IMPROVING LECTURES WITH CAST APPLETS

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Most statistical concepts and methods can be explained and illustrated using diagrams and in most places where a diagram might be used, a dynamic diagram is more effective than a static one. A few such diagrams per lecture quickly build to hundreds in an introductory statistics course. The collection of CAST applets for lectures contains over 400 including simulations to demonstrate the properties of sampling distributions and inference and many others that are uniquely designed to illustrate individual statistical concepts. Use of these diagrams helps to explain statistical ideas and methods, demonstrates calculations, breaks up the reading of static slides and adds some entertainment value. The paper also discusses the differences between applets designed for self-study and for use by a lecturer in both large and small classes.

INTRODUCTION: LECTURES OR SELF-STUDY?

Although on-line courses are becoming more sophisticated with platforms such as Blackboard (2009) and Moodle (2009) providing discussion boards, quizzes and other tools to encourage active learning, lectures remain a core part of most courses for internal students (Larsen, 2006). If distance students can learn well from self-study material, what value is added by lectures?

Pacing study

On-line courses have the advantage of being self-paced, but this is a double-edged sword. Some students find it difficult to study regularly and, if they are taking several subjects simultaneously, only study for each course when an assessment deadline approaches. Attending lectures regularly enforces some level of continuous study.

Active learning

Although conventional lectures can be very passive experiences—the author has attended lectures that were little more than dictation classes—a good lecturer can interact with the students in ways that encourage them to think. The scope for interaction depends partly on the class size since few students are willing to speak out in large classes, but regular questions can always be asked after which students are given time to think and discuss. Electronic 'voting' systems may be used to collect and display responses and they encourage students to be more honest than with a 'show of hands' (Draper & Brown, 2004; Fitch, 2004).

Another way that lectures can involve active learning arises because of the highly summarized bullet points that are generally used in PowerPoint presentations. Students can be encouraged to expand these into their own notes (or annotate printed copies of the slides) during lectures, making note-taking a form of active learning.

Motivation and entertainment

A good lecturer can hold attention by 'entertaining' the students while teaching them. Lesser and Pearl (2008) and Sowey (1995 and 2001) give examples of ways to make lectures more fun and memorable. Short videos will give a break from PowerPoint slides; clips from the Against All Odds series (2009) and many other videos about statistical methods have been published on YouTube. Dynamic computer-based illustrations are another way to give variety to a lecture and are the main focus of this paper.

Whenever a static diagram is used in a lecture (or textbook), some dynamic variation can usually make its point more clearly and/or more memorably. Diagrams on a whiteboard may be altered with a cloth and pen, but dynamic diagrams on a computer are more effective. Ten such diagrams per lecture accumulate to two or three hundred in a typical introductory statistical methods course.

Dynamic diagrams can be implemented in various ways but small programs called applets are often used. A few collections of 20-30 applets have been published such as these by Rossman and Chance (2009) and Lane (2009), and a Google search for "Statistics Applets" shows many

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php

others. The applets have considerable overlap and most use simulations to explain the concepts of sampling distributions and inference.

This paper describes a collection of over 400 applets that have been designed to support the lectures in typical introductory statistics courses.

CAST APPLETS FOR LECTURES

CAST (Computer Assisted Statistics Textbooks) originated as an electronic textbook for teaching introductory statistics that made extensive use of Java applets to help teach the concepts and methods. This e-book was viewed in a web browser and could be accessed over the internet from a remote server or downloaded and read from a local hard disk. CAST has since expanded considerably—the main e-book now contains over 450 applets and CAST also includes several other e-books and resources—but it is still based on a web browser and Java applets (Stirling, 2009).

Although CAST was initially designed for self-study, the interactive diagrams were also found to be useful during lectures to help explain important concepts in a memorable way and to break up a stream of overheads or PowerPoint slides with something more dynamic and entertaining.

A major problem with using CAST in this way was that each e-book applet was surrounded by expository text that explained the concepts in words, described how the reader should interact with the applet and summarised the insights that the applet should give. The surrounding text was necessary for self-study but was a distraction in lectures and often required scrolling to reach the applet itself. A second problem was that some diagrams were too small; Tufte (1983) recommended that simple diagrams be kept small in reports and books, but relatively larger text and diagrams are needed in PowerPoint presentations. The initial solution was a separate e-book for use in lectures with larger applets and text summarised by headings and bullet points; the author hoped to use these as a full replacement for PowerPoint slides.

