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Keeping it real, keeping them interested and keeping it in their minds

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Abstract

As part of many universities' Business degrees, students will undertake an introductory statistics course. Lecturers need to help these students appreciate and recognise the value of possessing quantitative skills and to learn and apply such skills. Three components to teaching that address these aims as well as the interdependence of these components as part of a process which enhances the teaching environment and student outcomes are described. Methods and examples to perform the techniques and ideas are provided along with a discussion of their implementation and effectiveness after delivery in a large first year course.

1. Introduction

University students enrolled in Business and related degrees will almost invariably be required to undertake an introductory Statistics course. Students approach the course with varying levels of trepidation based upon their perceptions of the value of Statistics to their area of study, their beliefs that Statistics is 'mathematical' and their own mathematical ability. Indeed the majority begin the course under sufferance, with a level of resistance related to their beliefs of the relevance of Statistics.

Students undertaking first year Business Statistics courses do not intend to become statisticians. However, they do need to acquire certain 'statistical' skills. Lecturers need to help students to appreciate and recognise the value of possessing quantitative skills in Business and help them to be better able to learn and apply such skills. If the opportunity to do so is not seized there is an increased risk of students not undertaking further statistical courses, not understanding basic statistical skills and being less equipped for the workforce.

This paper has several goals. The first is to provide a *structure* of themes, or *teaching outline*, for instructors to follow which will improve student rapport and learning, particularly in introductory

Statistics service courses. The *outline*, and each of the themes, should be viewed as a basis upon which the reader can be stimulated to create his or her own examples and methods. A second objective is to present, by example, innovative teaching methods which engage students, increase students' confidence and understanding of Statistics and support the proposed teaching outline and themes. The crux of such examples is to remove the mystery surrounding statistical concepts and techniques by enabling students to explain or define a concept *themselves* rather than simply being told the concept. The approach builds upon the concepts of "active learning" [1] (Bryce 2005)and "making it memorable" and "striking demonstrations" as theorised by Sowey (Sowey 1995, 2001); having both similarities and differences to the latter. A third objective is to present novel examples of how to engage students and aid their recall of certain important aspects of a Statistics course. Finally the paper reports upon the method of implementing the above in a large first year course and the results and perceived success.

Based upon research and reflection on my decade of teaching experience, student and peer reviews of my teaching methods and recently published text book and assessment of the effectiveness of the implementation of the teaching methods on students' course perceptions and outcomes, this paper describes three components underpinning the teaching of introductory Statistics that have shown to be associated with improving the learning environment and experience of Business students undertaking such a course. The components are introduced in this section and elucidated upon in Sections 2 to 4.

The first of these components is that lecturers need to 'keep it real'. There are many individual responses to the question 'what appeals to the Business student learning Statistics?'; however, one unifying description is 'context'. Providing information in a relevant context will help a student see its worth. Lecturers must engage students and help them recognise how the course content is relevant to their immediate life and activities as well as their likely future employment areas. Assisting students to see the value of learning (which parallels motivation) enhances a student's level of interest and ability to recall information (Romero et al 1995, Sowey 1995, Martin 2003). Innovative techniques to engage and assist students in this way are described in Section 2.

The second component involves methods for 'keeping them interested'. Whilst it is important to provide strong evidence supporting *why* something is important to learn, one way to *lose* someone's interest is to point out everything that they are doing wrong or everything that they don't know. Lecturers can maintain and generate further student interest in the area by providing sequences of semi-directed, or purposeful, questions that students *can* answer and will lead them to important statistical results, allowing them a sense of achievement. Then, what may have normally appeared a foreign idea if simply stated as fact is actually a conclusion which *they* reach. This not only increases students' interest but also their ability to learn and retain information. Elucidation of this idea and examples of such techniques are presented in Section 3.

The third component focuses on methods for 'keeping it in their minds'. Lecturers need to imaginatively aid students' abilities to retain, recollect and apply the new ideas and methods being taught. Memory jogs aid a student's recall and are an essential part of the learning process. Similarly, the relevant reference to popular television programmes can aid learning (and continue to keep them interested). Novel examples are provided in Section 4.

The paper is based upon these three broad components which are further delineated by five themes: 1. Reduce students' resistance. 2. Be appealing. 3. Enthuse and generate interest. 4. Facilitate self-learning. 5. Assist recall and understanding. The discussion of 'keeping it real' in Section 2 will involve points 1 and 2 from above. Section 3, which discusses methods for 'keeping them interested', covers points 2, 3 and 4, whilst 'keeping it in their minds', discussed in Section 4, covers points 4 and 5.

The paper is a consequence of a presentation I gave at the combined New Zealand Statistical Association and Statistical Society of Australia Incorporated conference held in Auckland, New Zealand, July 2006, following the many positive comments received from lecturers, industrial practitioners and secondary school teachers regarding the suggested teaching methods and examples. Whilst the structure of the teaching themes and techniques is applicable for any level of teaching, this paper focuses on teaching introductory Statistics service courses to Business students.

2. Keeping it real

Many students, particularly those with poorer quantitative skills, have phobias or barriers regarding learning Statistics. Lecturers would have commonly heard students' comments at the commencement of the course such as "There are too many definitions" or "I'm doing Business". These comments reflect students' perceptions that Statistics is seen as too tough and not relevant. Lecturers must reduce students' resistance to learning and overcome these impediments to their education.

2.1 Reducing resistance and being appealing

The aim is to help students see the Statistics course as simply another source of information having requirements not so different to their other courses, or indeed daily life. This approach of showing similarities, rather than differences, helps students overcome their views of Statistics being different or too tough based on having definitions to learn.

Years ago, a friend said to me that his lecturer was sick. Knowing the lecturer I was puzzled as he wasn't absent and he didn't seem sickly. Later in the conversation I realised that my friend was actually saying how good, or 'awesome', the lecturer was! Before introducing statistical terms in lecture I recount the conversation in detail to the class to show how they learn and use definitions or *jargon* in every day life. Lecturers without such a first-hand account of such language can still refer to the jargon people commonly learn. Lecturers can then remind students of how they are also learning new concepts and definitions in their *other* courses, such as leverage, hedging, derivatives and so forth to show how the course requirements are like their other courses.

