STATPLAY: MULTIMEDIA FOR STATISTICAL UNDERSTANDING

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StatPlay is multimedia for conceptual understanding in the introductory statistics course in any discipline. Its aim is to help overcome misconceptions about fundamental statistical concepts, and thus improve education and promote highly desirable reform of statistical practice by researchers in the social and behavioural sciences. StatPlay comprises simulations and tools in a number of microworlds in the broad areas of distributions, data, sampling, estimation and statistical significance testing. StatPlay design strategies include provision of vivid take-home images of concepts, multiple images of concepts dynamically linked, a high degree of interactivity, and a facility for the recording and playback of multimedia demonstrations. Classroom experience with StatPlay has been very positive, and commercialisation is now being sought.

We give a brief description of the goals, design and use of StatPlay, our multimedia for introductory statistics. The context is that we see two fundamental challenges for statistics educators: overcoming widespread misconceptions about key statistical concepts, and helping to reform statistical practice in psychology and other disciplines.

STATISTICAL MISCONCEPTIONS

Many researchers and students have severe misconceptions about conditional probability, statistical significance and other important concepts (Thomason, Cumming and Zangari, 1994). Overcoming these misconceptions requires better understanding of the underlying statistical ideas; helping achieve this is the central goal of StatPlay.

REFORMING RESEARCH PRACTICE

Psychology is among disciplines that rely very heavily on null hypothesis significance testing (NHST), but the pressure for reform is growing and changes in practice are now likely, with greater use of estimation (especially confidence intervals), power and meta-analysis, and reduced reliance on NHST (Thomason and Les, 1998). We believe that such reform is urgent and essential, and that improved statistical education is required if reform is to succeed. Helping achieve reform via improved education is a second goal of StatPlay.

UNDERSTANDING OF CONCEPTS: MULTIPLE REPRESENTATIONS, DYNAMICALLY LINKED

We regard learning as progress towards understanding, and a good conception of understanding as being the ability to express the target idea in a number of different ways, and to show how these relate. If you can describe a concept in words, give a definition, draw a picture, write the formula, explain an application, and see how these different representations link together, then you understand the concept well.

Working with multiple, linked representations should help students develop such rich understanding. This conclusion is supported for example by White (1993), who found that software providing multiple, linked representations helped learners overcome the misconceptions of naïve physics. Correspondingly, StatPlay seeks to assist students overcome the misconceptions of naïve statistics (Thomason et al., 1994) by having them work with multiple representations that are computationally linked. In the Data Playground, for example, four representations of a single dataset are shown simultaneously, including a simple list of numbers, a frequency histogram and a dot plot. Clicking on any values in any of the representations causes the values in all four representations to be highlighted.

UNDERSTANDING OF CONCEPTS: VIVID TAKE-HOME IMAGES

A further design goal is that representations in StatPlay will be sufficiently vivid and conceptually clear to serve as take-home images for learners. Such well-designed images should provide a pictorial anchor for understanding (Cumming, Thomason and Les, 1998). An example is the ‘mean heap’, a pile of triangles generated dynamically under user control that represents the sampling distribution of the sample mean. The mean heap underlies the StatPlay approach to understanding of sampling variability, standard error, confidence intervals, significance testing and power. A related take-home representation is the ‘dance of the means’, a moving image showing dramatically the amount of variability between successive independently sampled means.

STATPLAY INTERFACE AND SOFTWARE DESIGN

Alongside the above principles, excellent interface and software design is necessary. Early ‘guideline’ approaches to screen design grew from a graphics tradition and specified colours, layout and content limits. Then cognitively more sophisticated

approaches emphasised metaphor, and the user's mental models of the tools and objects provided by the software. Recent thinking has reached beyond cognitive psychology and human factors and become more diverse, with influences from theatre, various social sciences and post-modernism. The goal is to make the interface disappear: the user should be thinking about the task and the target concepts, ideally with no awareness of the tools being used to think with.

