

Flexible Learning and Large Numbers (A Case Study)

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INTRODUCTION

The Department of Statistics teaches a suite of equivalent first-year statistics courses which concentrate on providing students with an introduction to data analysis and statistical inference. This is a large and complex operation. In 2002 there were a record 3700 course enrolments in 17 streams spread over 3 semesters and 4 campuses using approximately 14 lecturers, 12 tutors, 17 assistance room tutors, 35 laboratory demonstrators, and about 60 student markers. Current indications are that numbers in 2003 will exceed those in 2002.

To deliver a consistent quality, we have had to adopt a sharing all-one-team culture rather than a model that relied on individuals, however brilliant, working independently. Within the team we have had, and continue to have, a rich variety of backgrounds and expertise. We look for and make a conscious effort to draw on the individual strengths and interests of members to lift the level of creativity and innovation in the production of teaching materials and general presentation. As in any operation involving large numbers of staff, there is considerable turnover. The team is continually revitalised with fresh ideas, enthusiasm and creativity. It is this aspect which can make turnover a boon rather than a burden.

As well as growing in number, our student body has become increasingly diverse in age, ethnicity, English-language ability, mathematical experience, work-schedule and other personal commitments. We have evidence suggesting that only about half of our students have English as their first language, and an almost similar proportion are relatively new arrivals to New Zealand, its education system and brand of teaching methods. Our students range from those who have scored extremely well in the end-of-high-school national Mathematics with Statistics examination, to mature students who may have last studied very elementary mathematics more than twenty years ago and may be using our course as an entry point in their first ventures of formal study.

This diversity creates the necessity to provide a flexible and challenging learning and teaching environment. Our underlying strategy is to provide multiple learning paths so that different types of students can learn in their own ways and at their own pace. Using the variety of skills found in the team, together with advances in technology and its greater than ever accessibility, we have been able to make enormous progress in flexible delivery of courses involving large number of students over the last three years.

LEARNING MATERIALS

The main learning materials used by the students are a lecture workbook, a textbook, the Internet and a CD-ROM. A major feature of our course presentation is the way in which we use and, encourage students to use, these teaching and learning materials in an inter-related manner.

The lecture workbook contains interactive/gapped worksheets for each of the 52 lectures in a course. The purpose of the gapped worksheets is to drastically reduce the preoccupation with copying and note-taking. It provides the students with the opportunity to think about concepts

presented, to participate in discussions and other learning activities, and yet also to have a record of a lecture's proceedings. At the end of each semester, lecturers refine and improve the quality of the workbook as a result of the comments and suggestions made by students and by other lecturers. The lecture workbook also contains course information, assignments for the semester, supplementary readings, extra tutorial resources, a summary and exercise answers for each chapter. The textbook [1] for the course was authored by departmental members Chris Wild and George Seber and recently published by John Wiley & Sons, New York. The text incorporates statistical skills needed in the computer age, research on the nature of statistical thinking, and ideas arising from teaching and assessment experiences.

TECHNOLOGY AND FLEXIBLE LEARNING

Four years ago we lacked the laboratory space to accommodate the number of students relying on us to provide them with computer access. Nowadays, the majority of students have access to a computer at home on which they tend to do most of their work. Advances in information technology (faster processing, greater memory, more user-friendly software, better Internet services, greater tendency for basic multimedia applications to come with computers) have greatly increased our capabilities in production and delivery of some of our learning resources. As the level of students' information-technology literacy continues to rise, we have become more comfortable with assuming a basic level of competency and we can cope with providing a help-service to the small number lacking necessary skills. Today there is almost an expectation from students that a course will have an information-technology perspective. We believe that for an increasing number of students, information technology is rapidly becoming the most preferred method of information gathering and we can exploit that preference when we provide students with a technology-based diverse learning environment.