Students' barriers to learning can then be further reduced by lecturers making other similar comparisons which students would otherwise be less likely to observe themselves. Lecturers can remind students that just as learning a foreign language would hold one in better position for *international* Business dealings, so too being armed with quantitative skills can also provide that 'competitive edge' over other people in Business. It is important to simply remind students that having knowledge of, and the ability to apply, Statistics provides them with another device in their 'tool kit' and how some may gain an advantage when seeking employment by having a photographic memory, others by being able to talk in a foreign language and others by having statistical skills. Introducing such ideas in this manner improves students' perceptions of the value of acquiring a range of skills, including the statistical skills they are to be taught.

It is recognised in the professional community that Statistics provides a valuable contribution to all careers emanating from University training as well as providing valuable careers in its own right (Smith, Vere-Jones and James 2005, Wilson 2004). Statistics' contribution to society and its more interesting elements are not so well-known to University students who are undertaking their *compulsory* introductory Statistics courses as part of their chosen undergraduate programs. There is a gap between the *reality* of the careers, opportunities and societal need for statistically and quantitatively-skilled people in many interesting areas and the *perception* of students.

It is important to appeal to students through 'what others say'; particularly employers! Providing examples of current employment advertisements for positions in which students will ultimately be interested and highlighting the sections of the desirable or required criteria which state 'quantitative skills', 'SPSS skills', 'degree in Statistics', 'ability to collect and analyse data', 'displaying statistical results graphically', 'simple statistics and more advanced analysis of survey data such as regression, factor and cluster analyses' and so forth is very important. Employment positions to show include market research, marketing, business, financial, market and risk management analysts, human resources manager, and the like, which identify such skills.

Techniques are universal, however, American-based students seeing Business applications in America, European students seeing those in their local area and Australian students seeing examples of businesses with which they are familiar, or are likely to work for, will improve the appeal to students. Using textbooks which provide such an area- or country-specific focus will further engage and encourage students. Whilst there have long been many American-focused text books, more recently Australian-focussed text books such as Howley and Gerlach (2006) have joined the market as have Australian-adaptations of American textbooks such as Selvanathan, Selvanathan, Keller and Warrack (2000).

Using the above methods of being attractive or appealing to the students will build a rapport in both large and small classes and help students overcome some of their initial concerns. Lecturers can then use this foundation and continue to engage students, enthuse and generate further interest and facilitate student learning as described in Section 3.

3. Keeping them interested

This section introduces a novel teaching technique which enables students to describe a definition or explain a concept to the lecturer in lieu of being told. It is an empowering, engaging and hence effective learning technique which reduces the mystery, and hence students' fears, of Statistics. Examples are provided in this section based upon:

a. providing diagrams and related questions which students can answer, cogitate upon and ultimately explain a concept or method; or
b. providing purposeful questions which students can answer and will lead them to the correct conclusion or concept by themselves.

3.1 Enabling students to see what they already know

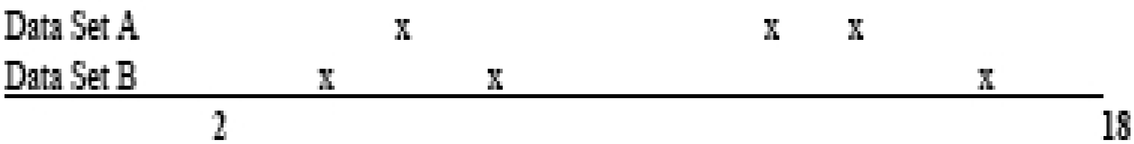
The techniques described in this section are sufficiently simple and low on time consumption that they may be immediately incorporated in any lecturer's present lecture format. The example in Section 3.1.1 exhibits the first of the two techniques listed above. The example in Section 3.1.2 exhibits the second technique. Sections 3.1.3 and 3.1.4 show additional examples of the techniques. They are described by including parts of the interaction I've experienced in lectures containing about 160 students.

3.1.1 The standard deviation – diagrams and questions to empower students

It is not uncommon for lecturers to want a course graduate to be able to describe, at least in layman terms, what a standard deviation measures. The following is an example of using diagrams and related questions which students can answer that helps them to describe the definition of a standard deviation in lieu of being told.

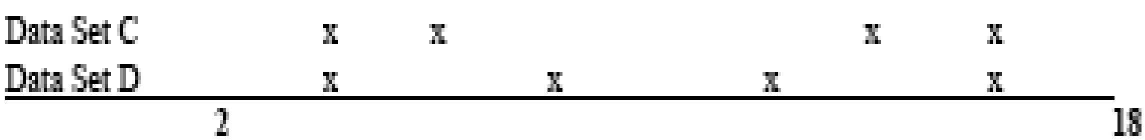
The class is shown a diagram similar to that in Figure 1 and asked to select which of the two data sets A and B they believe has the smaller standard deviation. It is important to draw students' attentions to the relative positions of the crosses representing data along the number line, not to focus on their exact values[2].

Figure 1. Abstract illustration 1 to understand what the standard deviation is measuring



A show of hands reveals unanimous support for Data set A[3]. A follow-up question asks why Data Set A was selected. If there is not an immediate response then reassuring the class that they have chosen correctly will invariably see a student suggesting that the data are less spread. It is important to use positive reinforcement *to that student* by informing them that they are correct that the standard deviation *is* a measure of spread but to then follow this with the question *to the whole class* of whether they are basing their decision on the range or something else. The class is shown that the range of Data Set A is clearly less than the range of Data Set B and asked whether it was this that lead them to say Data Set A had the smaller standard deviation or some other reasoning. This is left as an open question for students to ponder before quickly presenting them with Figure 2.

