Tertiary Teaching Excellence Awards 2003

Nomination for

The Stage I Introductory Statistics Team
Department of Statistics
The University of Auckland

Category Three: Excellence in Collaboration

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1 THE UNIVERSITY OF AUCKLAND'S INTRODUCTORY STATISTICS TEAM AND ITS TEACHING

The Stage 1 Introductory Statistics Team 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 this team taught 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.

The Stage 1 Statistics team has to cope with enormous diversity. Our students range from students who have recently scored in the 90% range in Bursary Mathematics with Statistics, to mature students who have seen no mathematics since the 5th Form more than twenty years ago. Students with various disabilities also enrol in Stage I courses. Diversity encompasses differences in age, experience, ethnicity, gender, and English-language ability. Our surveys suggest that only about half of our students have English as their first language. A student body with different experiences, abilities and backgrounds creates a diverse and challenging learning and teaching environment.

The courses taught are:

- STATS 101: Introduction to Statistics
- STATS 102: Statistics for Social Science
- STATS 107: Statistics for Science and Technology
- STATS 108: Statistics for Commerce
- STATS 191: Quantitative Methods for Business

Enrolment growth in these courses over time:

1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
1385	*1940*	*2193*	*2278*	*2589*	*2773*	*2909*	*2918*	*2917*	*2992*	*2643*	*3112*	*3741*

2 BACKGROUND AND AIMS

In the early 1990s, Chris Wild and Chris Triggs became interested in applying continuous improvement ideas to Stage 1 statistics. Then, as now, we were teaching large numbers with stretched resources. Our operation involved large numbers of people and considerable turnover. How could you deliver continuous improvement in such an environment? On first reflection it seemed almost impossible.

We soon realised that to deliver quality we had to adopt a team model rather than a model that relied on individuals, however brilliant, working independently. Having one stream of one course taught superbly to one group of students in one year by a truly outstanding teacher is of little help in achieving continuous quality improvement through time in the larger system. Our aim was to find ways to seal enhancements permanently into the system as a whole so that the courses improved each time they were taught, regardless of who taught them.

It gradually became clear that for a system with sufficient memory to retain the most important contributions from those who move on, turnover is a boon rather than a burden. It continually revitalises the team with fresh ideas, enthusiasm and creativity. Within the team we have had a rich variety of expertise — in statistical theory, in statistical consulting from a succession of experienced professional statisticians, in research skills, in teaching experience in the university environment and in the teaching skills of superb trained teachers who have come to us from the secondary school system. We have found ways to exploit our diversity and blend this rich variety of expertise with the freshness and enthusiasm of senior PhD students and staff with technological skills. This has enabled us to build a set of learning experiences for students immeasurably richer than any of us could ever have produced alone.

Our early thinking and practices in this regard, developed by adapting quality management principles, were sufficiently innovative to be the subject of a number of invited talks, including one to the American Statistical Association in 1994, and an invited paper for the *International Statistical Review* (Wild, 1995). The University of Auckland conferred a Distinguished Teaching Award on the team in 1995. The degree of collaboration has grown steadily over the decade from a set of largely autonomous teachers who began sharing some of the resources they had developed independently, to the current system in which almost all of the time invested in preparing teaching materials goes into building a common product for the benefit of all.

The team's approach to improving the quality of first-year statistics education at the University of Auckland is holistic. It extends from improving high school statistics education through teacher development workshops and a period of management of the bursary examination, to producing a whole package of innovative teaching, learning and flexible learning materials, to our own textbook published by a prestigious international publishing house. In addition the team has established systems that maximise the long-term benefits of collaboration and scaffold and enculturate beginning teachers, and carried out fundamental research in statistics education to guide our teaching and spark the innovations that will enable us to sustain and enhance excellence for the future.

To summarise, the aims of the collaboration are to harness team diversity and creativity to achieve continuous improvement in the set of Stage 1 statistics courses, and to use this as a mechanism for achieving excellence in all aspects of delivery of the courses.

3 DESIGN FOR LEARNING AND BENEFITS FOR LEARNERS

3.1 Design for Learning

On the one hand, the need for statistical methodology (often advanced methodology) is penetrating the research fabrics of most other disciplines to a greater and greater degree. On the other hand, and at a much more basic level, the importance of statistical literacy as a key educational outcome in preparing students to become more informed citizens and workers who can function effectively in an information-laden society is being increasingly recognised. For adults to participate in society, public debate, or action regarding national or community issues they need to be able to evaluate statistical information and data-based arguments and to discuss their opinions regarding such information.

Our aim is to address these dual needs to the best of our ability within the constraints under which we operate. Our goals in helping prepare students to understand research findings and carry out research are informed by the expressed or inferred needs of client departments and the experience of the

statistical consultants who have been members of the team. We are service oriented and focused on the needs of students and client departments.

Statistical service courses world wide began as watered down statistical theory courses. They emphasised cook-book recipes and the mechanical use of formulae for hand-calculator computation of statistical quantities. They were seen as second rate and boring. They *were* second rate and boring. It has taken some time and the advent of easy to use computer packages for the realisation to dawn that what is required is an almost entirely different course to build skills in scientific thinking, data production and analysis grounded in the whole investigative cycle from posing questions to drawing conclusions. The thinking required is as subtle as any in a theory course, probably more subtle. Everybody has been traversing this route, but we have been interested in taking it to its logical end and researching its requirements.

There have been obstacles in our way. Four years ago we lacked the laboratory space to accommodate the large number of students wanting to use computers. Most course streams were still calculator based. We have overcome these problems with a comparatively modest increase in laboratory space and computers, and by using software solutions that allow most of our students to do most of their computer work at home.

In our teaching and assessment, we attempt to stimulate real thinking and minimise rote learning. We have to challenge and convert students who enter our courses thinking that the core of statistics is finding some numbers to put into an appropriate formula, and that all the rest is time wasting distraction to be screened out.

Research-based Teaching

Advancing technology is progressively shifting the balance of 'what is worth learning' for the majority of students from the operation of mechanical procedures towards the 'art' of statistics. Statistics education has, however, been rather slow to respond. Good applied statistics is an art. Its creative heart is the development of new understandings about context realities using data in the form of measurements, categories and counts. The educator's problem is that the reasoning processes that professional statisticians use to do this is much more an osmotic product of experience, war stories and intuition than of any formal instruction. So, insofar as these processes are understood, they are understood at a vague, intuitive level, and are largely unexamined and unarticulated. So how can we transmit some of this to beginning students?

Starting from the broad, largely philosophical musings of Wild (1994), we have undertaken a great deal of research, mainly qualitative research with statisticians and students at various stages of development, aimed at characterising how statisticians think and solve problems – learning to articulate the important aspects of statistical problem-solving that 'everyone knows' but seldom articulates – to make the implicit more explicit to inform systematic teaching strategies.

Although the main researchers have been Maxine Pfannkuch and Chris Wild, this research has historically involved other team members, has been stimulated by the needs of Stage 1 teaching and many conversations with team members over the years, and the results have been fed back into the teaching. Ongoing projects are involving the whole team, and in particular Matt Regan and Ross Parsonage.

- **Statistics Education Research**

Of all the ways of stimulating innovation, educational research tends to be the one with longest time lag to practical benefits, but the one with the most potential for making really fundamental improvements. The Stage 1 Introductory Statistics Team continually seeks to improve the course through its own research. Below are two examples of how our research has been used to improve our

practice. First, our research has had a great influence on the content of the course and the natures of the tasks we ask students to undertake. In turn, this has been of significant benefit to students in understanding the nature of research, how it is carried out and the possibilities it opens for them. Our textbook drew on our research into the nature of statistical thinking (Wild & Pfannkuch, 1999; Pfannkuch & Wild, 2000). This research involved interviews with practising statisticians and undergraduate statistics students and drew on historical, statistics education, and statistical literature. The international reviewers commenting on the textbook have remarked on the way in which the book conveys the essence of statistical thinking.

'This excellent introductory text teaches what practising statisticians know but what many fail to convey to the students, namely, statistical thinking. It should be required reading for anyone embarking on a career as a statistician or in any field where critical evaluation of data is required. …. In writing this book the authors have performed a real service to the profession. The book is highly recommended.'

— *The International Statistical Institute's 'Short Book Reviews'*

'the authors are to be congratulated on a superb book. For several years, Introduction to the Practice of Statistics by Moore & McCabe (1999) has been the recognized benchmark to which other books aspire; Wild and Seber have now raised the standard of introductory textbooks another notch!'

— *The Australian and New Zealand Journal of Statistics*

[Moore & McCabe is an American text that first appeared in 1991. The 3rd edition was published in 1999.]

The full text of these reviews, and further reviews, is given at
http://www.stat.auckland.ac.nz/~wild/ChanceEnc/index.shtml

An extract from an unsolicited communication between a student, who is also a secondary teacher, and her lecturer, Maxine Pfannkuch, makes very similar points.

'Statistical thinking is encouraged in the textbook more so than in the lecture notes and again it must be stressed how remarkably well the authors have achieved a conversational style of writing this book. They also illustrate each nuance of statistical thinking by providing relevant and topical examples. … The wide range of examples is an equally useful method of writing as it disallows boredom and points to the vast range of areas in which statistics is being used. … It helped to put the statistical methods in perspective by enabling me to see the big picture and make connections.'

Second, our research is influencing new developments in the course. For example, research revealed problems in Stage 1 Statistics students' interpretation and evaluation of statistically-based media reports (Pfannkuch, 1996). Drawing on this and other international research, a new teaching unit has been introduced on the interpretation of statistically-based media reports. The implementation of this teaching unit is part of an action-research study that will investigate students' statistical literacy learning and the teaching process. This research will allow us to comment on whether the course is effective with regard to improving students' statistical literacy.

The delivery of the Stage 1 Statistics course also draws on statistics and mathematics education research. For example, using a number of different contexts, real data sets, and experiments, new content is introduced and from these experiences new theory and generalisations are formulated. This type of learning called *guided reinvention through progressive mathematising* is advocated by Realistic Mathematics Education learning theory. Other research including our own (Pfannkuch & Brown, 1996) has consistently shown that students' probabilistic and statistical intuitions are unreliable and hence one of the teaching suggestions is that before experiments are performed students should predict the outcome, a practice that is followed in Stage 1 Statistics.

- **Statistical Research and Consulting**

Since the Stage 1 Statistics Team has members from various fields of statistics who work in a variety of application areas, it has been able to influence the curriculum by incorporating new advances in

statistics and more applicable statistics. Thus the team and students are constantly learning new statistics. Sometimes teaching needs have led to new methodological research by team members to address a perceived gap (e.g. Wild and Seber, 1993). A number of innovative techniques are included in the textbook. Occasionally we have written them up for journal publication (e.g. Pfannkuch, Seber, and Wild, 2002).

To give a concrete example of how practical consulting experience informs the course and benefits students, this semester we have a team member who has just completed 5 years post-PhD working as the senior statistician for one of New Zealand's leading market research companies. He is drawing on his experience to work over the marketing thread running through the business sections of the course to improve the usefulness of what is being taught and the examples and case studies used in terms of their real-world immediacy. The heart of statistical thinking is the interplay between problem, data and real-world context, so we always endeavour to use examples that are real, relevant and address interesting questions.

3.2 Benefits for Learners

The main ways that learners benefit from the collaboration are:

- *A better targeted curriculum*
- *Better and more up-to-date real-world examples*

These arise from rotating people with varied expertise through the course and capturing their improvements as illustrated above. Another example is our involving of lecturers from the Psychology Department (an important 'client' department) in a similar way.

- *Better teaching*
- *Consistency / fairness to students*

Our systems provide huge levels of support for teachers and improve a teacher's 'performance' as experienced by the students. They also minimise the consequences for those students who end up 'in the stream with the worst teacher'. We document this in the next section. Consistency and fairness is also strengthened by having assessments thoroughly worked over by many experienced teachers and common assessments across the courses.

- *A richer variety of classroom activities*
- *Vastly improved teaching materials*
- *High-quality electronic and interactive learning aids*
- *More flexible learning and assessment environments*

The old adages of 'many hands make light work' and 'divide and conquer' make good sense but are seldom acted upon. The productivity advantages of collaboration have over the last three years, in particular, allowed the team to produce learning materials that are, we believe, second to none internationally in range and quality. With current trends significantly exposing local education providers to international competitors, there are advantages both to providers and the country of having top quality educational materials that are local intellectual property. The range of teaching materials used by the Stage I Statistics team has been developed using innovative and collaborative approaches. Individually or together as a teaching 'package', they are designed to meet the needs of a wide range of students and significantly enhance learning.

3.3 Teaching Materials

The main teaching materials used by the lecturers in the Stage 1 Statistics course are the Lecture Workbook, Lecturer Information and Resource Manual, lecture presentation resources, and the textbook. All these materials have developed over a long period of time, based on a philosophy of systematic evaluation and change through collaboration and innovation. The building of a sharing, all-one-team culture has led to creativity and innovation in teaching material resources since the team has drawn on the individual strengths and interests of its members. The current resources now contain the collected experience and expertise of a large and diverse team of people. Below the main teaching resources are described and their development briefly discussed.