User-centred design (Landauer, 1995) and construction of successive prototypes is required. Detailed observations with student and teacher users must be made. Carroll (1997) advocated 'throwing one away' in order to achieve a good version. Our first version of StatPlay was developed in Visual C++ under Windows 3.1, and comprised playgrounds for: Data, Distributions, Sampling, Confidence Intervals, Hypothesis Testing and Power (Cumming and Thomason, 1995; Cumming, Thomason, and Zangari, 1995). Figure 1 shows a screen from the Sampling Playground of this original StatPlay: the mean heap appears in the lower panel, and comprises 500 sample means (with sample size $n = 20$) taken from a freehand bimodal population. The heaps view of Figure 1 and an alternative dotplots view are components in the StatPlay attack on Law of Small Numbers misconceptions, including many erroneous beliefs about variability, confidence intervals, and the replicability of experimental results.

We decided however that the familiar off-the-shelf Microsoft graphical components (windows, panels, buttons, etc) used in the original StatPlay were too visually complex and confusing, and that we should throw this version away and undertake the large task of developing our own visually simpler graphical components. Figure 2 shows a screen from the Distributions Playground of the new StatPlay for Windows 95, illustrating the new components we have built and the clean, spare graphical style we now use. Note the contrast with the visual complexity of Figure 1.

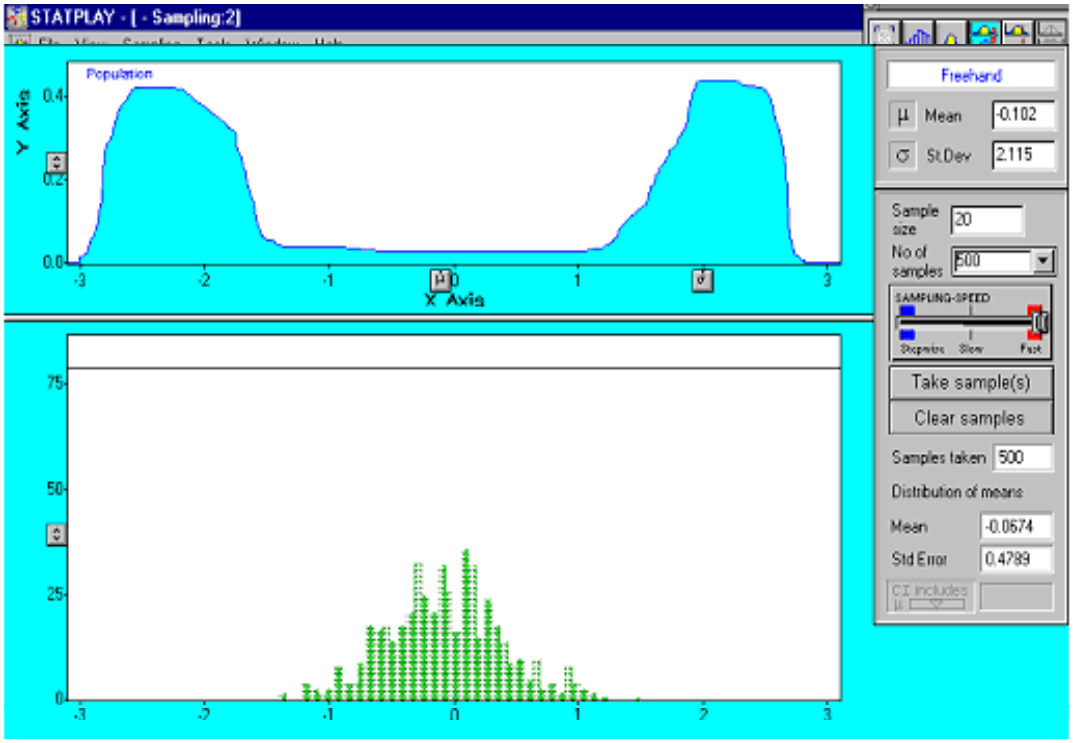

Figure 1. In the Sampling Playground of the original StatPlay, 500 independent samples of size n=20 have been taken from a freehand bimodal population (upper panel). The mean heap appears in the lower panel.