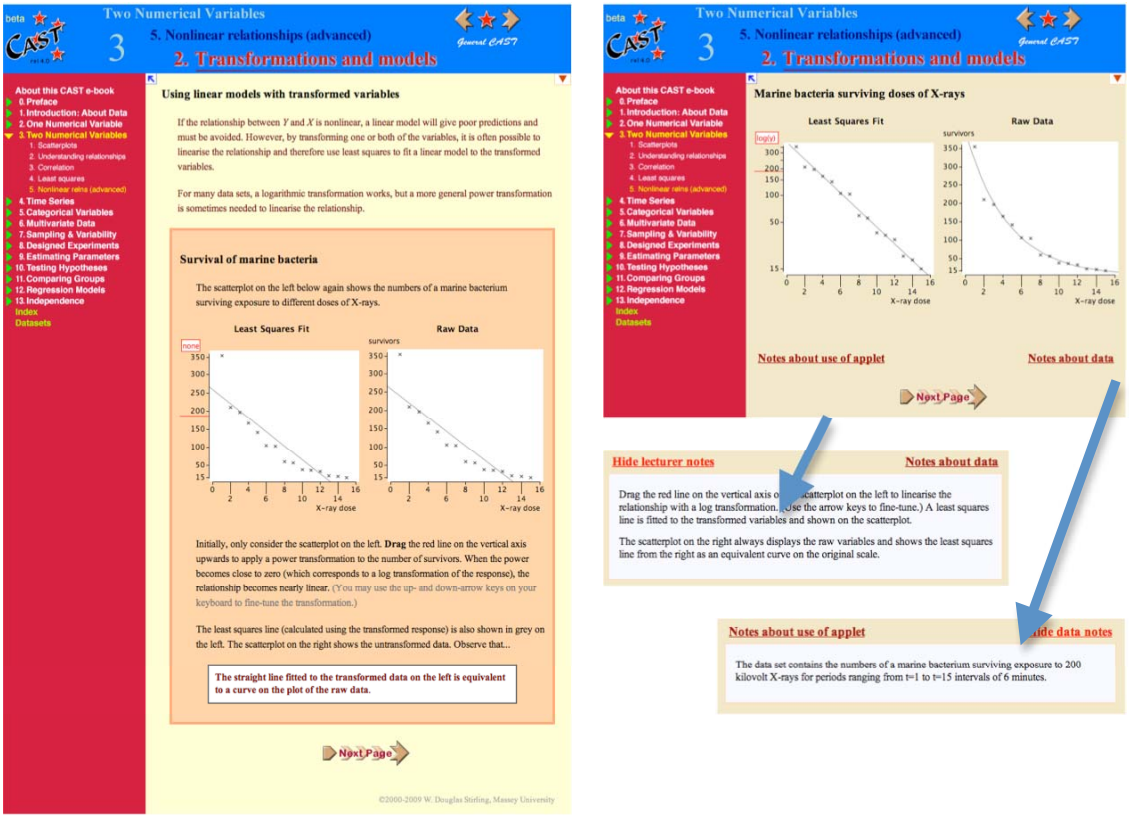
There were however still problems with this approach. Headings and bullet points looked far less professional than those that could be easily produced in PowerPoint so even the author reverted to PowerPoint as his main presentation tool in lectures. More importantly, every lecturer has a different approach to teaching topics and the bullet points often did not match this. For many lecturers, the text that remained on each page was, at best, a distraction and may even have clashed with approach being used.

To solve these problems, the latest release of CAST has transformed the main lecturing material into an ‘e-book’ that is hierarchically structured like other CAST e-books into chapters, sections and pages but is effectively a collection of over 400 applet resources. Each page initially displays a single applet without any surrounding text. Although this minimal display is ideal for use in lectures, a brief recommendation about the purpose and operation of each applet would often help the lecturer. A button is therefore provided at the foot of each page that expands into advice about usage. If the applet uses a real data set, a second button expands into a description of the data. Figure 1 compares one page from the self-study e-book with that from the lecturing e-book and shows the usage notes and data set notes available for the applet.