- **Lecture Workbook**

The Lecture Workbook contains an interactive / gapped worksheet for each of the 60 lectures in a course. The purpose of this material is to enhance student activity and discussion in a lecture and drastically reduce the preoccupation with copying and note-taking in a lecture. 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. Lecturers have developed the material for this workbook individually or in pairs since 1994. At the weekly team meetings, ideas and material are shared amongst the lecturers. Through the sharing of ideas about learning strategies, lectures are designed to include:

- experiments designed for use in a large class/lecture situation as a means of conveying concepts
- exercises for small group work in a large class/lecture situation
- relevant readings from newspaper articles and other media
- a major emphasis on real-world data-sets
- continual referencing to the course prescribed text for further readings

At the end of each semester, lecturers refine and improve the quality of their handouts as a result of the comments and suggestions made by students and by other lecturers. An increasing number of lecturers share and use each other's resources. In 1998, Matt Regan presented his worksheets in a workbook format. By then the same resource was being used by a number of lecturers. By the end of 1999 the lecturers agreed to use the same workbook rather than have individual lecturers presenting their own material. It was considered that this would be an efficient use of resources, use the best practice of the team, and allow time for more effective development of technological resources (see Technology and Flexible Learning below).

Over the 1999–2000 summer period, Matt Regan, Ross Parsonage, and Joss Cumming undertook a major updating of all the course materials, student resources, and lecturer resources. Stimulated by the new textbook and the new availability of laboratory facilities, there was a large-scale de-emphasising of hand-calculations and use of tables, and a primary emphasis was placed on computer usage and the interpretation of computer output. For the first time, a universal student *Stage I Lecture Workbook* and a *Lecturer Information and Resources Manual* was presented to the Stage I Teaching Team for use in Semester 1, 2000.

This pooling of a set of innovative materials from individual lecturers, some of whom had developed their own individual gapped lecture shells and handouts, changed the course from individual ownership to team ownership. This lecture workbook is reviewed every semester with lecturers and students providing suggestions for improvement and new material for incorporation. At the end of each year the workbook is updated and changed in the light of the feedback received.

Besides the lecture note material, the student lecture workbook contains information about the course, the lecture schedule, an overview summary of each chapter, the assignments for the semester, supplementary readings, and extra tutorial resources and answers for each chapter.

- **Lecturer Information and Resources Manual**

Paralleling the development of the Student Lecture Workbook has been the development of the Lecturer Information & Resources Manual. This manual has also finally become truly 'team-owned' as a result of shared efforts over the 1999 – 2000 summer period. It contains:

- a day-by-day lecture schedule for the semester.
- *Guidelines for Lecturing Chapter X* (chapter-by-chapter) which include for each chapter: chapter aims, specific learning objectives, learning resources, and suggested teaching approaches.
- some background readings for lecturers: stories to tell in class, etc.

- **Lecture Presentation Resources**

Many teaching strategies are used throughout a lecture. These teaching strategies have developed over time. Originally we used video-clips and class experiments but with the increasing availability of technology we have extended our repertoire of teaching strategies. Our teaching strategies 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:

- video-clips that demonstrate a real world problem and the statistics used to analyse it;
- experiments whereby data is collected from students in class to demonstrate a statistical concept;
- lecturer stories about the data-set under consideration to reinforce that statistics is learning more about the context;
- live demonstrations of Minitab or Excel software often using data from an on-line survey of the students themselves. This recent innovation not only generates data that is interesting to students but also allows them to learn how to explore moderately large data sets in a computer environment (the students can and do download the web survey data to explore themselves);
- animated JAVA applets for demonstrating statistical concepts dynamically.

- **Test and Exam Booklet**

Each semester a booklet of past tests and exams, together with answers, is made available to students. The course philosophy is that the assessment process is open and students should know how they will be expected to demonstrate their knowledge and the nature of the questions that will be asked.

- **Textbook**: ***Chance Encounters: A first course in data analysis and inference.***

Between 1994 and 1999, the Statistics Stage 1 courses were taught from a draft text by Chris Wild and George Seber printed locally. During this time the text was substantially rewritten as a result of changing conceptions of the statistical skills needed in the computer age, research on the nature of statistical thinking, feedback from team members and from classroom and assessment experiences, and ideas from team members discussed in our pedagogical team meetings. The textbook for the courses was published by John Wiley & Sons, New York in late 1999. Many team members read and commented most helpfully on its various drafts. Extracts from reviews are given above.

3.4 Technology and Flexible Learning

The increasing diversity in age, culture, language, work-schedule and commitments of today's students creates the necessity to provide a diverse learning environment. Our capability for catering for such diverse needs has also increased dramatically. After a considerable period of learning and exploration, we have made enormous progress in this area over the last three years.

- **Cecil**

The University of Auckland's platform for web-based delivery of learning and assessment resources is called Cecil. We use most features of Cecil including the chat facilities. The feature which generates most favourable comment from students is the way in which we use Cecil's on-line test capabilities. We have produced a question bank which contains over 600 items. Each test attempted is randomly generated from a subgroup of the data bank. We have developed two forms of tests:

- **learning and review quizzes** in which after every question attempted there is comprehensive feedback giving the reason(s) as to why their choice is correct or incorrect before proceeding to the next question. The student can attempt these review quizzes, which carry no course work marks towards the final grade, an unlimited number of times.
- **course work tests** which carry course work marks towards the final course grade. These tests give limited feedback to the student at the end of the test and there is a limit of three attempts per test.

'This was the only course that I have taken so far that provides a lot of excellent resources to help students through, partic Cecil tests, review tests . . . As a student I can't ask for anymore.'
Open-ended item: FFQ-Course, STATS 108 ST 2002 student response.

- **The CD-ROM**

Our CD-Rom, introduced for the beginning of 2002, is the centerpiece and culmination of all of the resources that we have produced to date. In part the CD is a replica of the Cecil site containing 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. 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. An invited article about these new materials by Rachel Cunliffe (who contributed most to making these ideas a reality) is to appear in *MSOR Connections*, the journal produced by the LTSN Maths, Statistics and OR Network, a subject centre of the British government sponsored 'Learning and Teaching Support Network' and they are to be presented at the Conference on Statistics and the Internet in Berlin in August. These materials include:

- **Narrated PowerPoint Lectures**

Our *complete lecture course* is presented as *animated, narrated PowerPoint* presentations which are displayed in a consistent, clear style with a great deal of animated graphics.

Adding synchronized narration to each lecture was a lengthy and involved process. We chose to offer narrated PowerPoint presentations over video footage as we felt that providing a person's face would add little value to the delivery of our course content. Creating video lectures would considerably increase the cost and complexity of the project. This summer, we found and purchased a new product that translates Powerpoint into Flash to be played through a browser (e.g. Internet Explorer), thus removing the need for students to have Powerpoint while maintaining the quality of image and

narration. Additionally, we have almost completed a version in which the sound track is in Mandarin as a means of helping ease the transition of our Chinese students into instruction wholly in English.

Rachel solved the problems involved in using compressed mp3 sound files with Powerpoint (necessary to get all of our lectures onto a single CD). At Microsoft's request, Rachel's set of instructions on how to do this was included on one of Microsoft's technical websites.

- **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 interactive computer tutorials on the Learning Resources CD. Each section of our manuals has a clickable movie icon that opens a 'viewlet' - an animated narrated presentation in which the viewer is talked through the instructions, sees them being performed and sees how Excel, for example, responds. There are over 100 of these little movies on the CD.

Viewlets are fast being adopted by many businesses, governments and education markets around the world as a way of training people. It is as if a student had a personal tutor sitting alongside them, teaching them how to use the program. Students may fast-forward and rewind each viewlet until they have fully understood the steps required.

- **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 to enable students to investigate these concepts in an *interactive* way. Students can change settings using sliders and watch how the graphic responds.

There are a number of other innovative types of learning resource on our CD and Cecil site. 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 through time using a statistical plotting programme, with time delays between the chunks of information (including narrative information) appearing on screen. The sequence was captured using a screen-capture program to form the movie.

We have also regularly explored the web looking for good learning resources and made the most effective of them available to our students.

3.5 Our 'Multiple Learning-Paths' Strategy

Our strategy is to provide multiple learning paths so that different types of learners can learn in their own ways and at their own pace.

The team provides all materials to the students at the beginning of the course (via the CD and Lecture Workbook) so that they can decide for themselves whether to work on their own at their own pace or to have the stimulus of daily classes (suitable and strong warnings are given). The do-it-yourself option applies mainly to confident learners, who can choose to attend some lectures and miss others. We have also found that this option can benefit those students with work commitments, lecture clashes, or who are not able to attend lectures for personal reasons.

Students who learn primarily by reading can obtain all of the course content from the text book. Those who need a simpler account can obtain this from the lecture notes. Visual/oral learners can make repeated use of the narrated lectures on CD and our interactive spreadsheets.

In lectures themselves, we try to approach concepts using written, oral and visual/graphic means simultaneously to cater for different learning styles.

The Stage I Statistics Team collaborate with the Student Learning Centre in the running of introductory/bridging workshops in some of the breaks before semesters, within semesters and just before exams. These give students from weaker backgrounds, students who have never studied statistics, or mature students returning to University level study, an 'entry point' into Stage I statistics.

We have a range of methods to offer assistance and encouragement for students enrolled in our papers. We have drop-in help facilities in Assistance Rooms running for over 40 hours a week and in Computer Labs running for over 60 hours a week. Students can book half-hour time slots with student advisers. Lecturers generally have an 'open-door' policy in addition to posted office hours, and lecturers and tutors provide support by email.

Should the need arise, the team can provide the visually impaired with large-print versions of teaching materials.

Our students are diverse in terms of ethnicity and gender, but also in terms of experience. Many of our mature students with limited prior mathematical education are women returning to study psychology later in life. They have to work really hard, and some find it a real struggle. A pleasing number, through hard work (and through making full use of our different teaching materials) come out with A's or A+'s and a huge sense of accomplishment.

- **Ethnic Diversity**

The Department of Statistics runs a Maori and Pasifika support service jointly with Mathematics, staffed by 2 Maori and Pasifika tutors. These tutors conduct special tutorials, have devised and run a student mentoring scheme, and provide help on a one-to-one basis. The facilities consist of two resource rooms containing computers, work space, lounge space, and tea and coffee making facilities.

The Stage 1 Statistics Team liaise closely with the Pasifika and Maori support teams. One of the Maori and Pasifika tutors attends team meetings. Some of our lecturers speak languages such as Mandarin.

The senior students who act as Assistance Room tutors and computer laboratory demonstrators speak a variety of languages that reflect those in the student body. From this semester, every Stage I Statistics lecture is available with a Mandarin sound track.

- **Engaging all Learners**

Using innovative teaching methods to engage and motivate students can dispel a widely held perception that Introductory Statistics is 'unexciting'. The Stage I Statistics Team have, over time, created an array of techniques to stimulate interest and enthusiasm. For example, we often use data in our lectures from on-line surveys of the students themselves, so that they are interested in what the data says and have a feeling of ownership. Live demonstrations of software and video-clip presentations are used in lectures. Student participation is encouraged, and we are always on the lookout for high-interest current issues from the media to provide a 'real world' context.

Course content is continually updated, and a lot of effort is put into exam / term test question contexts (new, real and interesting data stories) which students then use as learning resources for a three-year period before they are retired.

3.6 Assessment

On-course assessment consists of assignment work and on-line testing as discussed above. In assignments, there is an important emphasis on communicating statistical ideas coherently as well as

on computer use and data analysis. Our tests and examination make heavy use of multiple choice as one way of coping with our numbers. This is not easy when you are interested in contextual understanding and interpretation in addition to more mechanical tasks. We have written at length about the ways in which we use traditional means to address non-traditional ends in our invited chapter, Wild, Triggs & Pfannkuch (1997), in the only book ever published on assessment in statistics.

Among the points argued and exemplified in the paper are the following:

- Begin by collecting a file of real stories/data sets that, ideally, are context rich.
- Present the background, data and a fairly large array of numerical and graphical summaries derived from it as a complete package.
- Try to ask as many questions from the same story as possible, letting the story/data/situation suggest the questions.
- Include questions of five main types:
    - critiquing practical aspects of studies; interpreting data-information and making inferences from it; interpreting and understanding statistical ideas; specifying what techniques should be used in a given situation; and performing mechanical tasks (e.g. calculations).
- Break down tasks into subtasks and examine each subtask (alternatively, a coherent set of ideas) separately.
- Provide other information to cut down on unproductive rote learning.
- For questions about interpreting statistical concepts, or for 'what to use where?' questions, bury one false statement amongst a collection of true statements.
- Avoid statistical jargon in interpretative questions.

Similar sets of considerations drive the construction of assignment tasks which provide experiences in writing and computer work and assess aspects of learning that cannot be targeted with forced response assessments.

4 EVALUATING TEACHING AND LEARNING

Student Feedback and Evaluation

Both formal and informal methods of student feedback and evaluation allow the Stage I Statistics Team to gauge student response and to implement improvements in teaching or learning design.

Students are given the chance to raise concerns through the University's student representative system. This system allows each class to elect a representative who sits on the Departmental Student Staff Consultative Committee. The Stage I Statistics Team holds an additional two meetings with its class representatives to address any issues or concerns. Formal evaluation of Stage I Statistics courses is provided in the University's teaching and course evaluation system (administered by the Centre for Professional Development).