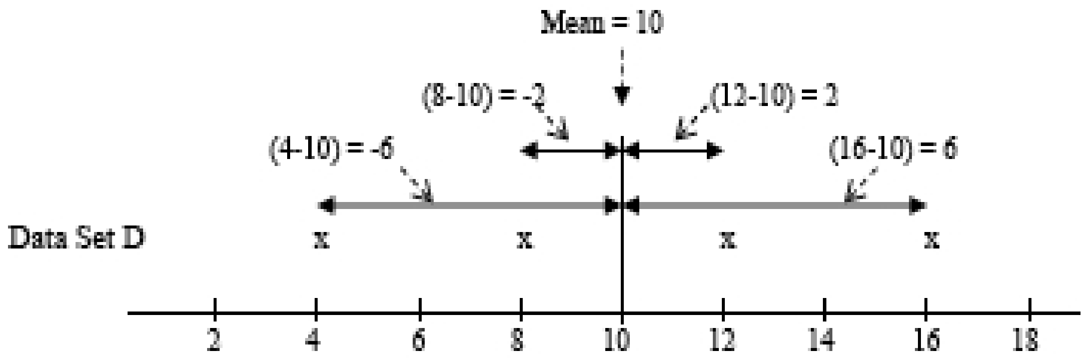
Figure 2. Abstract illustration 2 to understand what the standard deviation is measuring



After highlighting that the range is the same for both data sets C and D, students are asked to determine which data set has the smaller standard deviation. Unanimously, data set D is chosen. When the students are asked if they can say why they have chosen this data set, someone will comment, often after the class is told that they are correct, with words to the effect that "the data are closer to the centre overall" and "the data are closer to the mean on average" and "the data are less spread away from the centre". Before commenting on these suggestions, the class is asked whether they all chose data set D for this reason. After they agree it is simply a matter of saying, "Brilliant!". The students have identified that a standard deviation is a measure of how far spread the data are away from the mean and that essentially it measures the average distance from the mean.

If it is a desirable part of the course the formula can then be described using a diagram similar to Figure 3 to show why we cannot simply take the average distance. The important point, however, is that the students somewhat intuitively, or along with some prior knowledge, gave an explanation for what the standard deviation measures without having to be told this working definition.

Figure 3. Illustration of how to calculate the standard deviation of a data set



3.1.2 The sampling distribution - series of questions enabling students to see what they already know

This example provides purposeful questions which students are able to answer and leads them to describe the concept of a sampling distribution in lieu of a lecturer firstly explaining the concept.

The class is told that market research is required to estimate the anticipated profit from the sale of a new mature-aged Playstation3® game. They are informed that this will involve taking a random sample from the anticipated market of those aged 18 to 35 years, assessing their reactions and feelings towards the game and that, based on the responses, the proportion of people who will purchase the game is estimated from which the expected sales and profit can be estimated[4].

One person in the class is identified and told that they are to obtain a random sample of 200 people and report back the expected profit using the methods just described. A second person is identified and told that at the same time, independently of the first person, they are to obtain a randomly selected sample of 200 people and report back the expected profit. Finally the class is told that each member of the class is going to independently undertake this research and obtain a random sample in order to estimate the expected sales and profit.

The class is then asked whether or not they believe they would all get exactly the same mean if they each took a randomly selected sample from the population. The response is overwhelmingly "No". The class is asked whether they are saying the sample means would differ or vary[5]. The class all say "Yes", some with a puzzling look of ‘well of course’.

The class is then asked whether they are saying that the sample mean would vary depending on the sample obtained and hence their variance could be considered. Again, the class overwhelmingly says "Yes", as if it is obvious.

The class is asked whether all of the possible samples and hence sample means could be collected and the average of all of their individual values considered. The class is asked whether it sounds possible to consider the mean of all the possible means, based on all the possible samples that could be obtained. The class concurs. The class is asked if it sounds reasonable that a histogram could be constructed of all of the possible sample means and its shape could be observed. They all say, "Yes".

The interaction and class responses are then restated to the class in summary form, verifying that the class agrees that *they* have just indicated that associated with the sample mean we can measure the variance, the mean and the shape[5]. After the class agrees, the class is told how they have just indicated that the sample mean has a *distribution*, as they know that the three things which describe a distribution are shape and measures of variation and location. They are then told that distribution is called the sampling distribution of the mean.

The sampling distribution of any statistic can then be discussed. The significant point, however, is that rather than trying to describe the concept of a sampling distribution, the lecturer has, through a series of questions which students adamantly answer, enabled the students to describe the concept and existence of a sampling distribution to the lecturer!

To aid the presentation, it is advisable to have the follow-up questions and comments (i.e., after the class has provided their view) already written on an overhead projector transparency and revealed at each step. For instance, after establishing the scenario show the class the first question on the transparency "if each of you took a randomly selected sample from the population would you all get exactly the same mean?". Following their response (which will be 'No') reveal the next question on the overhead as 'So are you telling me that the sample means would differ or vary? Is that what you are saying?'. As well as reinforcing the verbal discussion with written commentary, it is somewhat intriguing, if not comforting, to students to see that they are telling you answers which you expected to hear.

3.1.3 The philosophy behind hypothesis testing and p-values – diagrams and questions to empower studentss

This section describes a second example of providing diagrams and related questions which students can answer that, this time, helps students describe the concept and method behind hypothesis testing. Passive learning[6] (Bryce 2005) may provide students with a 'recipe approach' to learning hypothesis testing, which can also be beneficial in providing students a structure to follow. However, enabling students to firstly tell the lecturer what is a sensible idea in hypothesis testing is a powerful and enriching procedure.

The class is told that as manager of a motel, they have contracted an organisation to service rooms following guest departures. The organisation claims that the mean time to service a room is ten minutes. The class is asked how one can test whether or not the organisation's claim that the mean time taken is ten minutes. The class may need some prompting, however, someone will identify the need for data. The class will concur with this suggestion when asked if this sounds sensible.