There is a further difference between the style of material that is most effective for self-study and the style that works best in lectures. Many authors write a small number of applets that are as flexible and fully-featured as possible (e.g. Dinov, 2008) but complex applets generally require complex usage instructions and, although useful in workshops (usually with printed guidelines and aims) and in lectures, they are relatively hard to use for self-study. For self-study, a succession of applets, each targeting a single concept with a simple user-interface, is a more effective way to build up knowledge and this has been the approach in the main CAST e-books. In lectures however, richer applets allow the lecturer to develop ideas with one diagram. As a result, the functionalities of some of the CAST applets have been combined in the lecturing e-book. For example, the applet in Figure 2 combines two applets from the self-learning e-books.

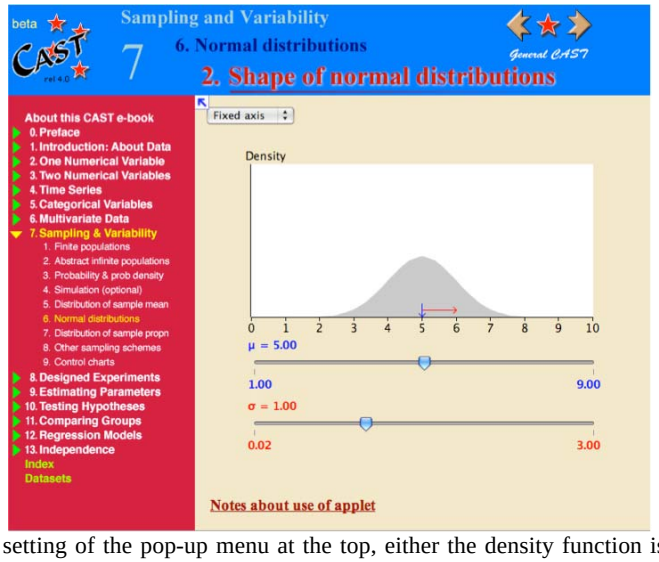
A few CAST applets are shown in Figures 1, 2, 3 and 4. All are dynamic and the lecturer must interact with the diagram in some way, dragging the red line on the vertical axis of Figure 1 to apply a power transformation to the response, dragging the sliders to adjust the normal parameters in Figure 2, using the red arrows to find the line that minimises the sum of squared residuals (blue area) in Figure 3, and clicking the checkbox and button in Figure 4 to build up the empirical

distribution of the estimation error. Many different styles of applets are used in the first half of the e-book but simulations such as that in Figure 4 are often used to explain concepts relating to sampling distributions and inference in the second half.



The two buttons under the diagram expand to show the information on the bottom right

Figure 1. A CAST page from the self-study e-book and the corresponding page in the lecturing e-book (after the response variable has been transformed)



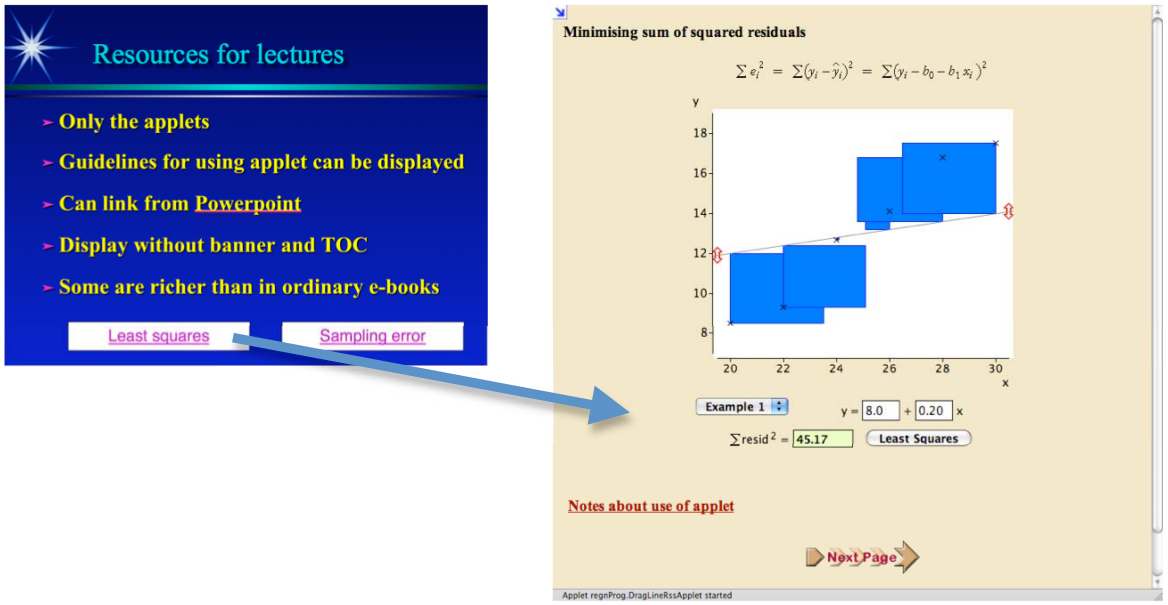
Depending on the setting of the pop-up menu at the top, either the density function is redrawn on a fixed axis or the density function remains the same and the axis is scaled. The applet shows that all normal distributions essentially have the same shape and combines two applets from the self-study e-books.