Students are given an informal means of response through the use of quick, three-question surveys distributed to a scattering of students, or through on-line surveys. These allow the team to reach students who do not regularly attend class, and enable the team to react quickly to problems raised. Issues are raised in class by lecturers as a means to allow further discussion, and to determine how 'real' a problem is.

Suggestion boxes, prizes for suggestions by students and a complaints procedure called the Oops Report were abandoned in the late 1990s. They had ceased paying dividends after we had fixed the more obvious problems.

The Team values all forms of feedback as a means to 'close the loop', respond to students' needs, and improve on current practices. Problems reported, or suggestions given from any of the means of student feedback are presented at Team meetings for the purpose of finding solutions. The Team has found solutions to real problems and issues presented by students. For example, the Mandarin narrated lectures were a response to student suggestions followed up by an on-line survey of demand. We have also scheduled additional tutorial streams in response to some student complaints that classes were overly full. Finally, students were offered the choice (on-line) between 5 assignments and a combination of 2 longer assignments and on-line tests. Student response indicated a preference for the latter, and that is what we did.

'Closing the loop' is also aided by discussion of test and examination performance in team meetings. Results are used as a stimulus for ideas about what we can do to improve student learning.

Below are the summary scores for 'overall effectiveness of teaching' on a 10-point scale from Centre For Professional Development student teaching evaluations.

	Course	Semester	Year	Overall Effectiveness
Teacher A	102	F	2001	7.55
	102	S	2002	8.98
Teacher B	101	A	2002	7.55
	108	F	2002	8.69
Teacher C	191	F	2001	9.02
	191	F	2002	9.23
Teacher D	191	F	2001	7.96
	108	F	2002	8.19
	191	F	2002	9.33
Teacher E	107	F	2001	9.17
	107	F	2002	9.59
Teacher F	108	F	2001	8.93
Teacher G	108	F	2001	5.18
	101	F	2002	8.73
Teacher H	108	S	2001	7.69
Teacher I	108	S	2002	8.50
Teacher J	108	F	2002	8.48
Teacher K	108	F	2001	8.33
	108	S	2001	8.53

These scores are remarkable when one realises that almost all of the students in these courses are there either because statistics is a requirement for another course or programme, or because, like going to the dentist, they may be better for it in the end. You could count on your fingers and toes the students coming into statistics first year courses because of a pre-existing love for the subject. Introductory statistics courses have had a long history as the most mind-numbingly boring on the planet. At the recent International Conference on the Teaching of Statistics it became clear that this reputation is still current in many places. The evaluation scores also show some important improvements. Teacher A's very creditable 7.55 came from that teacher's first attempt at lecturing. This is also evidence of the supportive environment the team provides for new staff.

Student Feedback

Students very frequently e-mail us informally about their views on the courses. The following are some excerpts from unsolicited feedback from students:

- I have just successfully completed my Stage 1 Stats paper as a requirement for my degree in psychology. As a mature student who has not studied maths since 6th Form in 1972 I was obviously very nervous about the course. I am absolutely delighted to have passed with an A+ (to my complete surprise!) but wonder whether you could pass my particular thanks on to Leila Boyle who has a knack of totally demystifying statistics for laymen. I know I am not the only one who found her help excellent and appreciated her patience and ability to understand our questions! This is in no way intended to reflect badly on the lecturers or course content but really emphasises the need to attend the tutorials and seek out all the help required. On reflection I did enjoy the course - it certainly extended me in a way that I haven't been extended for a long time and I also enjoyed it as a total contrast to my other Arts faculty papers. Thanks to all concerned.

- 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 (a breath of fresh air after 7th form Stats). Definitely the most professional university course I've undertaken so far! Great work to the Stats Dept!

- Hi Christine and David,
  …. I'm in my first year doing stats 108. I just want to thank you guys for running such an organised and interesting course. I studied stats in 7th form last year at Rangitoto College and struggled with it, so I wasn't looking forward to taking it this year at all! But to my surprise, I'm actually enjoying it! Everything is explained so clearly, Stephanie Budgett is a great lecturer and we go at just the right pace. 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.
  I thought I'd just take a minute to thank you and David because I'm sure you put a lot of work into this course. I hope others recognise your hard work and appreciate it as much as I do! Thank you very much.

- Hi david its me again!!
  I've done the cecil tests now and not even one messed up on me!! it was great!! Thanks alot with all your help, and your time, it is much appreciated... Stats 10x really is the best adminstered and taught course in the UofA, it brings truth to the course info guideline. I've done 5 of the tests (the best five count right?) and got: 10,9,10,10,10 so it wasn't so bad.. i try to attempt the tests eariler in semester for future papers to iron out any problems i might have.. I just hope the exam isn't too bad (yikes!) thanks alot for all your help once again...

- *Looking back*
  The 475.108 paper which I completed at Tamaki 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.
  The Assignments
  Again while I really did not enjoy these at all I received indirect help from the stats room tutors and through meeting other students who were similarly milling over problems. Both were encouraging to me and helpful. I'm sure the discomfort and struggle I experienced helped me prepare for the exam. It was also nice to get encouraging remarks from the people who marked them.
  The tutorials
  These were absolutely essential for me. They gave me a chance to absorb the information once again. The tutors or lecturers took the time to explain things in basic conceptual terms and assumed no knowledge on our part, which suited me immensely. On the city campus the tutorials were quite full while, to my surprise, the Tamaki tutorials were not well attended. I am amazed at this as the Tamaki tutorials were brilliant. The tutors and lecturers that stood out for me were: Selina (unsure of hyphenated name), Wayne Stewart, and Matt Regan – absolutely fantastic.
  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.
  Once again thank you for helping me conquer this paper. I don't think I will ever be the same again!

Student Feedback on CD-Rom

We conducted an on-line survey[1] of our students at the end of the first semester on the usage and value of the new CD-Rom resource. 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 to 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 comments follows:

- '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.'
- '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.'
  [Only about half of students in these courses have English as their first language.]
- 'The narrated lectures are a great idea. I wish I could have one for all my subjects!'
- '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.'
  - Shirley Butler, Mathematics Teacher, Papatoetoe High School

  [who took the course at a distance]

You will note that most students still come to class. Like us you will probably be relieved that there is something very attractive about human interaction! In the main students use the CD for review and the small numbers of times when they are prevented from getting to class.

[1] See http://www.scitec.auckland.ac.nz/~stats/cdsurvey/

5 PROFESSIONAL DEVELOPMENT AND LEADERSHIP

Team Professional Development and Communication Processes

The team teaches a suite of equivalent, but slightly differentiated courses in a way that leverages from a common core to promote efficiency and to maintain common standards. It has taken us time to learn to be a real team and, as shown above, the closeness of collaboration has increased greatly over time. An account of our early work is given in the following invited paper.

Wild, C.J., 'Continuous improvement of teaching: Case Study in a large statistics course', *International Statistical Review*, 63, 49-68, 1995.

Members of the team are regularly encouraged to attend Centre for Professional Development courses within the University to build upon existing teaching skills, or sharpen knowledge in particular areas. Team members are also encouraged to go to conferences. For instance, three members of the team attended the *International Conference on the Teaching of Statistics* in Capetown in 2002.

We have already talked a little about our group-based teaching philosophies. We want to capture as much as possible of what makes our best teachers good and transfer that to everyone in the group now and for the future. We discourage the reinvention of the wheel and encourage teachers to concentrate their efforts on adding those new elements that they are uniquely capable of contributing and, where those elements are transferable, building them into the common set of teaching materials for everyone else to use in the future. We have been a team without prima donnas. The student evaluations in the previous section demonstrate that we have some truly stellar classroom performers, and while it is entirely human for someone to get a buzz out of an evaluation score that comes out top-of-the-heap, the culture of the team has become one in which winning ideas are shared as everyone tries to ratchet up the performance of everyone else.

There are many layers of course organisation. Chris Wild has had an ongoing oversight and guidance role. There is a Course Coordinator. This person takes overall responsibility for the team and everything it does for a particular semester. This role has been rotated around experienced team members but Matt Regan has performed it more often than anyone else and has thus had a special leadership role. We have Lecturers (lectures and formal tutorials), Assistance Room Tutors, Computer Laboratory Tutors, and Markers (for assignments). Most people taking on the last three roles are senior students with excellent grades. The Assistance Rooms are staffed for over 40 hours per week and the computer laboratories for over 60 (including evenings and Saturdays). One very experienced Senior Tutor has always been Course Administrator taking responsibility for the operation of the assessment and record-keeping processes, and the hiring, management and development of student demonstrators, tutors and markers. Another team member assists with this, knows all the systems, and is ready to take over if that ever becomes necessary.

Accumulation of knowledge and expertise over time is accomplished by using the personal memories and knowledge of a small stable core of key people, and capturing new contributions in the comprehensive sets of teaching and learning materials and the lecturer information and resource manual described previously. More extensive quality-management-style documentation was abandoned after several years as not being cost effective.

Formal communication within the team is via weekly meetings for lecturers, for Assistance Room tutors, and for computer laboratory demonstrators to discuss the teaching that is coming up in the next week and conduct post mortems. Lecturer team-meetings focus on the sharing of ideas ranging from deep issues of pedagogy to what is and is not working, all the way to breaking news stories and humour. Of course administrative matters are discussed as well. This environment is great for enculturating new staff. Other development initiatives have included having new staff observe lectures of more experienced staff, and more experienced staff observe new staff. We may not be able

to make everyone an absolutely superb teacher, but we can and do significantly raise the average level of teaching experienced by students. Testimonials from two young PhDs who had their initiation to teaching as part of the Stage 1 Introductory Statistics Team follow. They were contributed as input to the University of Auckland teaching awards system.

- I arrived in Auckland as a postdoc in 1999, and took a large stream of STATS 10x as my first lecture course. The support that I received from the 10x team was tremendous. All lecturers were provided with a full set of lecture materials, including the custom-written textbook and OHP transparencies (now replaced by Powerpoint presentations). In addition, a lecturer resource book was packed with useful information, including presentation tips, timings, any pitfalls, and great suggestions for humour. Much creativity had gone into the design of the course, and lectures were enlivened by class experiments in which concepts of randomness or sampling could be demonstrated by student participation. Working on the STATS 10x team has given me many ideas for lecture presentation that I now carry through to the Stage 2 and 3 courses that I currently teach.

  For a first-time lecturer, being on the team provided an ideal introduction, not only to the 10x course itself but also to university teaching in general. All tasks and responsibilities were clearly outlined at an initial meeting before the start of the semester. Weekly team meetings throughout the semester were most valuable, where any issues arising from the previous week were discussed and forthcoming lectures outlined. This enabled everyone to benefit from the experience of others and share ideas for presentation of material, and it sparked lively debate that encouraged all of us to think meticulously about our approach to each topic. In addition to formal meetings, I received excellent advice and support from team members on a daily informal basis. I found the team exceptionally receptive to suggestions or concerns, and there is no doubt about the level of their commitment to the excellence of the course. Although no longer on the team, I continue to benefit from their enterprising activities. New developments, such as use of Powerpoint, Cecil, and distance learning media, are adopted with enthusiasm, and experiences are reported back to all staff in the department through seminars and demonstrations. All staff are also included in discussions about the continuing evolution of the course. I am most impressed by the strong focus of the team maintained within a friendly and welcoming environment, and I am certain that this ethos impacts strongly upon the quality of teaching produced. I am delighted to support the team for an Excellence in Teaching award.

  - Dr Rachel Fewster, December 2002

- I have been involved in the Stage 1 Statistics teaching team since 1998. Until the end of 2001 I was a busy PhD student, balancing the demands of teaching and studying. As such, it was amazing to join such a highly organised team, one that was more than happy to pool resources and ideas and to help out a new person lecturing as much as possible.

  The sheer size of Stage 1 Statistics enrolments necessitates a team of teaching staff, all of whom I have found to be excellent to work with and eager to help. The teaching and personal support has always been impeccable, and the team is committed to continually improving the course. I have always felt completely welcome in asking more experienced tutors and lecturers for teaching advice. Personally, the most outstanding aspect of the entire teaching support has been all the resources that are available to be used - from the lecture notes, to the Powerpoint presentations, the CD-ROM for students and staff, plus all the additional examples for in-class demonstrations. I could not have asked for a better university-based first teaching experience.

  - Dr Jenni Holden, December 2002

Leadership in Statistical Education

The team has placed a major emphasis on improving the statistical background of incoming students, and contributing to the well-being of the country more generally, by building links with schools — particularly for the professional development of teachers of Mathematics with Statistics at the Year 13 level, but also providing input to the national examination and curriculum development systems.

- **Contribution to National Examination and Curriculum Systems**

In 1996 and 1997 Matt Regan visited 8 secondary schools, giving talks to Form 7 Mathematics with Statistics students. In those years teachers and their students were seeking guidance on the Internally

Assessed Component of the University Bursaries Mathematics with Statistics course. Matt's talks addressed issues relevant to the internally assessed component by identifying the main aspects of the cycle of a statistical investigation. The talks covered ideas and suggestions for conducting and reporting on a statistical investigation. The internally assessed component counts towards 20% of the final mark and teachers were grateful to have a clearly outlined process that they could incorporate into guidance for their students. The concept of this statistical investigation cycle was new to many of these teachers and their use of it enhanced the quality of their teaching and the projects submitted by their students.