CECIL

We use Cecil [2], the University's own platform for Internet delivery of resources, course information, communication and administration. It is an innovative, flexible and reliable online system which provides a consistent framework for students to manage their learning across all courses. Cecil can be accessed from anywhere in the world using a browser. Cecil has all the features of other course delivery and management platforms. The feature which generates most favourable comment from our students is the way in which we use Cecil's online test capabilities.

In recognising that an important aid to successful learning is the opportunity for self-assessment and immediate, guiding feedback, we produced a database which contains over 600 items. Each test attempted is a random selection of ten multi-choice questions from a relevant section of the database. We have developed two types of online tests:

- **Learning/Review Quizzes:** These provide comprehensive immediate feedback giving a reason why their choice is correct or incorrect. The student can attempt these quizzes an unlimited number of times. They do not count towards their final grade.
- **Course Work Tests:** These make up a small portion of the final grade. At the end of a test, students receive purposely limited feedback. This includes their mark and topic areas which need further attention. There is a limit of three attempts per test.

The online learning/review quizzes provide weaker students with a safe environment in which to learn. There is no other party involvement, there is no record kept of the number of times a

quiz is attempted or the level of performance. The quizzes can be taken at any time and anywhere the student has access to the Internet.

The five course work tests, due at intervals throughout the semester, aid learning by encouraging students to regularly revise work covered and also provide them with another measure of their progress. The tests, like the quizzes, can be taken at any time (prior to the due date) and anywhere the student has access to the Internet. There is a security issue – we cannot be sure who has taken the test and so we limit the amount of credit to 5% of the final course grade. To offer a secured assessment of this nature would require scheduling and supervising all students in laboratory sessions which would prove difficult, if not impossible, to manage with our student numbers. The tests are auto-marked and results stored without any lecturer involvement.

CD-ROM

As a result of obtaining a University of Auckland Flexible Learning Grant, we produced a “Learning Resources” CD-ROM [3]. The CD was introduced for use in the course at the start of 2002, and it is the centrepiece and culmination of all of the resources that we have created to date. In part, the CD contains many of the resources available on Cecil including standard course resources (in pdf format) such as the filled-in version of the gapped lecture notes, course assignments, previous term tests and examinations, readings etc. On insertion, the CD automatically opens in a web browser to a welcome page with a spoken greeting. The CD is designed to run entirely via a web browser interface and it mimics Cecil’s design in appearance and navigation system. This design consistency provides an explicit link between these two media.

Its raison d’être, however, is a raft of additional resources, produced in an attempt to enhance the learning process, where the resource file size is too large for routine web delivery. The need to connect to the Internet to access Cecil and/or websites is minimised with obvious advantages for the University network, households, and those without Internet access at home. These additional resources include narrated PowerPoint lectures, interactive computer tutorials, and explorative Excel spreadsheets.

Narrated PowerPoint Lectures

Our complete lecture course is presented as animated, narrated PowerPoint presentations [4] which are displayed in a consistent, clear style with a great deal of dynamic graphics. These are viewed in a browser and the content may be conveniently resized to fit the entire screen, or part of it. The lecture content is animated sequentially while narration explains or gives additional background to the information that has just appeared. The narrated lecture plays as a continuous show unless it is interrupted by the student. A list displaying slide titles on the side and buttons (play, pause, rewind, fast forward) at the bottom allow for ease of navigation within the presentation.

Interactive Computer Tutorials

Our course relies heavily on the use of computer programs as tools for statistical analysis. We utilize Excel and MINITAB. In addition to computer laboratory demonstrators and tailored computer program manuals, we introduced over 100 interactive computer tutorials on the Learning Resources CD. Each section of the manuals has a clickable movie icon that opens a “viewlet” [5]: an animated narrated presentation in which the student is shown how to use the computer program by being talked through the instructions, seeing them being performed and

then seeing how Excel, for example, responds. It is as if a student had a personal tutor sitting alongside them, teaching them how to use the program. Students can pause, fast-forward, and rewind each viewlet until they have fully mastered the steps demonstrated. Viewlets are fast being adopted by many businesses, governments and education markets around the world as an effective training tool.