The class is then asked if they would believe that the true mean time is not ten minutes if some data (a representative sample using appropriate sampling techniques) were collected which had a mean time of 10.01 minutes. If desired, this can be worded as whether it provides strong evidence that the true mean time is not ten minutes. The consensus response from the class is "No".

The above is repeated replacing 10.01 with 10.3 minutes. Again, overwhelmingly the response is "No". The class is asked whether anyone is starting to think perhaps it is not ten minutes. The decision about a firm 'Yes' or 'No' is not the key issue.

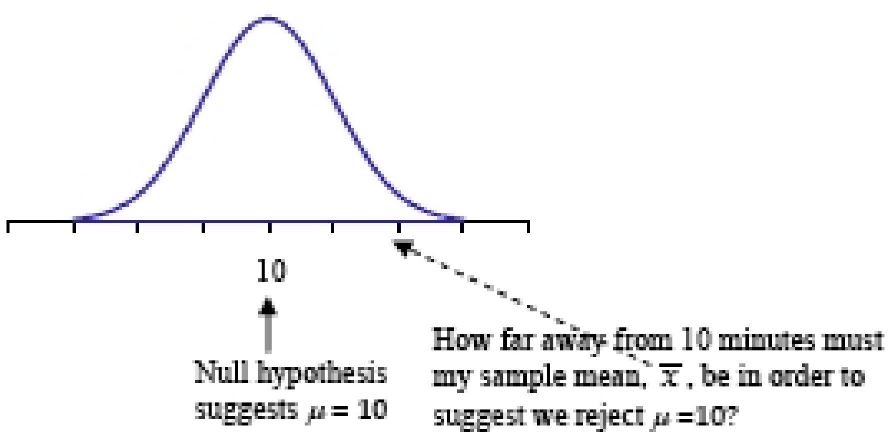
This is repeated with values of 10.7, 10.94, 11.03 and 11.5 minutes. A show of hands at each of these values sees less and less support shown for the ten minutes. It is at this juncture where the class is asked whether they are suggesting that there is some point, or value, at which they are going to reject the ten minutes, whatever that point may be. If it is desirable, this can be posed to the class by also asking whether they are suggesting that there is an increasing level of evidence against the value of ten minutes. The class will reply positively.

The class is then asked whether they are saying that a sample mean value that is *near to* ten minutes will see them not rejecting ten minutes as the true value, and that a sample mean that is *far from* ten minutes will see them rejecting ten minutes. The class indicates that this is the case, which is great. They are told that they have identified that the underlying idea of a hypothesis test is effectively getting some data and seeing if its value is close enough or far enough away to be able to reject or not reject the proposed value.

When the class is asked why they would not reject (or are unlikely to reject) ten minutes as the mean time, when the sample yields 10.01 minutes considering 10.01 is not the same as 10, class discussion results in the students identifying the aspect of it being based on one sample, and hence it could be a lucky or unlucky sample, or words of that nature. Note that no new terminology has been introduced and students are identifying the concept of sampling variation and its role in determining the strength of evidence to reject ten minutes.

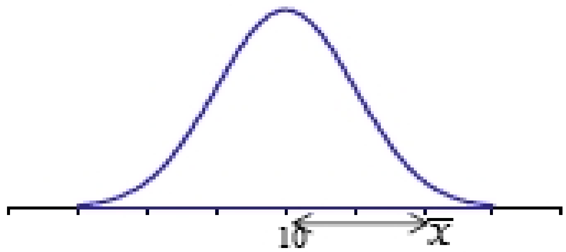
After a reminder of the central limit theorem and the sampling distribution, the students are then shown a diagram like that in Figure 4 of what the students have essentially been describing. The notion of null and alternate hypotheses can be introduced at this time.

Figure 4. Understanding the hypothesis testing idea: testing population mean service time, μ, of 10 minutes



To help students to be able to describe the relationship between a p-value and the strength of evidence against the null hypothesis, the class is shown a diagram like that in Figure 5 proposing that the sample mean, $\bar{x}$, is at the position indicated. Whilst pointing at the distance represented by the double-headed arrow between 10 and $\bar{x}$, the class is asked whether or not they would reject 10 if the distance between $\bar{x}$ and 10 was BIG[7]. The class will suggest to reject it. A similar question is asked in the event that the distance between $\bar{x}$ and 10 was SMALL. The class will suggest to not reject it. It can then be stated to the class that their comments indicate that by knowing what BIG means, or SMALL, decisions about the mean can be made[8].

Figure 5. Visual display of the relative position of the sample mean from the null's 'hypothesised value'



After shading the area beyond $\bar{x}$ on the diagram in Figure 5, as shown in Figure 6a, the class is asked whether the remaining area would be BIG or SMALL if $\bar{x}$ was a long way away from 10. Students respond that it would be small. Similarly using a diagram like Figure 6b the class is asked whether the remaining area would be BIG or SMALL if the distance between $\bar{x}$ and 10 was SMALL.

Turning this around, whilst pointing at the area on the diagram in Figure 6a the class is asked whether $\bar{x}$ is close to the hypothesised mean or far from it (relatively speaking) if the remaining area is small. Students respond "far from it". The class is then asked whether or not the hypothesised mean should be rejected if $\bar{x}$ is far from it. The class responds with "reject it". The class is told how they have just indicated that the remaining area can be used to help determine whether or not to reject the hypothesised mean value. The class is asked that they concur with this observation.