The Auckland Mathematical Association (AMA) is an organisation with a membership made up mainly of secondary school mathematics teachers. One of the major roles of the Association is to provide professional development opportunities for their members. As a consequence of his talks to schools Matt Regan was invited by the AMA to make similar presentations to a wider audience. The invitation was made to teachers of Mathematics with Statistics and their students. These presentations occurred in 1997 and 1998, with a large turnout at both meetings.

The introduction of the Time Series topic to the University Bursaries Mathematics with Statistics prescription was also a concern to Form 7 teachers because many had not studied it in their university courses. In 1996 Matt Regan, in conjunction with Associate Professor David Scott, presented two courses on Time Series and Index Numbers. The first course was a three-hour after-school course and the second was for a whole day. Each course was attended by 28 secondary school teachers.

Two core members of the team have had a major role in the national examinations system and several other team members have also had a significant role. Matt Regan was Mathematics with Statistics Chief Examiner and Chief Marker for the University Entrance, Bursaries and Scholarships Examinations for 1997, 1998 and 1999, and Ross Parsonage was Assistant Chief Marker and Assistant Chief Examiner. The examination, with approximately 12,500 candidates, had the second largest enrolment of all bursary examinations.

One of the most important contributions made was increasing the emphasis on real data. The Chief Marker and Assistant Chief Marker are responsible for forming a panel of suitable markers, organising and overseeing the marking process, training of the markers, carrying out quality control of their marking, and reviewing all candidates' appeals. There were approximately 33 markers on each marking panel. In each of the three years at least 5 of the other markers were members of the Stage I Statistics Team.

This provided an opportunity for members of the team to appreciate the Statistics background of students coming to university, and a valuable insight into sections of the Mathematics with Statistics course that cause students difficulty. This has had an ongoing beneficial influence on the teaching of the team at Stage I level. The benefits flowed in the other direction to teachers as well as this extract from a letter from the 2002 President of the Auckland Mathematics Association attests.

'… the Auckland Mathematical Association would like to acknowledge the contribution to the professional development of teachers by two members of the team, Matt Regan and Ross Parsonage, who were the University Bursaries Mathematics with Statistics Chief Examiners and Chief Markers from 1997-1999. The University of Auckland became the base for the examiner for these 3 years and this gave approximately 30 practising statistics teachers the opportunity to work with a national examiner. Being involved in this whole process was an invaluable experience. Marking meetings were conducted in a professional and highly rigorous manner.
On a personal level, I found this experience not only sharpened up my own marking procedures but it made me more aware of some of the teaching points I could emphasise more effectively with my students. I was able to share much of this with members of my own department. I have no doubt that other teachers who were fortunate enough to be included on these marking panels found the experience enriched their teaching also.'
- Julie Saikkonen (HoD Mathematics, Westlake Girls High School, marker in 1997- 1999).

All markers attended two marking meetings (about 8 hours of meeting time) which covered administration of the marking process and a full explanation and discussion of the marking schedule.

This was followed by the marking of the papers (over a two to three-week period) which included a thorough check marking of a selection of scripts. Each marker received detailed feedback from their check marker on four or five batches of check marking. A close professional working relationship was established between the marker and the check marker over this time. This has resulted in continued support of secondary teachers by Matt Regan and Ross Parsonage. Throughout the teaching year many teachers made (and still continue to make) contact about content and/or resource issues concerning the Mathematics with Statistics course.

It is a mark of recognition of his contribution as Chief Examiner that the New Zealand Qualifications Authority requested that Matt Regan run a training workshop for all of the new (in 2000) Universities Bursaries Chief Examiners and Chief Markers. Matt did this in September 2000.

- **Contribution to the Professional Development of Year 13 Statistics Teachers**

Another positive outcome of the involvement in the bursary examination was the requests for further workshops for Mathematics with Statistics teachers. In 1999 Matt and Ross presented invited workshops to the Auckland Mathematical Association (2 workshops), the Waikato Mathematical Association, and the Bay of Plenty Mathematical Association. At these workshops Matt and Ross used their experience from setting and marking the examination to identify areas of the curriculum where common misconceptions were occurring. They also presented teaching strategies and identified useful learning resources (including software) that could be employed in the classroom to help students overcome these misconceptions. This is another example of collaboration that has contributed positively to the development of the teaching of Statistics nationally.

In July 2000, in conjunction with the AMA, Matt and Ross and another team-member ran an on-campus workshop designed for teachers who were new or relatively new to the teaching of Mathematics with Statistics. This was attended by approximately 50 teachers. There was a strong emphasis on the use of computer technology to enhance the classroom learning experiences of Mathematics with Statistics students. Presentation focused on web resources, the Minitab software package and how it can be incorporated into meaningful classroom learning experiences, and an interactive Excel resource for understanding the concept of confidence intervals by the team.

'Many thanks for your work with the statistics course for new teachers last week, it was an outstanding success. The feedback was very, very positive and from my point of view it was valuable professional development for me too. Most of all can I thank you for your time in preparation and skill and enthusiasm at presenting and teaching, it really was very good.'
Mark Phillips (HoD Maths, Macleans College President, Auckland Mathematical Association, 2000)

A second workshop in this series was held on November 2001 for a broader spectrum of Mathematics with Statistics teachers. It was well attended, with 53 teachers registering. The focus was again on innovation in the classroom, with an emphasis on how web-based learning resources can improve students' ability to understand some key statistical concepts.
The most recent workshop was held in November 2002 and drew 78 teachers. Chris Wild gave the teachers a glimpse of the wide range of research projects in which he has been involved. Some teachers commented that they were enthralled with the diverse range of applications of statistics and would communicate this usefulness to their students. Matt Regan (with Julie Saikkonen) presented a session on using web-based learning materials (different resources from previous years) which included student workshops that can be used directly in the classroom.

An important innovation Matt introduced was to make sure that presentations included lesson plans that were immediately usable by teachers. Ross Parsonage presented thoughts, clarifications and exemplars on the role and purpose of scaffolding and contexts in assessment items at Year 13 with particular reference to the draft NCEA Statistics Scholarship Standard. The team also brought in Leslie Hooper who has educational responsibility for Statistics New Zealand and current Bursary

Mathematics with Statistics Examiner, Bruce Dunning, to give presentations. The letter of thanks from AMA President Julie Saikkonen included the following:

'The most recent of these Professional Development days was held last month on the Tamaki Campus. Seventy-eight Year 13 Mathematics with Statistics teachers registered for the day which was a substantial increase on the 53 registrations in the previous year. A high proportion of those teachers who had attended in 2001 attended again this year. Feedback in an end of day survey this year was very positive and indicated that the teachers found the day to be extremely worthwhile. Several teachers made comments to me regarding the quality of the workshops and the presentations at these days and how the standard improved each year.'

In July 2001 Maxine Pfannkuch's contribution to secondary mathematics teaching was recognised by the New Zealand Association of Mathematics Teachers when they invited her to give a plenary address at their biennial conference in Wellington. Maxine's topic was 'Statistical thinking: What it is and how can we develop it?' Maxine also conducted a workshop for secondary teachers at the conference, and was a guest speaker for the Bay of Plenty Mathematical Association in 2001. She ran a workshop on developing students' statistical thinking with teachers from Auckland Girls Grammar School and spoke about statistical thinking to past and present University of Auckland secondary mathematics teachers graduates and their heads of department. The contact with Auckland Girls Grammar has led to a joint action-research project to begin this year.

In 2002 the team 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.

'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.'
- Shirley Butler, Mathematics Teacher, Papatoetoe High School

The two *LOGOS: Research Issues in Statistics Education* workshop days run by Maxine Pfannkuch in 1999 and 2001 targeted the school-university interface, each attracting 50 participants from schools and universities. They were addressed by a number of team members and national and international speakers.

In early 2002 four team members and a member of the Mathematics Education Unit prepared a detailed submission to the Ministry of Education on the Scholarship Standard in Statistics for the National Certificate of Educational Achievement. Two members of the Mathematics National Assessment Panel visited in April 2002 to discuss our ideas.

'The panel would like to thank the Auckland University Statistics Department and Mathematics Education Unit for the significant submission on the draft scholarship standard. Your comments were helpful in the ongoing development and many of your views have been incorporated into the amended standard and accompanying rationale …
I appreciate the time that was given to the members of the panel in meeting prior to the panel meeting, which they found most valuable. The contribution of a source of appropriate questions and background supporting papers has helped to clarify the thinking of the panel.'
Geoff Gibbs, Curriculum Facilitator NCEA, Secondary Education Group, Ministry of Education

Ross Parsonage has made other contributions to the work of NZQA, such as evaluating the validity and consistency of the moderation system for Unit Standards in Mathematics. There have been many smaller contributions by team members such as talks to New Zealand Association of Mathematics Teachers conferences, moderating exams and judging student mathematics competitions.

6 CONCLUSION

The Stage 1 Introductory Statistics Team is a collaboration that works. Through coordinating the efforts of team members, great benefits have been brought to the team's students. Increased productivity from efficient teamwork has allowed the team to provide a much more comprehensive set of services and learning experiences to address the needs of its students. Team discourse has sparked innovation. It has enhanced the skills of its member teachers, with obvious flow-on benefits for all of their students. This collaboration shows that you can use the power of a team to produce courses that are better than the courses an individual could produce. It shows how the diversity of expertise and background in a team can be marshalled to enrich the learning experiences available to students. It shows that teams can run courses in a way that they improve continuously over time, despite turnover in teaching personnel. It shows how a coordinated team approach can reach beyond serving the immediate students of the course and add value to the educational environment nationally, and the pedagogical discourse of the discipline internationally.

Supporting Material

Appendix A Recognition of Innovation and Excellence over the last six years

Appendix B Publications Related to the Collaboration

Appendix C References from Colleagues or Past Students

Appendix D Teaching Materials

APPENDIX A

RECOGNITION OF INNOVATION AND EXCELLENCE OVER THE LAST SIX YEARS

Invited Addresses at International Conferences

1996	*Statistical Thinking*, 7th Annual European Workshop on Statistical Methodology in Clinical Research & Development (Copenhagen), Chris Wild.
1998	*What is statistical thinking?* ICOTS-5: The Fifth International Conference on Teaching of Statistics (Singapore) (Chris Wild and Maxine Pfannkuch).
1998	*Investigating the nature of statistical thinking* at ICOTS-5: The Fifth International Conference on Teaching of Statistics (Singapore) (Maxine Pfannkuch and Chris Wild).
2002	*Statistical Thinking Models*, The 6th International Conference on the Teaching of Statistics (venue: Capetown, South Africa); (Maxine Pfannkuch and Chris Wild).
2003	*Statistical thinking: How can we develop it?* In the session 'Teaching and Learning Approaches Aimed at Developing Statistical Reasoning Thinking or Literacy', The 54th International Statistical Institute Conference, Berlin, (Maxine Pfannkuch and Chris Wild).
2003	Maxine Pfannkuch, Session Organiser, *Statistics Education For Media Reports*, 54th International Statistical Institute Conference, Berlin.
2003	Delta 3, the Fourth Southern Hemisphere Symposium on Undergraduate Mathematics Teaching to be held this year in Queenstown, Chris Wild has accepted an invitation to give plenary.
2003	Inter-American Statistical Institute in Rio de Janeiro, Chris Wild accepted an invitation to give plenary.

Invited Plenary Addresses at National Conferences

1996	*Statistical Interpretation of Media Reports*. At the 47th New Zealand Statistical Association Conference, Wellington, 30-31st August, (Maxine Pfannkuch).
2001	*Statistical thinking: What is it and how can we develop it?* At the 7th New Zealand Association of Mathematics Teacher Conference. 3-6 July, Wellington (Maxine Pfannkuch).

Miscellaneous

Chris Wild's recent election as President of the International Association for Statistics Education is in large measure due to the work described here. Chris has also held the following positions:

- Associate Editorships for the *International Statistical Review*, and the *Statistics Education Research Journal, Biometrics* (the Journal of the International Biometric Society)
- ISI55 Programme Co-ordinating Committee
- ISI55 IASE Programme Chair
- ISI55 IASS Programme Committee

[ISI is the International Statistical Institute whose main meeting is held every 2 years, IASE is the International Association for Statistics Education, IASS is the International Association for Survey Sampling.]

Chris Wild is also the current editor of the *Australian and New Zealand Journal of Statistics*.

APPENDIX B

PUBLICATIONS RELATED TO THE COLLABORATION

Evidence that our team conducts in-depth, sustained, and innovative research over a number of years to guide the future directions of our teaching is illustrated by the following research papers. Some notes are added to the papers to provide evidence that the research is advancing the content and pedagogy of the Stage 1 Statistics course and that the research is recognised internationally.

Wild, C.J. and Seber, G.A.F. 'Comparing Two Proportions from the Same Survey', *The American Statistician*, 47, 178-181, 1993.

Wild, C.J., 'On Embracing the 'Wider View' of Statistics', *The American Statistician*, 48, 163-171, 1994.

Wild, C.J., 'Continuous Improvement of Teaching: Case Study in a Large Statistics Course', *International Statistical Review*, 63, 49-68, 1995.

Pfannkuch, M.& Brown, C. 'Building on and Challenging Students' Intuitions About Probability: Can We Improve Undergraduate Learning?' *Journal of Statistics Education* 4, 1, http://www.amstat.org/publications/jse/ , 1996.
[Paper exploring the probabilistic and statistical thinking of a small group of Stage 1 students.]