Figure 2. Applet allowing a normal distribution's parameters to be changed

OTHER FEATURES

Two further features improve the usability of the CAST applets in lectures. Firstly it is possible to open a CAST page directly from PowerPoint with a hyperlink. Clicking the hyperlink in

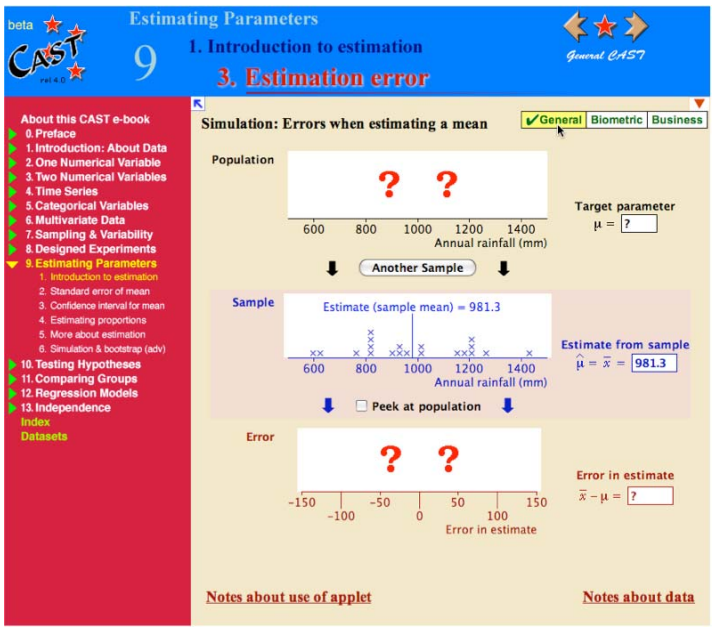
a presentation tells your browser to display a specific CAST page without its red table of contents on the left or blue banner on the top. Figure 3 shows an example.



The blue banner shown on the top of Figure 2 and the red table of contents on its left are initially hidden; clicking the blue arrow on the top left displays them.

Figure 3. Clicking the Least squares hyperlink on the PowerPoint slide displays the CAST window on the right

Another new feature in CAST is easy access to alternative versions of many pages. Two extra versions of the main introductory CAST e-book were written that cover very similar material but contain data sets and scenarios from business and biological sciences and there are corresponding alternative versions of the lecturing e-books. When displaying any CAST page, alternative versions of the page can be directly accessed from a pop-up menu on the top right. For example, there are three different versions of the page displayed in Figure 4.



The pop-up menu on the top right allows the lecturer to display versions of the applet with biometric or business scenarios.