Figure 6a Diagram showing when $\bar{x}$ is a **LARGE distance from the null hypothesis' value of 10, the area** ***even further away*** **is relatively SMALL**

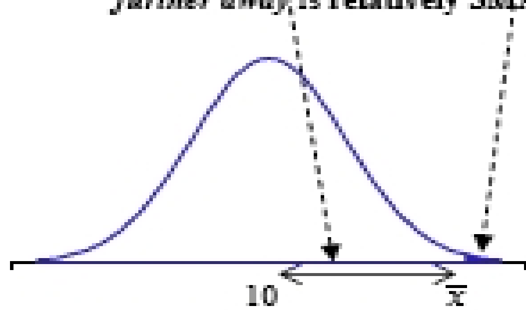
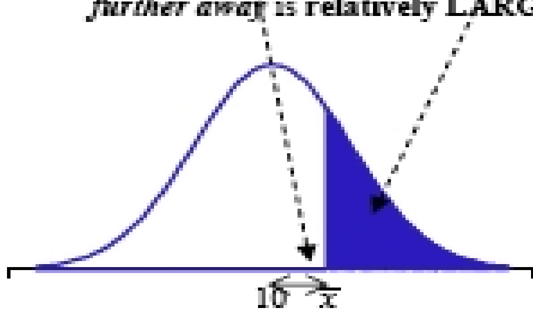


Figure 6b Diagram showing when $\bar{x}$ is a **SMALL distance from the null hypothesis' value of 10, the area** ***even further away*** **is relatively LARGE**



The class can then be told how this area (or double it for two-tailed tests[9]) is called the p-value and will help to identify whether or not to reject the null hypothesis. The concept of a significance level and how it is what can be used in order to determine the relative smallness or largeness of this remaining area can then be discussed. However, significantly, the important concepts of the philosophy of hypothesis testing, its process and the method of making a decision based on nearness or distance (and ultimately the size of the remaining area) have been introduced and described by the class without the need for terms such as p-values and significance levels. These methods and measures, which the students have identified themselves, can later be labelled.

3.1.4 *Z* scores - series of questions enabling students to see what they already know

This section gives an example of providing purposeful questions which students can answer and will lead them to describing the concept of a *Z* score to the lecturer.

The class is told to consider a variable, *X*, measuring monthly return on investment that has a mean of $500 and a standard deviation of $100 and asked to consider how many standard deviations $600 is from the mean. This is repeated replacing $600 with $700 and $650.

Students are told that a value of $600 corresponds to a *Z* score of 1 and asked whether they can see what *Z* represents, assuring them that they are not going to be asked to tell the class. This is repeated replacing $600 with $700 and $650 and the *Z* score with 2 and 1.5 respectively. This is also written in short form on an overhead projector transparency or Microsoft Powerpoint display as the questions are posed.

The class is reminded that the standard deviation is 100, the mean is 500 and for a value of 600, *Z* is 1 and for a value of 700, *Z* is 2 and for a value of 500, *Z* is 0 and for a value of 400, *Z* is -1. This is simultaneously written and displayed to the class as:
"The mean is 500, the standard deviation is 100.
For a value of 600, Z=1.
For a value of 700, Z=2.
For a value of 500, Z=0.
For a value of 400, Z=-1."

The class is asked whether anyone now believes they know what the *Z* score represents, telling them again that they are not going to be asked to describe it. If sufficiently many feel confident then the class is asked if anyone would like to offer their suggestion. Otherwise the class is asked "What was the value of the standard deviation? How many standard deviations is 700 above 500? How many standard deviations is 400 below 500?"

At this point the class is asked for a suggestion regarding what the value of *Z* is representing and the class identifies that it is telling us how many standard deviations above or below the mean the value of *X* is.

To reinforce this after the discussion, and in case there are some who are still unsure, it is restated how the value 700 is 2 standard deviations (2 times 100) above the mean of 500 and hence Z=2. Similarly, 400 is 1 standard deviation (1 times 100) below the mean of 500 and hence *Z*=-1. The value 450 is ½ a standard deviation below the mean of 500 and hence *Z*= -½.

It is valuable to ask the class to consider how they were calculating the *Z* score in their minds themselves first. They should then be informed that they are most likely considering the difference between the value and the mean and then see how many times the standard deviation goes into that difference; giving them an example with 700. The formula for standardising can then be introduced, showing them how it is doing what they were calculating in their minds; again with the same example of 700.

4. Keeping it in their minds

In addition to the methods suggested in Section 3, given the many new concepts that students need to learn, it is important to take advantage of any useful analogy or "retrieval cue" that can assist memory retrieval (Myers 1998 p.289, Martin 2003). In the case of experimental design, the three important concepts to incorporate can be recalled as the 3Rs; not Reading, Writing and Arithmetic but Randomisation, Replication and arrr Blocking (Howley 2003). When describing the distribution of a random variable one needs to consider its shape and provide measures of its variation and location, or central tendency. One can observe that we need to use "the 3Ss" to describe the distribution, namely "shape, spread and…centre". Describing this method of recall gets a laugh from the class…but invariably they remember to use the three measures to describe a distribution when tested in the course quiz.

In addition to such retrieval cues, the appropriate use of popular television programmes can be a useful conduit to increase the chance of a concept or content being recalled. This is exemplified in the following subsections.

4.1 Non-random sampling

Many readers will be familiar with the example of the 1948 presidential elections which saw the *Chicago Daily Tribune* print their headline "Dewey defeats Truman" prior to the ballots being counted. The newspaper was left embarrassed when Truman was found to be the victor. Investigations revealed that their reliance on public opinion polls which use non-random sampling was the cause. Consequently, random sampling methods were used for future elections (Freedman, Pisani and Purves 1978). This is an important point regarding non-random sampling, however, it is relatively old and uninspiring.

Enter The Simpsons™. The class is asked, "HEY SIMPSONS FANS!! Do you remember this episode?" and the following is presented to them:

Homer and Lisa are watching the History Channel on T.V. and the November 1948 U.S. presidential election is being broadcast. The T.V. narrator says "Victory seems imminent for Governor Thomas E. Dewey". Homer begins supporting Dewey, "Dewey, Dewey, Dewey" he chants. Lisa informs Homer in a droll voice that Truman actually wins.

The T.V. narrator says, "The newspaper headlines proclaim Dewey defeats Truman". "Woo hoo, I win the bet. Who’s your daddy?" yells Homer to Lisa.