Pfannkuch, M. 'Statistical Interpretation of Media Reports', *New Zealand Statistical Association Research in the Learning of Statistics Conference Proceedings*, Victoria University of Wellington, 30-31st August 1996, 67-76.

[Paper on a small group of Stage 1 statistics students' interpretation of media reports.]

Pfannkuch, M. 'Statistical Thinking: One Statistician's Perspective'. *MERGA 20 Aotearoa Conference People in Mathematics Education Proceedings, Rotorua, 7-11 July 1997*, 406-413.
'*The quality of the research papers in stochastics presented at MERGA has continued to improve over recent years as new workers in the field have refined their skills. Singling out one paper is perhaps unfair but, for this reviewer,* ***Maxine Pfannkuch's paper*** *on Statistical Thinking (pp. 406-413) was* ***outstanding and innovative****. Maxine, from the University of Auckland, has been conducting interviews with practising statisticians to assess how they reason in their work, and she summarised in a most interesting way her work with one of these statisticians. ....'.*
[Quote from: Truran, J. (1998). Research Report: Recent Research in Stochastics Education in Australia and New Zealand. *Teaching Statistics*, 20(2), 55-56.]

Wild, C.J., Triggs, C.M. and Pfannkuch, M., 'Assessment on a Budget: Using Traditional Methods Imaginatively', *The Assessment Challenge in Statistics Education*, Iddo Gal and Joan Garfield (Eds.), International Statistical Institute and IOS Press, pp. 205-220, 1997.

Wild, C.J. and Pfannkuch, M., 'What is Statistical Thinking?' (*Invited paper*), In: *Proceedings of the 5th International Conference on the Teaching of Statistics*, L. Pereira-Mendoza, L.S. Kea, T.W. Kee and W-K Wong (eds), International Statistical Institute: Voornurg, The Netherlands, 1998.
[This paper discussed an emergent model for statistical thinking from a statistics-discipline perspective.]

Pfannkuch, M. and Wild, C.J., 'Investigating the Nature of Statistical Thinking.' (Invited paper) In, *Proceedings of the 5th International Conference on the Teaching of Statistics*, L. Pereira-Mendoza, L.S. Kea, T.W. Kee and W-K Wong (eds), International Statistical Institute: Voornurg, The Netherlands, 1998.
[This paper discussed, from a statistics-education perspective, an emergent model for statistical thinking based on interviews with statisticians.]

Wild, C.J. and Pfannkuch, M., 'Statistical Thinking In Empirical Enquiry' (With Discussion). *International Statistical Review*, 67, 221-266, 1999.
[This was the lead article in the flagship journal of the International Statistical Institute. The discussion was by statisticians who were world leaders in social statistics, medical statistics, statistics education and quality management. The paper is becoming widely quoted in statistics education. A plenary address at the 2002 International Conference on the Teaching of Statistics described it as 'the famous Wild and Pfannkuch paper' and used it as a model of research to inform teaching.]

Pfannkuch, M. and Wild, C.J., 'Statistical Thinking and Statistical Practice: Themes Gleaned from Interviews with Professional Statisticians,' *Statistical Science*, 15, 132-152, 2000.

[This presented research on the thinking modes of professional statisticians as a guide to educational goal-setting and a primary input to the theories of the ISReview paper.]

Pfannkuch, M. 'A Model for the Promotion of Statistical Thinking.' *Mathematics education beyond 2000. Proceedings of the 23rd Annual Conference of the Mathematics Education Research Group of Australasia. Fremantle, Western Australia,* 5-9 July*,* 2000, 503-510.

[This paper used the Wild and Pfannkuch (1999) framework for statistical thinking in empirical enquiry to analyse a Stage 1 statistics extended response assignment question. Recommendations were made for improving future assignment questions to enhance students' statistical thinking.]

Wild, C.J. and Seber, G.A.F, *Chance Encounters: A first course in data analysis and inference*, Wiley, New York, 2000, 611 pages.

Wild, C.J. and Seber, G.A.F, *Instructors Manual for 'Chance Encounters'*, Wiley, New York, 2000, 207 pages.

Pfannkuch, M., Seber, G.A.F and Wild, C.J. 'Probability with Less Pain', *Teaching Statistics*, 24, 24–30, 2002.

Shaughnessy, M. & Pfannkuch, M. 'How Faithful is Old Faithful? Statistical Thinking: A Story of Variation and Prediction'. *Mathematics Teacher,* 95, 4, 252-259, 2002.

[Using the Wild and Pfannkuch (1999) statistical thinking elements a data-based teaching activity was discussed. Cliff Konold, Scientific Reasoning Research Institute, University of Massachusetts, a highly regarded international statistics education researcher wrote: *'Wonderful article in April's math teacher. The best job ever in this journal of communicating what data analysis is about (and having some interesting data to boot!)']*

Pfannkuch, M. and Wild, C.J., 'Towards an Understanding of Statistical Thinking'. Chapter to appear in the edited volume *The Challenge of Developing Statistical Literacy, Reasoning and Thinking,* D. Ben-Zvi and J. Garfield (eds)

[We were invited to write this chapter as we are considered to be the leaders in statistics education research in the area of statistical thinking.]

APPENDIX C

REFERENCES FROM COLLEAGUES OR PAST STUDENTS

I would like to support the nomination of the Stage 1 Introductory Statistics Team for a Tertiary Teaching Excellence Award in the **Excellence in Collaboration** category.

As a first year student in 2000, I had not previously studied at University level and I did not know what to expect of either lecturers or other staff at the University. I found that the lecturer and tutor were both very relaxed and friendly, they were encouraging and helpful. They knew each student as an individual, and spoke to us by name in the lectures, computer laboratories and around campus.

Involvement, participation and questioning were encouraged in the lectures and tutorials. Lectures were fun to go to, never a drag or boring. The lecturer covered the material in the workbook thoroughly, elaborating where necessary and using real life examples. The lecture materials were set out logically, with the aims of each section and references to texts clearly stated. The overheads shown reflected the content of the course book accurately. Tutorials were relevant to the work just covered in lectures and problems individual students had were addressed. Assignments were marked and returned very quickly.

Both the lecturer and tutor were available when required. Their 'open door' policy meant just that, they were available outside of their posted office hours, to drop in and see, or talk to over the phone.

Staff in the statistics department were extremely well organised in their administration. From the very first day, the lecturer went out of his way to make sure that I knew where and when to purchase the necessary texts.

The Course Resource Book was available that first day and outlined clearly the aims of the course, course requirements, due dates for assignments, how to go about getting a good grade in the paper and how the staff in the department would assist students. Having all this information from the very beginning of the course meant that I knew what was expected of me and how I could get help when I needed it.

Other resources were always available at the times and places that were advised, which was often immediately following a lecture, not days later. As I was enrolled only at the Tamaki campus, I greatly appreciated that all the necessary resources were available at Tamaki.

I have found the Statistics department the best organised, most friendly and helpful department that I have dealt with at University and I am sure that the efforts of the Stage 1 Introductory Statistics Team in helping me settle into life at University, making me feel a valued member of the class, and in their encouragement of my efforts contributed to my great results in stage 1 Statistics.

Suzanne Cripps

November 29, 2002

I have, during 2002, been very privileged to be part of a group of teachers studying Stats 101 A/B at the University of Auckland.

I have taught Secondary School Mathematics to Year 12 for many years and this year was offered a Year 13 Maths with Stats class. I took up the challenge but I was very aware that things may have changed since I graduated with a BSc in Maths back in 1974!! I was relieved when I received information about the distance course being offered at the Tamaki Campus. Help was available!

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 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.

I must also add that the one-day course offered to teachers of Statistics was a very useful and informative day.

Mrs Shirley Butler
Papatoetoe High School
Nicholson Ave
Papatoetoe

Tertiary Teaching Excellence Awards
Excellence in Collaboration

I would like to support the nomination of the Stage 1 Introductory Statistics Team for a Tertiary Teaching Excellence Award in the **Excellence in Collaboration** category.

The Stage I Introductory Statistics courses (STATS 101, 102, 107, 108 and, more recently, 191), known collectively as STATS 10x, have a total enrolment of around 3000 students each year. Most of these students do not continue in Statistics, indeed many of them take a Statistics course only because it is required. Many have little mathematics background, and begin the course with some trepidation. To successfully teach such students is an exceptional challenge. The Stage I Introductory Statistics Team has sustained an impressive teaching record over the last six years.

Development of the course teaching materials and learning resources is ongoing. STATS 10x was one of the first courses to collate lecture notes and other teaching and learning resources into a Lecture Workbook and Course Resource Book.

In 1999 the class text by Seber and Wild, which had been printed by the Department of Statistics for many years, was revised and published by Wiley. This revision necessitated a major rewrite of the teaching materials. At the same time the computing software was changed to include the use of Minitab.

The team has also been working to provide flexible learning resources. In 1999 and 2000 courses taught at the Tamaki campus trialled a CD-ROM based learning resource called *ACTIVSTATS*. The STATS 10x web page has been used to provide web-based and other learning resources. Utilisation of Cecil has increased and is now used extensively to provide computer-assisted learning in the form of review quizzes and course work tests.

A major innovation has been the STATS 10x Course CD. This is updated every semester, including Summer School. A powerful feature of the CD is a set of narrated lectures for the STATS 10x course. Another valued aspect is the 'filled in' version of the lecture notes. The CD also has a comprehensive range of other teaching and learning resources and this resource has superseded the Course Resource Book.

Lectures involve discussion, video clips, computer software demonstrations, class experiments as well as the traditional presentation of material. Lecture delivery has evolved from using OHP transparencies to using PowerPoint.

The whole course is underpinned by a research base, with two of the team being international leaders in the area of statistical thinking and statistical teaching pedagogy.

The Stage I Introductory Statistics Team would be a well-deserved recipient of a teaching excellence award.

Associate Professor Alan Lee
Statistics Department
The University of Auckland

Tertiary Teaching Excellence Awards
Excellence in Collaboration

I would like to support the nomination of the Stage 1 Introductory Statistics Team for a Tertiary Teaching Excellence Award in the **Excellence in Collaboration** category.

The Stage I Introductory Statistics Team has a record of quality performance and ongoing innovation. The text developed by two Statistics Department staff, Prof. George Seber and Prof. Chris Wild, was rewritten in 1999 to take into account research into pedagogy and statistical thinking. Understanding statistical concepts has become much more important than applying technical skills. Feedback from those in the team with extensive university and secondary school teaching experience was used in the rewriting of the text.

With at least two members of the team active in research into the teaching and learning of statistics the team is in a strong position to continue to make changes that keep the STATS 10x courses at the forefront of teaching introductory statistics.

The innovation and quality is evident in the style of lecture delivery. Although lecturing large classes, often up to 300 students in a stream, lectures include class experiments, videos, opportunities for interaction and discussion, computer software (Excel and Minitab) demonstrations, and dynamic learning material from Excel spreadsheets and from web sourced material.

The evolution of student materials also illustrates ongoing innovations. By 1998 the lecture handouts primarily developed by Matt Regan were put together in a manual. After the rewrite of the course material, necessitated by the text rewrite, the material evolved into a Lecture Workbook and Course Information Workbook for students, and a Lecturer Information and Resources Manual. During this time the STATS 10x web page provided students with other non-paper learning materials. In the last few years STATS 10x has used Cecil extensively for review and test material. Students have reacted very favourably to this development.

The Course CD, which includes course information, tutorial worksheets and answers, copies of past tests and exams (with answers), worked examples (to help guide students in assignment questions), Minitab and Excel manuals, and many learning resources (web-based and interactive Excel spreadsheets), provides students with flexible learning opportunities. Especially popular with students are the narrated lectures and the lecture material with the missing gaps filled in. This Course CD contains a lot of material that was formerly in other paper-based resources.

The team maintain close links with secondary school teachers, especially those who teach Mathematics with Statistics. This ensures an appropriate transition into such introductory Statistics courses.

The team would be a worthy recipient of a teaching excellence award.

Professor Alastair Scott
Statistics Department
The University of Auckland

In Support of the University of Auckland Stage I Statistics Team's Application for a Tertiary Teaching Excellence Award in the category of Excellence in Collaboration.

December 8 2002

The Auckland Mathematics Association support this application for the reasons detailed below.

For the past 3 years AMA and the Statistics Department have worked together to organise Professional Development days for Mathematics with Statistics teachers throughout the wider Auckland area. In particular, Matt Regan and Ross Parsonage have spent numerous hours organising a varied programme to stimulate and support the teaching of Statistics in schools and provide teachers with an appreciation of the function of Statistics in society and research.

They have organised speakers from the universities and Statistics NZ to speak at these professional development days and provided resources for teachers to use in their own lessons with Year 13 classes.

This year the 'Statistics Day' was held on 20 November. One of the features of the day was a Computer workshop session showing teachers some of the Java Applets available to use in teaching of this course. Several teaching resources were provided for students to use with these applets. The resources and applets can be accessed from the Stats Dept website www.stat.auckland.ac.nz

Another feature of this day was the session conducted by Ross Parsonage on Scaffolding and Context in Mathematics with Statistics Assessment Items. In this session Ross mentioned some of the consultative work the Stage I Statistics Team had done with the NCEA Level 4 Scholarship Standards Group.