Explorative Excel Spreadsheets

We identified some of the main statistical concepts in the course which many students have difficulties in understanding. We then produced Excel spreadsheets [6] to enable them to investigate these concepts in an interactive way. They can change settings using sliders and watch how the graphic responds.

Some examples are as follows:

- Exploring each type of probability distribution covered in the course. E.g., visually and dynamically illustrating the relationship between the Student's t -distribution and standard Normal distribution by using a slider to increase the degrees of freedom of the Student's t -distribution and seeing the plot of its distribution rise to approach that of the standard Normal's.
- Dynamically finding normal and inverse Normal distribution probabilities via an interactive graph which connects distribution probabilities with shaded regions.
- Interactively engaging with some elementary exploratory plots by dragging existing data points or entering new values into a spreadsheet. This includes: dot plots, box plots and histograms, guessing and fitting the least squares regression line. E.g., the student can grab and move any of the data points on the graph and the summarising least-squares trend line changes position automatically. This gives an intuitive feel for the types of points which have a large (or small) influence on the trend line's position.
- Observing the Central Limit Effect in action. Students select a distribution (triangular, uniform, quadratic U, or exponential) and see its graph. They then choose a sample size and 10,000 random sample means are plotted. By increasing the sample size, students can see the shape of the plot tending towards a bell-shaped symmetric curve.
- Understanding the concept of long-run probabilities via a coin-tossing experiment.
- Trying an interactive version of the infamous Monty Hall problem, while keeping track of the conditional probabilities.

Other

There are a number of other innovative types of learning resource on our CD. One example is a set of little movies illustrating the effect of sampling (particularly on inferences from data) in various situations. These were built by producing a sequence of frames using *R* [7], with time delays between the chunks of information (including narrative information) appearing on screen. The movie was formed using a screen-capture program.

For any topic or concept in a course, there is a vast, potentially overwhelming, array of learning resource sites available on the Internet. We regularly scan the Internet, carefully selecting one or at most two resources which we consider to be the best available for a particular topic or concept covered and provide hyperlinks to these in a chapter-by-chapter listing on the CD.

Production Issues and Problems

The resources on the CD came about after a considerable period of learning which involved experimentation with many systems. The combination of obtaining a University grant and our team model approach gave us the time and space to explore and experiment.

Narrated PowerPoint presentations were chosen over video footage as we felt that the added value of a talking head did not warrant the increase in cost and complexity of production. In addition, the narrated PowerPoint presentations were built on the already existing resources used in lectures. Most people, with a little training, could produce narrated PowerPoint presentations. The sound files were recorded and compressed into mp3 format in order to fit all the lectures onto a single CD. These were then synchronised to the animations in the material.

File security is an important issue, and not just an issue of other universities gaining from the fruits of our labours. These materials will inevitably find their way into local high schools. We don't want incoming students to find them "old hat". There is not much we can do about this except try to ensure that they can only be viewed carrying our branding. We initially used a PowerPoint add-in wizard which turned the presentation and its sound files into a single protected executable file, essentially disabling editing capabilities. However this required students to have access to a computer running Windows and a full version of PowerPoint in order to view the presentations. We, and some students, experienced several problems with navigation. Often when attempting to replay a section of a presentation, the soundtrack synchronisation would be lost.

We located Wanadu's [8] new ICreate software that converts PowerPoint presentations into Flash format, providing platform independent delivery. Image and sound quality were excellent, and there were none of the previous navigation problems. The presentations are viewed in a web browser with the free Macromedia Flash Player plug-in. NPD Research [9] in March 2003 found that over 98% of web users can now experience Flash content without having to download and install the plug-in.

To produce multimedia software training, we originally experimented with video-editing screen-capture systems. We had problems with the time taken to produce files, video quality, output formats, final file sizes and portability across platforms. We researched alternatives and chose Qarbon's screen-capture software, ViewletBuilder [10]. This initially produced Java applets, but now outputs in Flash format, enabling platform independent viewing via the Internet or CD. We found it straight forward to add synchronised narration to these viewlets and we were impressed with the quality and functionality of the final product.