"But the headlines are dead wrong" the T.V. narrator continues. Homer is mortified, "Harry Truman triumphs by 2 million votes"; Lisa wins the bet and gets to choose the day’s father-daughter activity, "We’re building homes for the homeless" Lisa says.

Starting with this excerpt from The Simpsons™ engages and enthuses the audience as they recall the episode themselves with fondness and become attached to the scenario. At the end of describing the scenario the class is asked "Did you know this event and this incorrect expectation actually happened!?" The above statistical aspects of sampling can then be discussed.

4.2 Correlation not Causation

When explaining the difference in the concepts of association and causation another example from The Simpsons™ works well. Lisa has been listening to Homer trying to make a point and comments that it is specious reasoning. Homer says, "thank you honey". Lisa continues and then points out that by his reasoning she should claim this rock (as she holds it up) keeps tigers away. Homer is intrigued and asks, "How does it work?". Lisa replies "It doesn't … But I don't see any tigers around here, do you?" Homer ponders a moment and then decides, "I'd like to buy that rock from you Lisa".

Delivery is important and indeed holding that final pause in Lisa's reply and holding Homer's final decision to be revealed only at the last moment is critical.

5. Assessing success

The need to run multiple lectures, randomly assign students to class times, have sufficient numbers of students to test and similar issues have prevented the desired large scale randomised controlled block trial to assess the magnitude of the benefits of the techniques and ideas described in this paper. However, subjecting successive cohorts of students to differing techniques and comparing the results was achievable. This was undertaken to assess the techniques and ideas described in this paper by applying the described teaching techniques in the delivery of a first year 'Statistics for Business' course in Semester 1, 2006 and comparing the students' test scores and responses to questionnaires with the 2004 and 2005 cohorts of students in the same course at The University of Newcastle, Australia.

5.1 Background

The above first year course is delivered in a 13-week semester to cohorts of about 200-250 students enrolled in a Business or related degrees. Students are directed to attend both a two-hour lecture and a smaller two-hour workshop session combining computer and tutorial exercises each week; the latter seats up to 28 students.

Lecturers and part-time tutors deliver the two-hour workshop sessions after firstly attending a weekly one-hour tutors' meeting. The course coordinator conducts the meeting and informs the tutors on how to discuss the workshop content with the students and what additional examples and ideas should be taught in the workshops. The existing structured workshop exercises involved any or all of data creation, manipulation, analyses, interpretations and reporting and were used in all three deliveries.

The lecture topics and workshop materials remained the same from 2004 to 2006. The 'Powerpoint' lecture slides have always provided a thorough outline of the lecture material, including examples and in-class exercises, with students able to download copies prior to the lecture.

5.2 Method

In 2006, the lecture slides and presentation were modified to incorporate the ideas and methods described in this paper. Current local and international employment examples were shown to the class, with the relevant criteria highlighted, and the discussions of the course's similarities to daily life and their other courses were included as described in Section 2. This occurred primarily in the first two lectures, with additional employment examples also used as reminders throughout the course. Throughout the course new topics and concepts were introduced using the technique identified and illustrated in Section 3. Memory jogs and reference to television programs were included in the lectures as illustrated in Section 4. Additionally, in 2006, tutors were instructed to use the ideas and techniques described in this paper. Specific examples and instructions on how and where to do so were provided at the weekly tutors' meeting.

To facilitate the conveyance of the methods and techniques further, a new textbook was recommended to the students in 2006, and the tutors were also given a copy of the textbook. The textbook provided additional examples of the methods and ideas for teaching described in this paper. Each week, tutors were informed of where, when and how to address students and inform them of ideas in the manner described in this paper.

The textbook was coauthored by a lecturer presently at Sydney University and me. It was written in the second half of 2005 and completed in February 2006 in time for its first release and use in the 2006 cohort of students[10]. The book states one of the principles it follows as "Removing the mystery and enabling students to *see it themselves* rather than simply being told – to learn by thinking and doing, *prior to reading the how and why*, and recognise why certain techniques are used. This is done via leading questions, introductory discussions of the ideas behind techniques, advocating and displaying the use of diagrams, and worked examples when applicable", as maintained in Section 3 of this paper. A second principle is stated as "Placing Statistics in context – Business students need to be enthused by seeing how Statistics is used in their 'Business' environment, rather than being too weighed down by theory and history." A third principle is stated as "Enhancing the reader's sense of familiarity and hence recognition of Statistics in their likely working environment – this is achieved by providing Australian examples and exercises whilst maintaining an international flavour." The latter two principles are maintained in Section 2 of this paper. Hence sections of this book were identified to tutors in 2006 to help explain and provide further examples of the ideas and methods that they should then convey to the students, in line with the ideas and methods described in this paper.

Examples were identified in the textbook for the tutors to use in their class of applications of statistical methods and theory which were familiar to students and their likely environments (as mandated in Section 2) and descriptions of how to enable the student to explain an idea (as mandated in Section 3), although the latter was primarily addressed in the lectures by the lecturer when first introducing ideas or new topics. The examples of memory jogs (as mandated in Section 4) such as the 3Ss to describe a distribution were also further mentioned by the tutors in the workshops.

For all three of the years, students were expected to read and attempt designated 'homework' exercises from the prescribed textbook on a weekly basis in order to obtain a weekly mark. This was one of many assessment items which contributed to their final grade. The only change to this task in 2006 was that exercises were assigned from the new textbook instead of the old textbook.

Another of the assessment items contributing to the final grade in all three years was a supervised test. The content of the tests and the materials they covered were the same across the years and involved questions that were commonly used, or similar, across the years. Questions included both multiple choice and short answer style responses.

