final lecture for the week mean students can make use of the space and tutor help. Tutorial rolls are no longer necessary as the students may choose to attend or work on-line in another venue or at a different time. Students in first year (100 level) courses have, in the past, been encouraged to attend tutorials by having attendance count towards assessment. This strategy was intended to enable students to improve by working through problems with guidance and meet other students with whom they might interact and share a learning experience. Attending tutorials, though, did not mean students were engaged in learning the material. Tutor feedback suggested that many students would arrive at tutorials without a calculator and often without even looking over the questions beforehand, despite this expectation being made clear to them by various means. This attitude can be counter-productive to a learning environment and de-motivating for other students in the group.

In our course the tutorials are computer-based and provide the opportunity to practise the material assessed in the skills tests. This removes the need to keep attendance rolls and puts the onus back on the student to improve their understanding and competency by their own efforts. Students are encouraged to help each other, they can view the lectures and annotated course notes as they work through the questions. The students work at their own pace on examples related to the material covered in lectures and tutors are available to help, guide and discuss.

Many students are capable of working through the questions on their own, and may work remotely, meaning the tutors can focus their attention on those students who seek help. Additional regular drop-in help-sessions, initiated as a result of student feedback, are offered on the non-tutorial days with good response from students. Each tutorial selects from a bank of questions and can be accessed as often as necessary to become competent. Skills tests use questions similar to those used in tutorials so the students are clear about what is expected of them.

Designing questions and refining those we had from various sources has been the key to the success of the new course. This is an on-going and evolving process. We prefer to avoid using too many multiple choice questions in the assessed tests, so time has been invested in developing questions that require a numerical input from students to avoid use of guessing strategies.

FEEDBACK AND DEVELOPMENT

The introductory survey mentioned above is available as the students enrol and begin the course. Students are invited and encouraged to participate by adding their responses to the survey questions during the first week of term. Some ideas for relevant and interesting questions came by adapting survey questions from ‘Census at school’ (http://www.censusatschool.org.nz/) an educational link from the Statistics New Zealand official web site (http://www.stats.govt.nz/) and included questions relating to educational background and facility in statistics. The survey finished with “what is your main concern regarding this course?” a question giving students an opportunity to voice any concerns. The data set, presented in an Excel spreadsheet, also formed a starting point for the first assignment. In this assignment students were asked to use Excel to summarise and graph fields of interest, to investigate aspects of the data, and to ask and answer their own chosen questions. Also, other fields from the spreadsheet provided data for two sample hypothesis tests (using the male/female results) when hypothesis testing had been covered.

The mid-course survey asked which aspects of the learning materials were most useful and which were least useful. Other questions asked which aspects of the course helped their learning and asked students for suggestions regarding how we might help their learning and their thoughts on how the course may be improved. As a result of these comments we introduced tutor name

badges and additional tutors to support the busy popular tutorial times. The most and least useful aspects of the course were (not surprisingly) dependent on student learning styles and those thought most useful by some were also least useful for others. A large proportion of the students are keen to contribute and very positive–they appreciate being asked for feedback.

The end of course survey asked for details of students' views on the way the course was run, aspects that were helpful in their understanding, how they now viewed the subject, and their level of confidence in a successful outcome.

CONCLUSION

The student feedback sought at the beginning, middle and end of the course (but before the exam) provided valuable insights into the students, their concerns and their expectations. Students appreciated the support and guidance given by the lecturers and tutors. Those students who had participated in the course in 2008 (unsuccessfully) and were retaking it made positive comments regarding the changes. In particular, students liked being in control of their learning and knowing they could improve their scores on the tests by their own efforts. Next year, data relating to the time spent working on-line on the course and the final mark will be used to introduce scatter plots and association. This should help reinforce the message that time spent working on the course and final grade are related. Many students went into the final exam feeling confident of passing. Encouragingly, students who had expressed anxiety about the subject in the initial survey felt their fears had reduced as the course progressed.

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