While there are many Java applets available on the Internet, we chose to develop our interactive spreadsheets using Excel. This allowed us to adapt and build on the already existing interface and code to create new materials in an extremely short period of time. Furthermore, the level of expertise required to produce these spreadsheets is a lot less than that to program in Java.

Thousands of students have already used our Learning Resources CD and only a very small number have expressed problems when trying to use it. We acknowledge that there will always be such problems brought about by, for example, out-dated and/or incompatible computers. We focused on the largest market – PC computers and tested on a variety of configurations. Aside from a browser with the Flash plug-in, the other main software

required to fully use the resources are Microsoft Excel and the free Adobe Acrobat Reader (provided on the CD).

Our course material is continually being updated and refined. Due to the inter-related nature of our resources, this evolution creates considerable (initially unforeseen) work with substantial associated costs to propagate the changes. Efforts need to be made to find ways of working to minimise these additional maintenance costs.

Each semester an updated version of the CD-ROM is produced. Remarkably, the cost of CD-ROM duplication itself is now relatively small, e.g., the production cost of a single copy of the CD is less than the cost of a photocopied thirty-page version of a single resource provided on the CD.

STRATEGIES AND SYNERGIES

Students are provided with all of the materials at the beginning of the course (via Cecil, CD and Lecture Workbook) so that they can decide for themselves whether to work on their own at their own pace (suitable and strong warnings are given) or to have the stimulus of daily classes. The do-it-yourself option applies mainly to confident learners, who could choose to attend some lectures and miss others. This option could also benefit those students with work commitments, lecture clashes, or those who are unable to attend lectures for personal reasons. Students who learn primarily by reading could obtain all of the course content from the textbook. Those who need a simpler account could obtain this from the lecture notes. Visual or oral learners could make repeated use of the narrated lectures on the CD and our interactive spreadsheets.

However, we have found that most students still come to class. In the main, they use the narrated PowerPoint presentations on the CD for previewing or reviewing a lecture (the PowerPoint lectures on the CD are the same as those used in the live lectures) and for the small number of times when they are prevented from coming to class.

Many teaching strategies are used throughout a lecture. Over time, and with the increasing availability of technology, we have been able to extend our repertoire of teaching strategies. These are aimed at building understanding of statistical concepts, making connections between different representations, stimulating students' statistical thinking, and providing interest and motivation. The basic PowerPoint lecture material, which allows students to complete their gapped notes, is supplemented by:

- lecturer stories about the data-set under consideration to reinforce that statistics involves learning more about the context;
- experiments whereby data is collected from students in class to demonstrate a statistical concept;
- live demonstrations of MINITAB or Excel software often using real data from an online survey [11] of the students themselves. This recent innovation not only generates data that is interesting to students but also allows them to learn how to manage and explore moderately large data sets in a computer environment (the students can and do download the web survey data to use themselves);
- some of the explorative Excel spreadsheets are introduced and demonstrated in class in the hope that students will be motivated to investigate and learn from these resources themselves;
- video-clips that demonstrate a real world problem and the statistics used to analyse it;

- animated JAVA applets for demonstrating statistical concepts dynamically.

Instead of in-class coverage of some areas of content, some lecturers direct students to the CD's narrated lectures for an equally effective delivery.

Using a variety of innovative teaching methods to engage and motivate students can dispel a widely held perception that Introductory Statistics is 'unexciting'.

Distance Learning

In 2002 we ran a pilot distance learning course in which we sought and obtained a small group of practising secondary school teachers who wanted to improve their skills for the purpose of teaching the Year 13 Mathematics with Statistics course. An activity planner was carefully designed to encourage these students to engage in their studies on a regular basis. It also made them aware of the different learning resources available and when it was timely to use them. Some of the students primarily used email contact to obtain assistance/clarification while others made use of an after school drop-in service. We also offered three on-campus meetings during the course. The first was held in a computer laboratory providing the opportunity for members of the group to meet and to be introduced to the workings of the CD and Cecil.