Anonymous surveys were conducted each year to assess the students' perceptions of the course and teaching methods. Students responded on a five-point likert scale of Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly Agree (5) to various statements. Statements common in the 2004-2006 deliveries of the course which relate to a comparison of the new teaching ideas and methods (in 2006) with previous methods included:

1. The lecturer encourages thinking during the class

2. The lecture and workshops make valuable reference to practice and real life
3. The lecturer has demonstrated keenness for you to understand the course's concepts and applications
4. The current 2-hour workshop sessions provide practical application of the lecture material

An anonymous survey was also conducted in 2006 during workshops in the 12th week of the semester to assess students' perceptions of the textbook. The majority of the questions were consequently focused on the textbook, however, certain questions did indirectly ascertain the students' perceptions of the methods used in this paper, as the textbook was based on such techniques. In particular, the students were asked to respond to the following two statements on the same five-point likert scale as above:

a. I found the text book's 'language' easy to read
b. I found the text book's 'language' aided my comprehension of the material

Whilst the course was delivered twice annually, only the results from the first semesters in 2004 and 2005 are compared with the results in the 2006 Semester 1 delivery, in order to preclude between-semester differences from affecting the results. For example, Semester 1 cohorts will primarily be students having just completed high school the previous year and hence not previously exposed to University life and study practices. Semester 2 students, however, are able to have learnt how to study at University and modify their study behaviours, and even their expectations, in the second semester based upon their Semester 1 results and experiences. Additionally, this precluded the 2005 Semester 2 cohort potentially contaminating the comparisons as they undertook the course whilst the course coordinator co-wrote the textbook.

5.3 Results

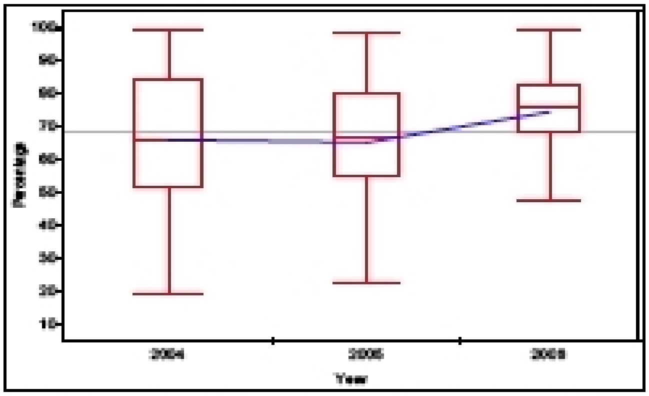
Table 1 displays the test results for the three cohorts of students undertaking the first year course. The implementation of the new methods, ideas and examples in the lecture and via the tutors through the meetings, textbook and workshops in 2006 are associated with the average test scores increasing from about 66% (SE 1.3%) for the previous two years to 74% (SE 0.9%). ANOVA (allowing standard deviations to be unequal), Tukey-Kramer and Student's t tests identify the mean score in 2006 is significantly higher than the 2004 and 2005 mean scores ($p < 0.0001$). Levene's test for homogeneity of the variances shows there is a significant reduction in the variance in the scores in 2006 compared with the 2004 and 2005 variances ($p < 0.0001$).

Table 1: Test score results for cohorts of students exposed to the older and new teaching methods

	Sem 1, 2004 **OLD TEXT and METHOD**	**Sem 1, 2005** **OLD TEXT and METHOD**	**Sem 1, 2006** **NEW TEXT and METHOD implemented**
Number of Students	241	216	204
Mean test score	66.0	65.3	74.4
Standard error	1.3	1.2	0.9

Figure 7 visually displays the results for the three cohorts and shows the shift in the distributions and the reduction in the variance.

Figure 7. Parallel boxplots of the test score results for cohorts of students exposed to the older (2004, 2005) and new (2006) teaching methods^



^ Line between boxplots is joining the mean scores

Table 2 displays the mean scores and standard errors of the responses to the four statements assessed through a class questionnaire. The mean scores in 2006 are consistently above those achieved in the previous deliveries.

The lecture topics and workshop content remained unchanged; only the methods of teaching had been modified. Hence the improved 2006 mean responses to statements 2 and 4 in Table 2 positively support the new teaching methods in both the lectures and workshops, suggesting an effective transference of the teaching methods and ideas to the tutors, and are associated with the improved test scores.

Table 2. Mean scores (and Standard Errors) for Likert Scale responses

	2004 **OLD TEXT and METHOD**	**2005** **OLD TEXT and METHOD**	**2006** **NEW TEXT and METHOD implemented**
1. The lecturer encourages thinking during the class	3.5 (0.11)	4.0 (0.07)	4.5 (0.08)
2. The lecture and workshops make valuable reference to practice and real life	3.1 (0.12)	3.6 (0.08)	4.0 (0.12)
3. The lecturer has demonstrated keenness for you to understand the course’s concepts and applications	3.8 (0.11)	4.0 (0.07)	4.4 (0.09)
4. The current 2-hour workshop sessions provide practical application of the lecture material	3.6 (0.11)	3.7 (0.09)	4.1 (0.11)

Whilst it would be nice, as coauthor, to think that the book itself contributed to the improvement in students' comprehension of the course, students undertaking first year Business Statistics courses tend to read as little of a prescribed textbook as possible. Of the 140 responding to the survey question eliciting the students' use of the textbook, only 32% of students indicated that they read the majority of the textbook, irrespective of whether or not they completed the homework questions.

Of the 32%, the average response to each of the statements regarding the book's language and its aiding in their comprehension of the material was 3.6 (SE 0.1), with 31 out of 45 (69%) indicating they 'Agree' or 'Strongly Agree' with each of the two statements, and 14% responding 'Neutral'.

6. Summary

Teaching a service introductory statistics course that engages, enthuses and educates students entails many issues. It involves initially assisting students to recognise the benefits of learning the course content and to help reduce their previously-held misperceptions and fears of the course. This is achievable by providing students with information from various sources, including the students' likely employers, examples of real business applications in their likely working environments and showing them similarities between the Statistics course requirements and their other courses and even daily life. This immediately has students reflecting upon their initial thoughts about the relevance and difficulty of learning Statistics in light of the information presented to them and provides an improved foundation for their Statistical education.