These days are always well attended by teachers – over 80 teachers attended the day last month.

The Stage I Team also offer a Distance Learning Statistics Paper (101) for teachers wishing to begin teaching the Year 13 Mathematics with Statistics course. This paper is also available for well-prepared Year 13 students. This course is well supported with 3 on-campus meetings and Problem Clinic assistance.

In addition to the above, the Auckland Mathematics Association would like to acknowledge the contribution to the professional development of teachers by Matt Regan and Ross Parsonage when they were the University Bursaries Mathematics with Statistics Examiners from 1997 –1999. Auckland University became the base for the Examiner for these 3 years and this gave approximately 30 practising teachers the opportunity to work with a national examiner. Being involved in this whole process was an invaluable experience. Marking meetings were conducted in a professional and highly rigorous manner.

On a personal level, I found this experience not only sharpened up my own marking procedures but it made me more aware of some of the teaching points I could emphasise more effectively with my students. I was able to share much of this with members of my own department. I have no doubt that other teachers who were fortunate enough to be included on these marking panels found the experience enriched their teaching also.

In conclusion, the Stage I Statistics team have made an important contribution to fostering strong links between schools and Auckland University. A large number of students from Auckland Secondary Schools attend Auckland University and a large proportion of these students will complete at least one Statistics paper. Our Professional Association value this strong relationship and appreciate the work that the Stage I Statistics Team do to assist Mathematics Teachers in the teaching of Statistics.

Julie Saikkonen

President Auckland Mathematics Association,
and HOD Mathematics, Westlake Girls High School.

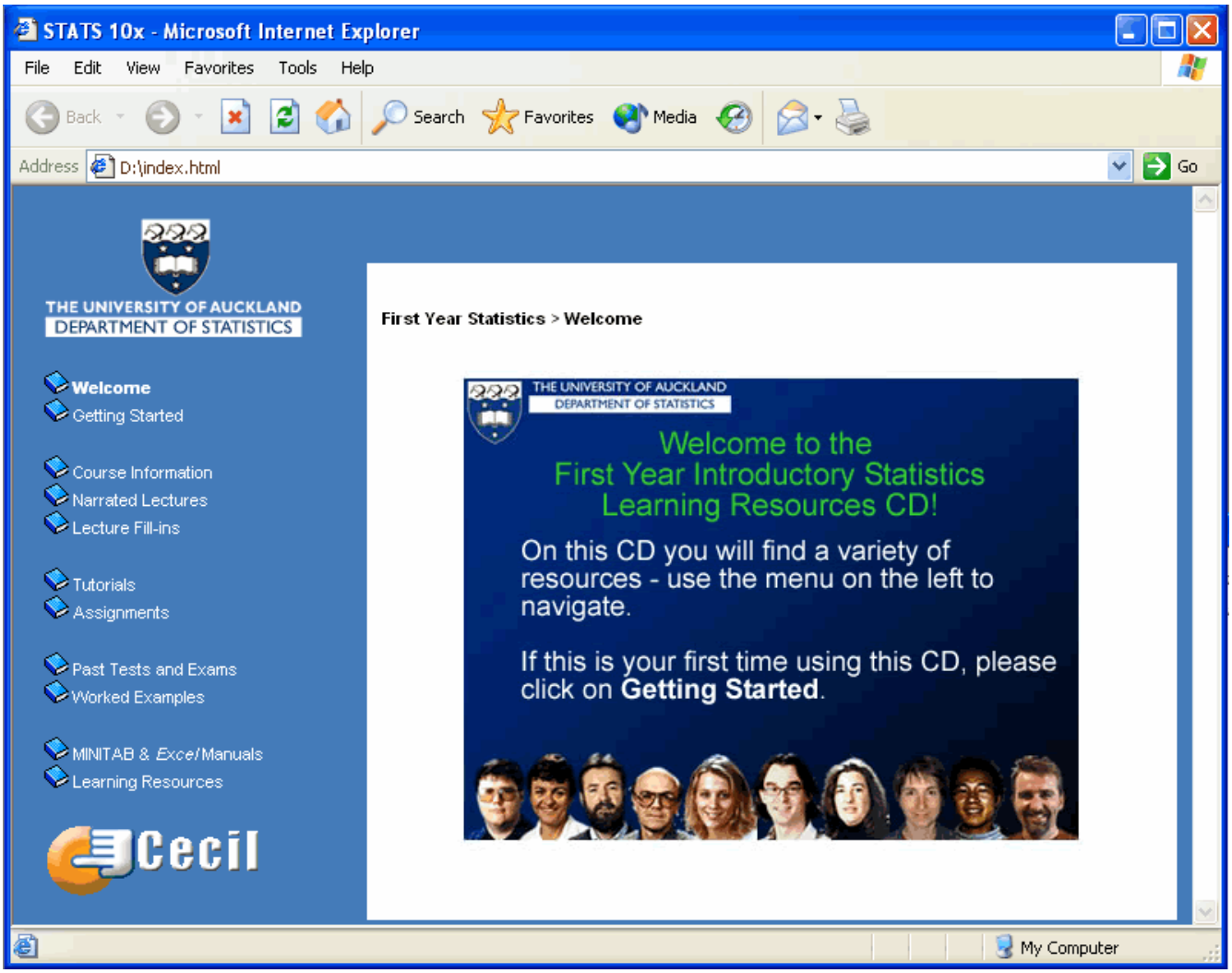
APPENDIX D

TEACHING MATERIALS

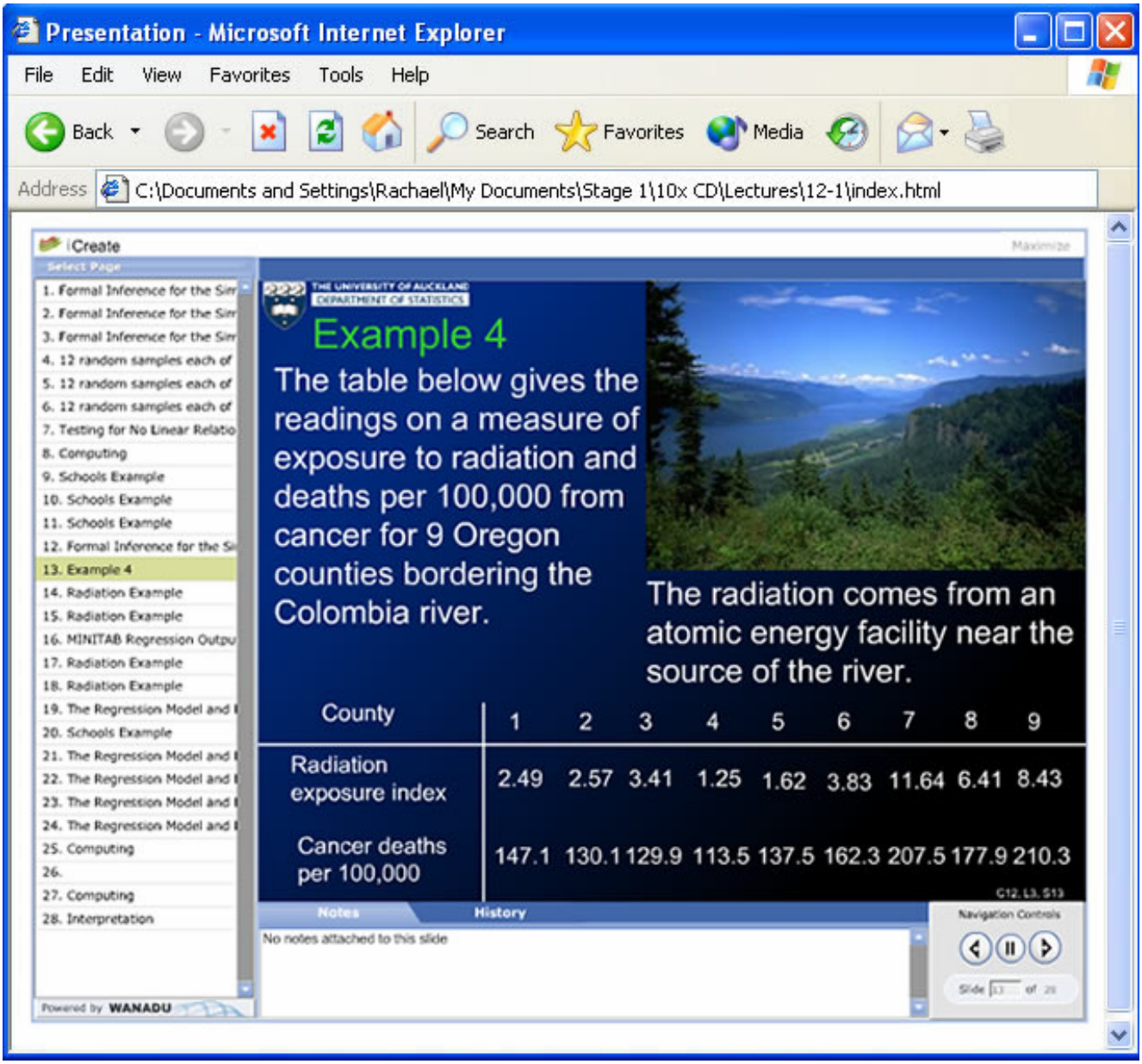
- **The CD-Rom**

    - On insertion into the drive, the CD automatically 'opens' to this page with a spoken welcome message.
    - Navigation to the various resources is on the left-hand side.
    - The Cecil page looks essentially the same.

    [Cecil is the University of Auckland's flexible-learning delivery platform]



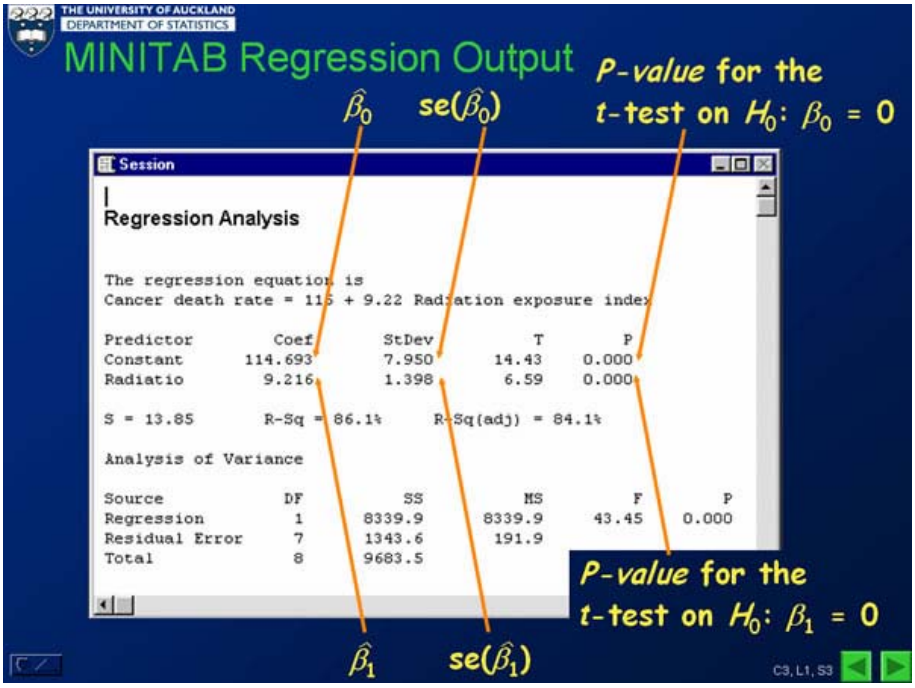
- **The Narrated Lectures**
  - A specimen ‘page’ from one of the narrated-lectures-on-CD follows:

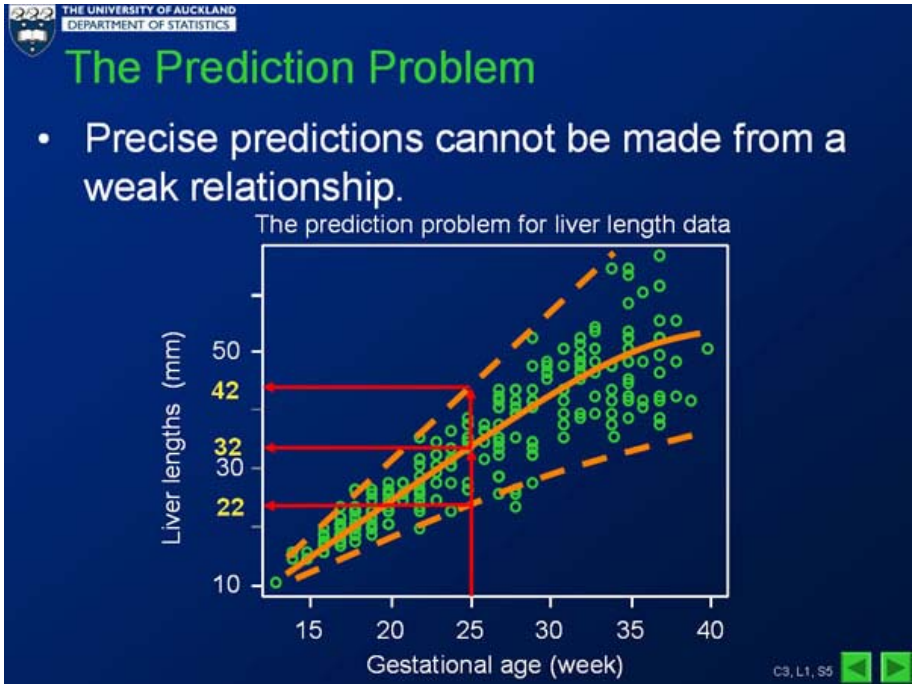


  - The narrated lecture plays as a continuous show unless it is interrupted.
  - Slide titles on the left hand side and the buttons at the lower right-hand corner provide alternate means of navigation.