"The course was just what I needed. It was imperative that I brushed up my personal skills so that I had the confidence required to front a classroom of 17 year olds. I did not have the time to attend regular lectures but was able to study at the computer at home when the time allowed. The lectures on the CD were excellent and it was like being in a lecture theatre without any of the hassles of getting there. At the back of the workbook was a planner with the weeks set out to cover the lectures, assignments, tutorial exercises and tests and I was able to keep to this to avoid getting behind. I also appreciated the assistance given from the University. I received e-mail messages with reminders and encouragement. I was able to phone for guidance with assignments and other queries. The benefits of this course were invaluable for my teaching of Statistics. The textbook, lecture workbook, CD and lecturer on standby, were useful when I was unclear on anything I needed to teach in the classroom but also I was able to give the other stats teachers at our school the inside story about the way things are done at the University – terminology etc – which will assist our students in the transition."

Mathematics High School Teacher

STUDENT FEEDBACK

The team values all forms of feedback as a means to 'close the loop', respond to students' needs, discuss and address any issues or concerns, and improve on current practices. Student feedback and evaluation is obtained formally via the University's teaching and course evaluation system and in meetings with class representatives. Informally, quick in-class three-question surveys, frequent spontaneous emails from students and online surveys provide valuable insight.

The team has found solutions to real problems and issues presented by students. For example, an online survey offered students the choice of 5 assignments or a combination of 2 longer assignments and the online Cecil tests. Their response indicated a preference for the latter, and that is what we did.

At the end of the semester in which the CD-ROM was first included as part of the course learning materials, we conducted an online survey [12]. This was an attempt to evaluate student usage and opinions on the value of the resource. Approximately 700 of the 2000 or so students responded. Of those responding, 60% used the narrated lectures occasionally and 32% used them often. The free-response comments made by our students in the final section of the web survey ran many pages. Virtually all of the comments were highly positive. The few negative comments referred mainly to technical difficulties experienced by a small number of students.

A selection of the more positive comments which convey the variety of ways students use the CD to support their learning follows:

“This was the only course that I have taken so far that provides a lot of excellent resources to help students through, particularly Cecil tests, review tests... As a student I can't ask for anymore.”

“Just thought I'd let you know that I am thoroughly impressed with the structure of the Stats101 class. Excellent resources (full Internet support, great coursework and lecture manuals) and concise and well taught lecture material. Definitely the most professional university course I've undertaken so far! Great work to the Stats Dept!”

“I think the Cecil tests are a really good revision tool and the assignment was great for helping me understand the material and apply it. Stats is the most smoothly run course I take - I always know exactly what is going on and what I have to do.”

“The paper which I completed still rates as one of the most organised papers I have been enrolled in, not just as a mature student but also in the previous degree I completed. I am sure that you will continue to refine the way in which you run this paper given that you seem to continually seek feedback from the students. As a ‘coach in training’ I look forward to being able to encourage other mature students to take on the statistics course. I have a new appreciation for statistics and its relevance.”

“I found this CD so far hugely valuable. A couple of times when I was unable to attend lectures due to illness, the lectures on the CD kept me right up to date and made returning a lot easier as I was ready to get back to work as soon as I got back... I would like to congratulate the Stats team on being so modern in their teaching approach. Many other faculties would be wise to look at the way you have created resources which are relevant and easy to access and which add to the learning process.”

“Best learning aid I have ever seen at University. I like the narrated lectures because if you miss a lecture or are not clear on something, no need to panic because you can go over things again in your own good time. Brilliant.”

“I liked it very much, it's just like a private tutor in my room.”

“I have found the narrated lectures invaluable for revision and assignment work.”

“I really liked the CD resource, I failed stats last year and so far I am doing above average. This is all thanks to the CD resource. It allows me to catch up on missed lectures, enables me to use the narrated lectures to go over what I did not get in the lectures again.”