The teaching technique exemplified in Section 3 uses diagrams and series of questions to enable students to successfully explain or define a concept themselves in lieu of being told. This innovative technique empowers students and removes the mystery and foreignness that would otherwise accompany the learning of such concepts. The technique also facilitates student discussion of an appropriate approach or decision-making process in the presence of a scenario and hence teaches students about when to apply statistical tools. The approach provides valuable support in continuing to engage students and overcoming students' concerns, enthusing students' interest and facilitating self-learning and is able to be easily included within the lecture forum.

Context and memory jogs are important parts of supporting the students' learning experiences and ability to recall information. The use of relevant, related excerpts from popular, well-known television programs like those shown in Section 4 support this.

This paper provides an *outline* or process for instructors to follow which focuses attention on *all* of these elements of teaching as well as showing their interdependence in enhancing the learning environment and experience. Significantly, this paper provides much needed novel, relevant and modern examples and novel teaching methods which facilitate student learning, as well as showing the implementation of these methods and examples to be positively associated with students' test results and perceptions of the course and its presentation.

7. Epilogue

The suggested presentation methods and the examples provided in Sections 3 and 4 are "sufficiently clear and self-contained to be immediately grasped", "immediately enlightening…(and)…surprising", "provokes reflection" and can be "presented as to enhance the impact of the foregoing three characteristics". Hence they constitute examples of striking demonstrations (Sowey 2001) and "making it memorable" (Sowey 1995, Martin 2003). However, whilst Sowey's 'striking demonstration is after the "aha!" reaction and 'now I see' and "(b)ut that contradicts what I already know" (Sowey 2001), this paper's approach is after the "wow!" reaction of 'gee I didn't realise what I already knew' and hence is a different way of building confidence using a '*striking* demonstration'. It is also 'memorable' for the students because it is an event which each will reflect upon as they unwittingly describe a new concept to the lecturer.

It is intended that lecturers will reconsider their methods of presentation in light of the approach described in Section 3 and that lecturers will add to these examples. For instance, the example in Section 3.1.3 can be extended by asking the students' opinions on whether or not to reject the mean service time as 10 minutes if the sample mean was 10.5 based on 3 services compared with their opinion if the sample mean was 10.5 based on a sample of 1000 services. This enables them to see their own understanding or consideration of the sample size and hence standard error or precision in decision making. Similarly, asking the students' opinions on whether they are more likely to reject the mean time of 10 minutes if a sample of 12 services had a mean of 10.5 minutes but ranged from 9.6 to 10.8 minutes compared with a sample of 12 services which had a mean of 10.5 minutes but all 12 times were 10.5 minutes enables the students to see their own understanding or consideration of the variance in decision making. Additionally, ad-hoc examples based on asking the class what they would like to measure can be beneficial in further engaging the class.

Care should be taken to not simply present examples that are interesting or clever only to the lecturer but instead are interesting to the young, and often disinterested, novice. Business students are not looking to be shown how clever Statistics can be; they often already have that perception and is part of why they are scared of Statistics. Instead, lecturers must remove the mystery and be encouraging towards students by enabling them to feel that they can learn Statistics; that it is not so different.

Footnotes

[1] "Active learning is concerned with … how (students) gain insight into main ideas, technical details, and intuition. It is contrasted to passive learning in which information is presented to students who are expected to absorb it through contemplation and memorization of notes and textbook material. Students can learn actively by working problems for themselves, thinking about concepts to form their own summaries and statements…" (Bryce 2005)

[2] In the lecture it is useful to simply identify the lowest and highest values along the number line and place the crosses between them to ensure students are not being distracted by numbers. An interactive hand-drawn sketch in colour pen on an overhead transparency can aid the presentation, reducing the rigidity that may be felt if Figure 1 was typed up and pre-prepared for display in the class.

[3] It must be mentioned that students are exposing themselves, and leaving themselves vulnerable, if they are expected to hold their hand up clearly in the air in support of an answer. This can reduce a student's willingness to participate and reduces the lecturer's chance of assessing their understanding. Accordingly, students should be asked to place their fist against their chest and raise their fore-finger in support so at least it can be seen by the lecturer if they are firstly thinking and secondly choosing correctly. This reduces students' concerns of being seen as ignorant by their peers; I've successfully used this in lecture theatres seating some 160 students.

[4] For brevity the interaction with the students on how to undertake such research (including sampling

instead of a census) has been excluded, however, this is another valuable part of the scenario as students can participate.

[5] Students are reminded that the lecturer is not saying they are wrong but merely wanting to ensure that the class' perspective is clearly stated, not accidentally misrepresented. It is vitally important that the lecturer slowly restates the class' response and verifies that this is what *they* have decided before progressing, not something that the lecturer is deciding! Words such as "is that what *you* are telling *me*, I don't want to be putting words in your mouths" and "I'm not suggesting you are wrong, I just don't want to be putting words in your mouths" should be used before progressing at each stage.

[6] Passive learning involves the presentation of information "…to students who are expected to absorb it through contemplation and memorization of notes and textbook material." (Bryce 2005)

[7] This may alternatively be stated as 'if $\bar{x}$ was a *long way away from 10*'

[8] It was deliberately decided to describe this from the perspective of rejecting or not rejecting at a significance level, rather than going straight to the p-value representing a level of strength of evidence against the null hypothesis. Although many may suggest that the significance level is often somewhat arbitrary, the concept of not making a definite decision but instead leaving it as 'strength of evidence' alone can leave students unsatisfied; the latter can be taught after they firstly learn the significance level approach.

[9] This scenario could easily be presented as either a one- or two-tailed test. The two-tailed scenario would identify management's competing concerns that if the time taken is considerably (i) less than 10 minutes then they are overpaying the contractors for their time, and (ii) more than 10 minutes other processes (including the availability of the room to arriving guests) are delayed.

[10] Neither the textbook's coauthor nor I was the course coordinator in Sem 1, 2005.

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