Figure 4. Clicking 'Peek at population' displays the underlying normal population, the value of μ and the sampling error; selecting further samples builds up the empirical distribution of the error

A recent addition to CAST has been a collection of exercises (Stirling, 2008, 2010). Although they are mainly intended to support self-study, the simpler exercises can also be useful as a focus for interaction with the class in lectures. For example, the exercise on the left of Figure 5 asks for a guess at the value of the correlation coefficient — it does not need to be accurate. The exercise on its right asks which statement correctly interprets the parameters of a least squares line. In both cases, the class can be given time to answer before being given shown the solution (using the 'Tell me' button). As in all CAST exercises, the button 'Another question' generates a random variation of the question, changing as many aspects as possible, including the scenario.

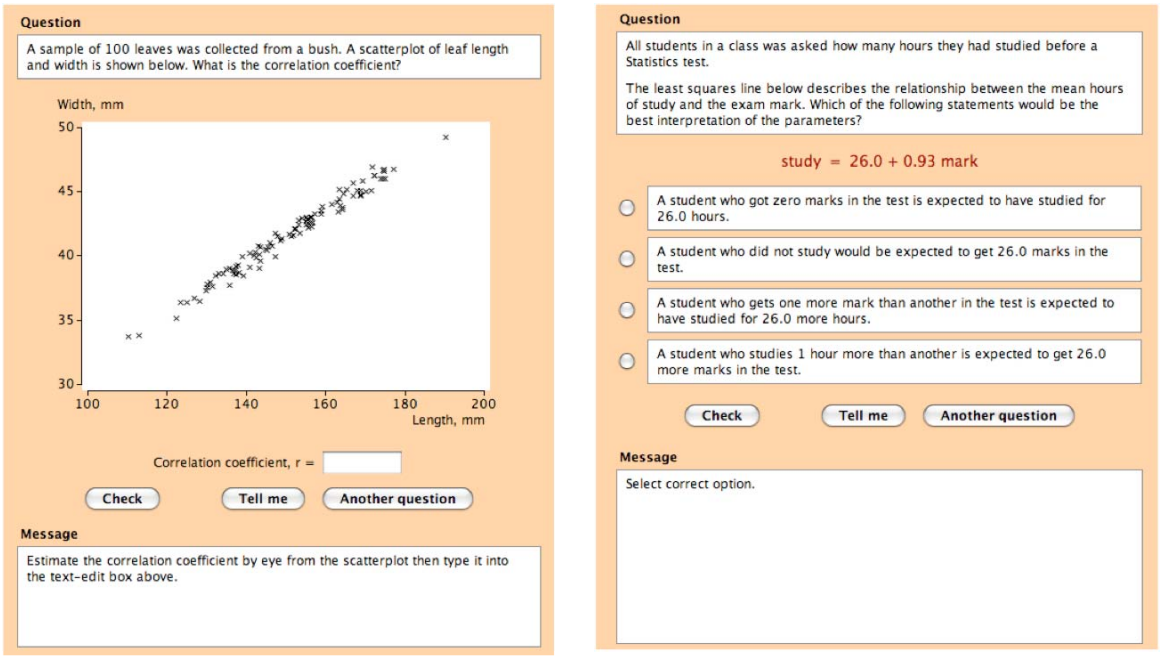


Figure 5. Two CAST exercises

CONCLUSION

Despite the wealth of web-based resources for self-study, lectures still have an important role to play in teaching statistics, and are particularly useful for pacing student study, emphasising important points and generating interaction between lecturer and students. Nowadays, computers underpin most lectures with PowerPoint presentations and other multimedia, and computer-based dynamic illustrations and demonstrations are an effective way to explain statistical concepts and methods.

General-purpose teaching software such as Fathom (Finzer et al., 2000) can be used to create custom simulations and other demonstrations but these take some time to set up by the lecturer; simulations can even be performed with spreadsheets and statistical analysis software. However it is much easier to include a few applets in each lecture to dynamically explain concepts and methods and the collection of over 400 CAST applets provides a large pool from which to choose them.

Although the focus of this paper (and the CAST applets for lectures) has been introductory statistics courses, similar dynamic demonstrations are equally useful for more advanced statistical methods courses. Although CAST includes advanced e-books about multiple regression and experimental design with many applets, there are still no lecturing versions of them and the self-study e-books must currently be used. This is an area for future development.

CAST (Stirling, 2009) is freely available under a Creative Commons licence. It can be used directly from the CAST web site or, preferably, downloaded from there and run from a local hard disk or web server.

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