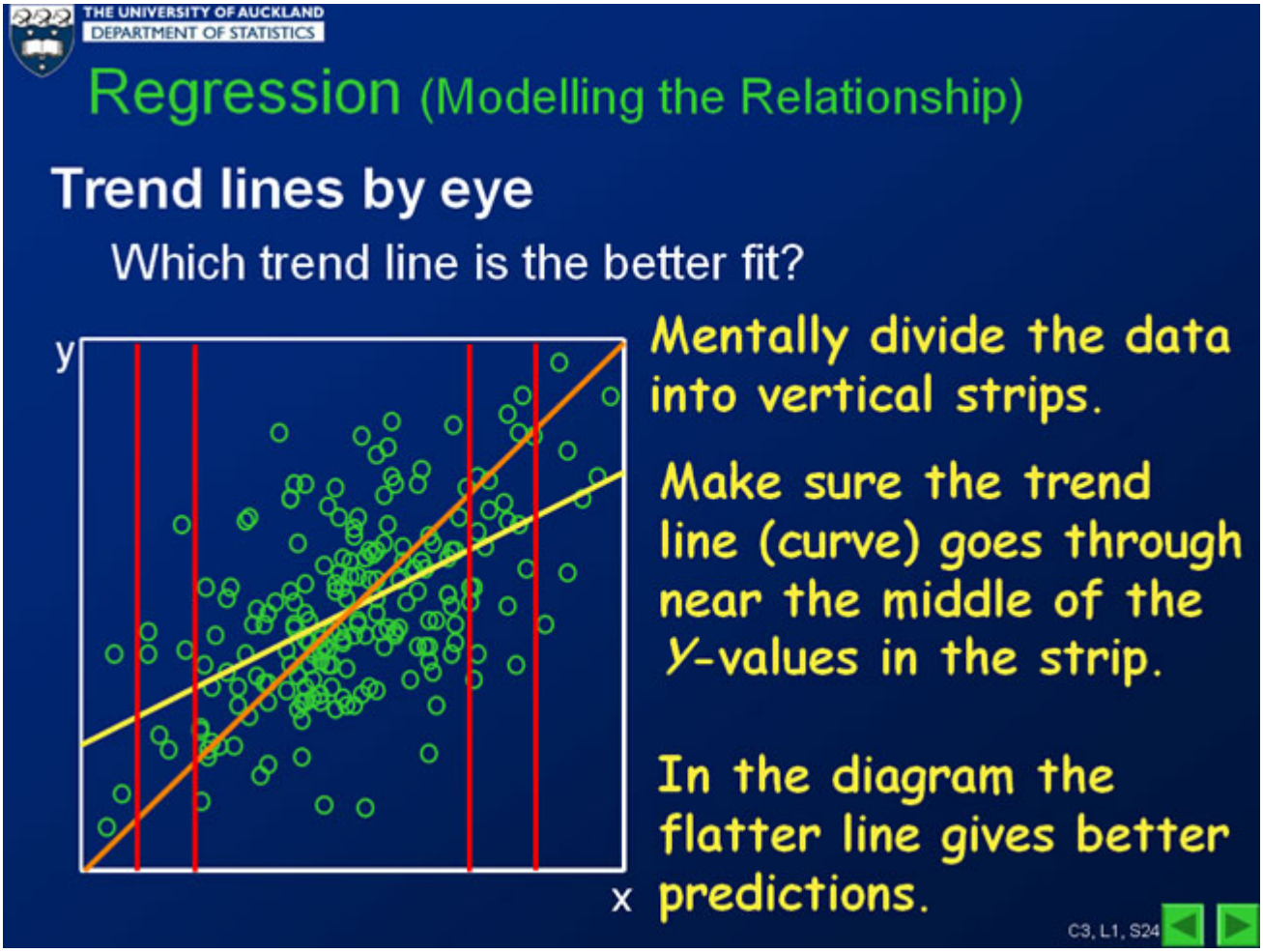
For future slides, we have suppressed the navigation portions and just show the slides which are the same slides used in class.

Some annotated analysis output for this data set:





- **Information**, including the pieces of graphics as shown on these two pages, **is built up sequentially** with the lecture, or the narration, explaining or giving background to the information that has just appeared.



- **Relationship to the gapped Lecture Notes**

  - Gapped lecture notes form part of the *Lecture Workbook*.
  - They have quite a few pieces of information missing.
  - Missing information is in yellow (text in yellow Comic Sans font).
    - The coding enables students to quickly spot the things they may have missed.
    - providing gapped notes is a commonly-used strategy for cutting down on writing (too much deflects attention) but keeping students active to prevent them drifting off into daydreams.

- The lower half of the page that follows is the part of the *Lecture Workbook* that applies to this particular slide.
    - But this is the filled-in version – see the 'Lecture Fill-ins' button on the CD's homepage.
    - The words in the dark font are not present in the *Lecture Workbook*.
    - We provide the filled-in versions on the CD on the grounds that those leave-it-to-the-last-moment students who have traditionally just copied notes off their friends will be better off with a version that is actually correct!

Regression (Modelling the Relationship) §3.1.2 page 107

One variable, X, is used to try to predict or explain the behaviour of the other variable, Y.

X is called the **explanatory** or **independent** variable.

Y is called the **response** or **dependent** variable.

Y must be **random** and **continuous**.

The two main components of a regression relationship are:

- **trend**

  The trend curve summarises the relationship.

- **scatter**

  The scatter indicates how well the trend curve does its job.

Trend lines by eye

Which trend line is the better fit?

Mentally divide the data into vertical strips.

Make sure the trend line (curve) goes through near the middle of the *Y*-values in the strip.

In the diagram above the flatter line gives better predictions.

Features to Look for in a Scatter Plot

- Trend
- Scatter

Figure 3.1.6(a)

A linear trend with moderate, constant scatter about the trend line.

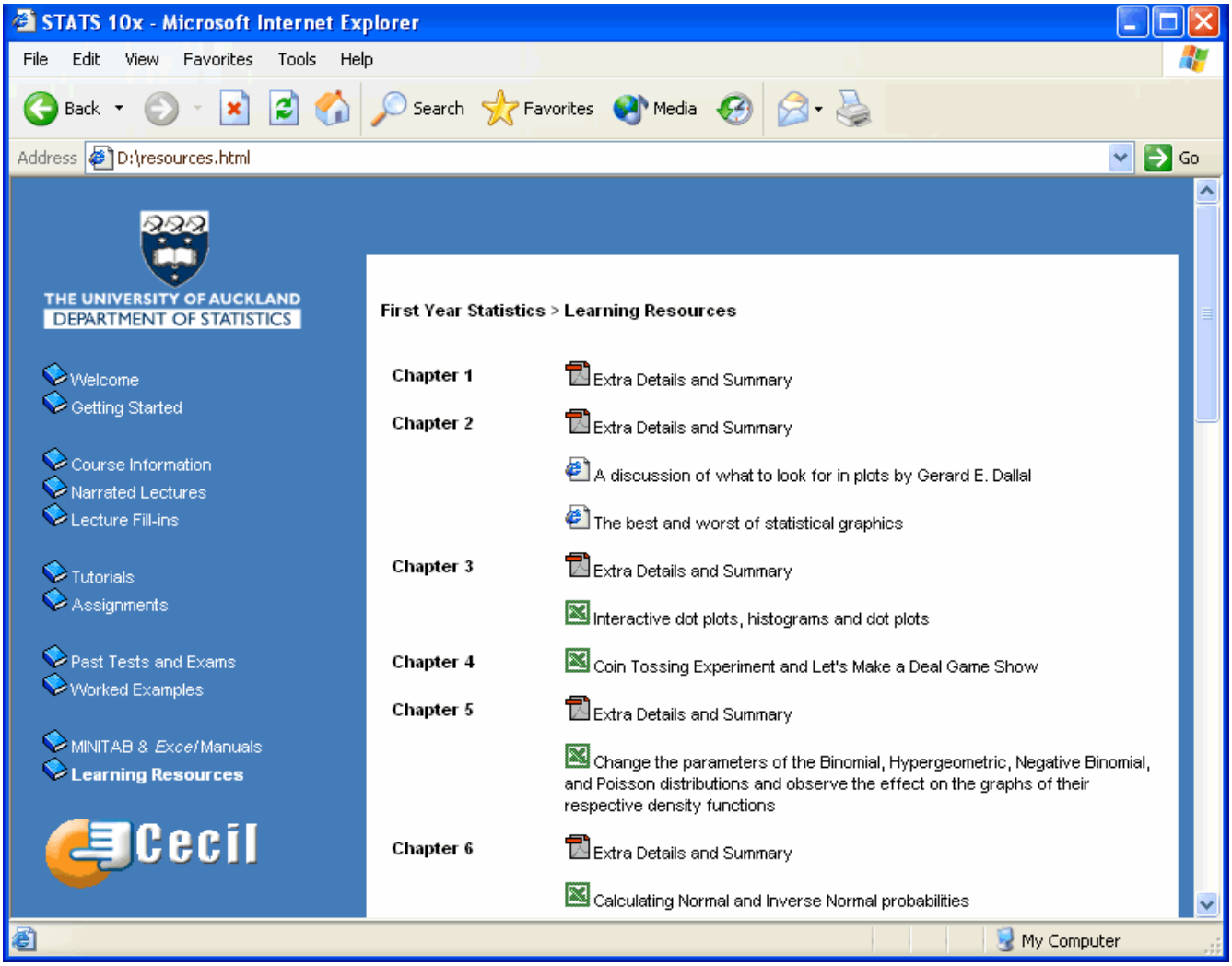
Figure 3.1.6(b)

A non-linear trend with very little scatter about the trend curve.

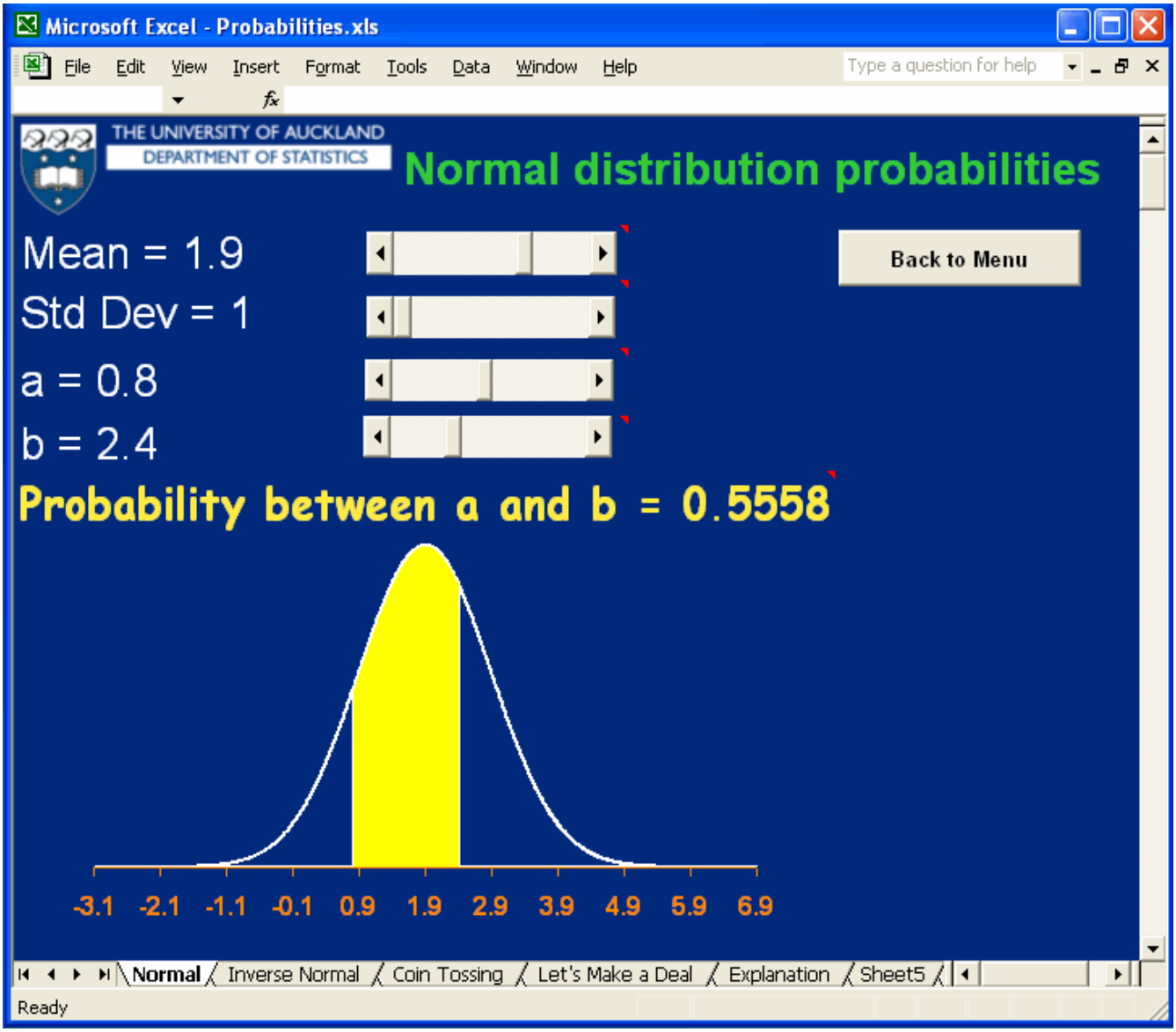
Figure 3.1.6(c)

A non-linear trend with non-constant scatter about the trend curve. There is less variation in the liver lengths of young babies than there is among older babies.