“I think it was very well thought out... At the moment I am laid up with two (yes it's true) twisted ankles and I am unable to make it to lectures so having the lectures on the CD means I won't miss out on anything and it also means I can rehash anything I need to go over again. Good work.”

“It is very useful as I don't always have time to go to lectures (as I am third year and this is my eighth paper) and I also work during the day. I find that I can miss lectures and not miss anything as everything so far seems to be on the CD. It is a great resource and definitely worth paying the money for.”

“I like the CD very much as I'm a foreign student. Sometimes it's hard to understand the English of the lecturer, so I really stick with this CD. It's very helpful to me.”

“The narrated lectures are a great idea. I wish I could have one for all my subjects!”

“This CD is like one of my most valuable things this semester. Especially for assignments when you need the manuals. Saves you carrying around papers and books in your bag.”

“I found the CD really helpful, particularly the MINITAB manual, really good stuff. It's also very comprehensive - effectively it gives me enough resources to pass the course without leaving my computer. I think it's really good and can only wish my other courses had a comparable resource. Cheers!”

“I liked the narrated lecture material on the CD so you can do fill-ins before the lecture and concentrate on what the lecturer is actually saying during the lecture”

“The narrated lectures on it were excellent if you didn't understand something/you missed a class.”

Comments such as these provide us with evidence of the many benefits enjoyed by students in a very flexible learning environment.

WHERE TO FROM HERE?

We will continue to update and improve our current set of resources. We have recently formalised a process for monitoring journals, periodicals, Internet sites, and other media publications. We will funnel good teaching ideas, teaching materials, advances in technology, data sets, examples and stories into our teaching and learning resources reservoir. The team will continue to turn over and we will maximise the use of the skills, ideas and creativity of its new members.

Next year we will offer a distance learning course and this time target a larger group than in 2002: Mathematics teachers wanting to improve their statistical background, well-prepared high school students, and on-campus students who are attracted to the advantages of a full year (rather than semester) no-lecture course delivery.

We have just completed a version of the narrated PowerPoint presentations in which the soundtrack alone is translated into Mandarin [13]. This resource aims to help ease the transition of our large cohort of Chinese students into instruction wholly in English. The

initiative for this project came as the result of a response to student suggestions followed up by an online survey of demand and has been largely funded by a University Teaching Improvement Grant.

We have just started a project which will apply what we have been discovering about flexible learning environments to our second year data analysis courses. One of the desired outcomes is a CD-ROM containing resources similar to those found on the first year's CD including a set of narrated PowerPoint presentations of the second year's lecture material.

The team received The University of Auckland 2002 Excellence in Teaching Awards in the Sustained Excellence and Collaboration categories. It has just recently been announced that we have also received a New Zealand Tertiary Teaching Excellence Award for 2003. These awards have given us exposure and as a result have already generated considerable interest in those learning resources which have the potential to be useful to developers in other courses. We have been and will continue to share what we have learnt, especially in the technology field, through talking informally with staff in other departments and formally in University seminars and professional development computing workshops.

CONCLUSION

The productivity advantages of a highly collaborative approach to teaching have, over the last three years, allowed the team to produce an extensive set of innovative high-quality flexible-learning materials. Individually or as an integrated package, our learning resources are designed to meet the needs of a wide range of students working under a wide variety of constraints and to significantly enhance learning. Technology provides us with the means of producing resources which allow for multiple learning paths and which would not have otherwise been possible with our large student numbers. Because of their different learning styles and circumstances, students are making use of these resources in a variety of ways. But we have found it reassuring that, offered a free choice, most students continue to choose a rich, human, lecture-room environment over a machine! Extremely positive student feedback motivates us to continue on this path and to keep abreast of advances in the Internet and broader technology so that we can exploit the opportunities that they provide to better serve the diverse learning needs of our students.

Website References

- [1] <http://www.stat.auckland.ac.nz/~wild/ChanceEnc/index.shtml>
 - [2] <http://www.cecil.edu/html/about.htm>
 - [3] <http://www.stat.auckland.ac.nz/cd/>
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