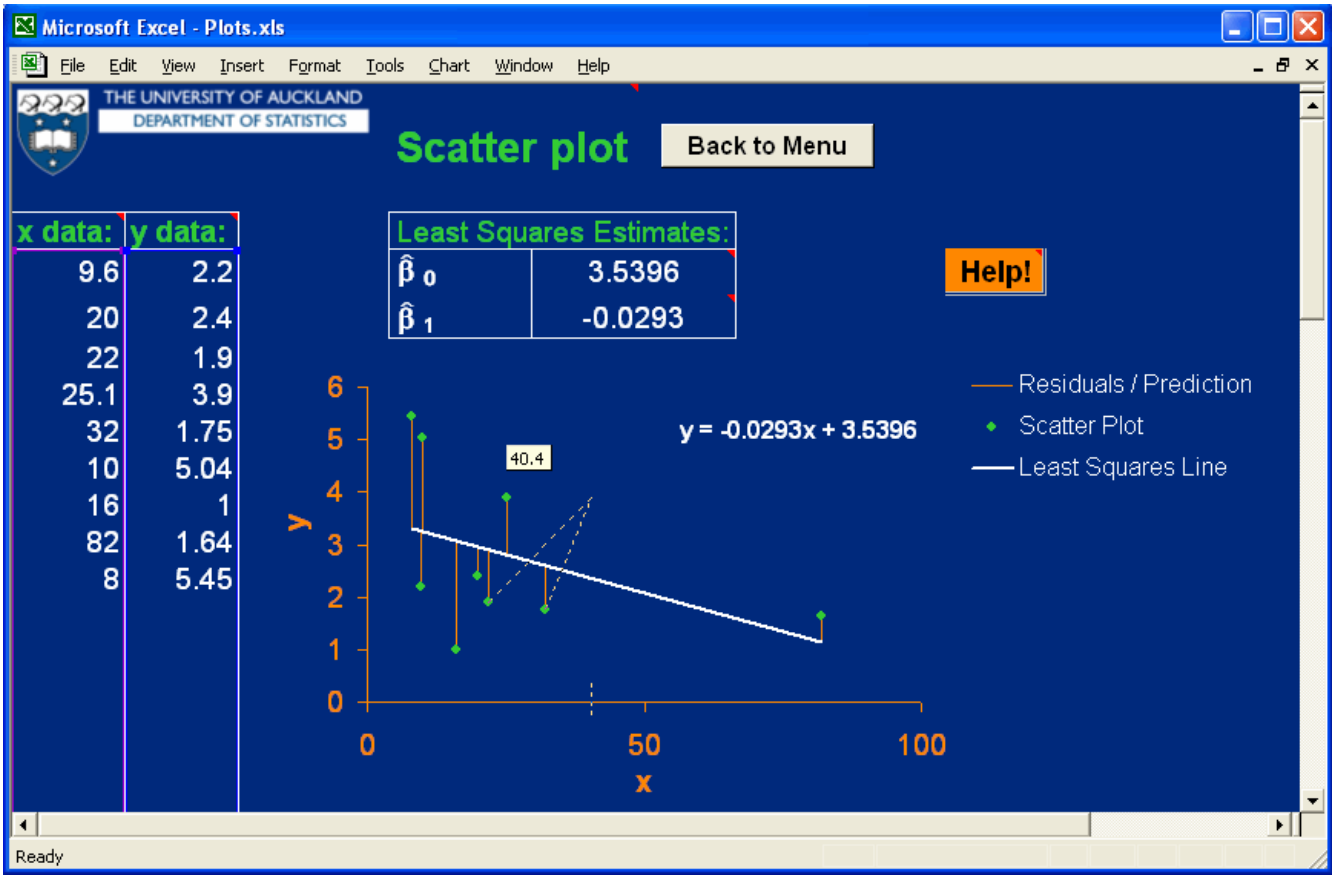
- **Learning Resources**
  - Below is the top of the Learning Resources page.
  - Many of these resources are Java applets or interactive spreadsheets.



Screenshots from three interactive spreadsheets follow:



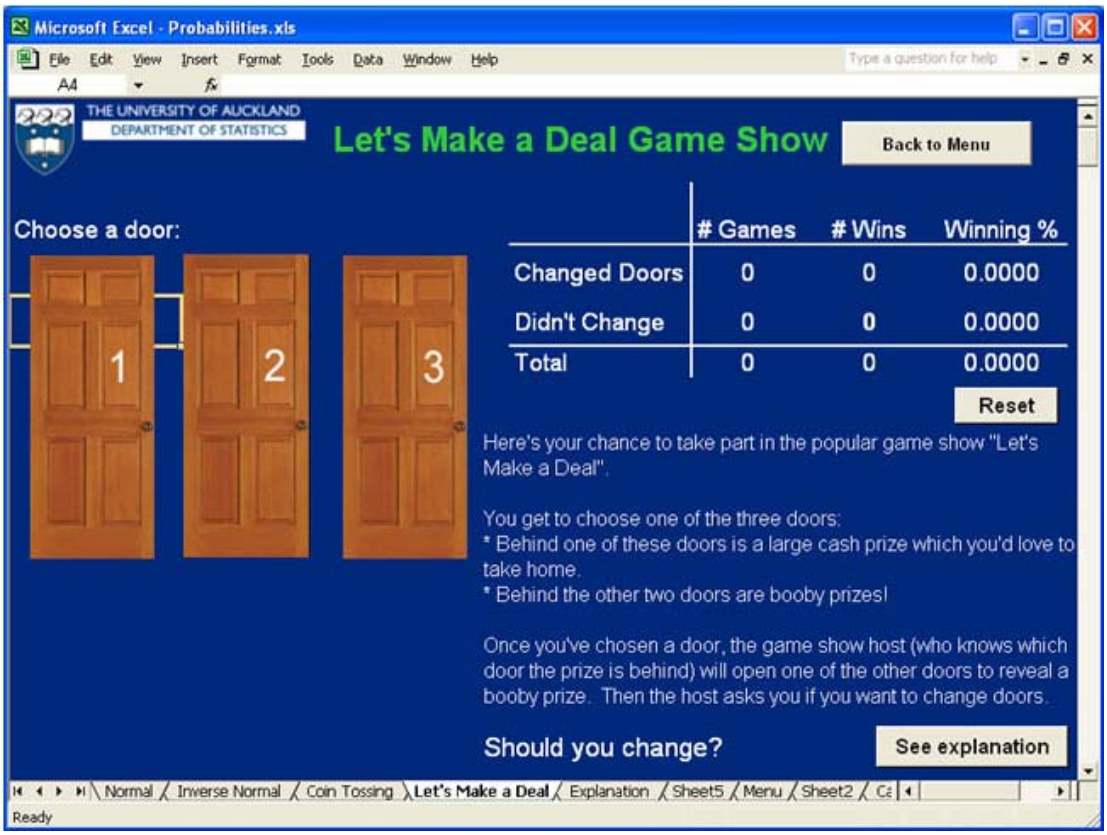
- This page of this sheet enables students to change settings using sliders.
- As they change the settings the shaded region under the curve (between a and b) and the calculated probability change automatically.

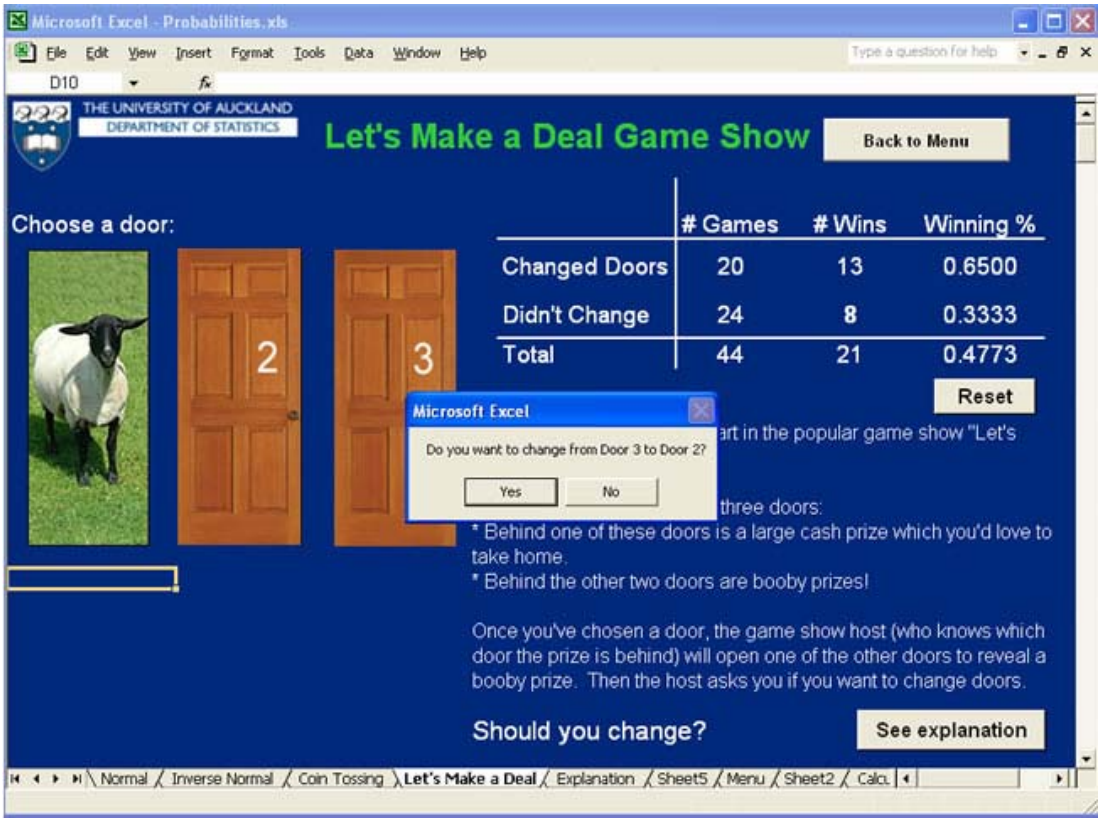


This sheet is a little more sophisticated:

- The student can grab any of the data points on the graph and shift it around.
- The summarising least-squares trend line changes position automatically.
- This enables students to get an intuitive feel for what sorts of points have a large influence on the position of the trend line and what points do not.
    - This complements theoretical/verbal accounts in the textbook and Lecture Workbook.
- Students are not limited to the demonstration data set. A new set of data can be pasted onto the spreadsheet.
- As with all of these tools, we both use it for classroom demonstration and provide it for the students to 'play with' themselves after class.

The last of these pages shows two views of a spreadsheet which enables students to play a version of a TV game called 'let's make a deal'. It helps to teach some lessons in conditional probability.


Microsoft Excel - Probabilities.xls
File Edit View Insert Format Tools Data Window Help
A4
THE UNIVERSITY OF AUCKLAND
DEPARTMENT OF STATISTICS
Let's Make a Deal Game Show
Back to Menu
Choose a door:
1
2
3
Games
Wins
Winning %
Changed Doors 0 0 0.0000
Didn't Change 0 0 0.0000
Total 0 0 0.0000
Reset
Here's your chance to take part in the popular game show "Let's Make a Deal".
You get to choose one of the three doors:
* Behind one of these doors is a large cash prize which you'd love to take home.
* Behind the other two doors are booby prizes!
Once you've chosen a door, the game show host (who knows which door the prize is behind) will open one of the other doors to reveal a booby prize. Then the host asks you if you want to change doors.
Should you change?
See explanation
Normal Inverse Normal Coin Tossing Let's Make a Deal Explanation Sheet5 Menu Sheet2
Ready


Microsoft Excel - Probabilities.xls
File Edit View Insert Format Tools Data Window Help
D10
THE UNIVERSITY OF AUCKLAND
DEPARTMENT OF STATISTICS
Let's Make a Deal Game Show
Back to Menu
Choose a door:
2
3
Games
Wins
Winning %
Changed Doors 20 13 0.6500
Didn't Change 24 8 0.3333
Total 44 21 0.4773
Reset
Microsoft Excel
Do you want to change from Door 3 to Door 2?
Yes
No
three doors:
* Behind one of these doors is a large cash prize which you'd love to take home.
* Behind the other two doors are booby prizes!
Once you've chosen a door, the game show host (who knows which door the prize is behind) will open one of the other doors to reveal a booby prize. Then the host asks you if you want to change doors.
Should you change?
See explanation
Normal Inverse Normal Coin Tossing Let's Make a Deal Explanation Sheet5 Menu Sheet2 Calcu