EXPLORATION, BUT WITH GUIDANCE

Learning environments such as StatPlay can offer a rich space for educational exploration, but learners may not see what is best to try next. The software looks wonderful, but what do you actually do? The challenge is to provide learners with guidance and explanation, without removing the scope for initiative. In the research field of Artificial Intelligence and Education a number of approaches are being investigated to achieve this, beyond the traditional printed worksheet. Our approach has been to develop a tool for recording and replaying multimedia demonstrations ('demos') of the software in use, with simultaneous spoken commentary. This is Sam, as in 'Play it again…', (Les, Thomason and Cumming, 1997; Les and Maillardet, 1998). Students can make their own choices about combining their own exploration with seeing and hearing Sam demos that introduce concepts, explain examples and set challenges.

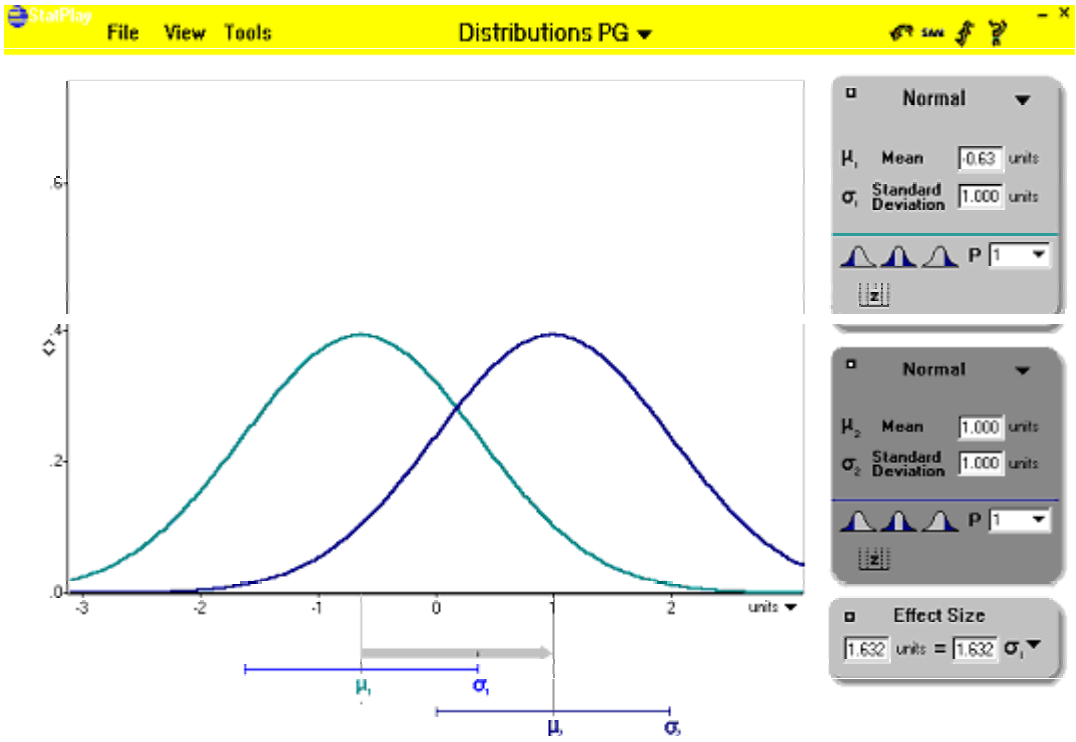

Figure 2. Screen from the Distributions Playground illustrating the clean graphical style of the new StatPlay.

STATPLAY IN USE

Reception of StatPlay by students and teachers has been very positive, and in 1997 the original version was used by some 3500 students across 12 departments at The University of Melbourne. Response to initial classroom trials with Sam has been especially enthusiastic. We have conducted a range of evaluations of learning outcomes with psychology undergraduates at La Trobe University (Finch and Cumming, 1998).

FUTURE DEVELOPMENTS OF STATPLAY

We are currently working on the commercialisation of StatPlay, while continuing teaching and research based on StatPlay use. Major developments of the new version of StatPlay are in progress, and include:

- *addition of playgrounds on analysis of variance, correlation and regression, meta-analysis, probability, and statistical misconceptions;*
- *development of further estimation games, to strengthen intuitions about magnitudes and relationships;*
- *expansion of basic facilities for analysing your own data, with links to the images that support understanding of the concepts relevant to the analysis; and*
- *further development of ancillary materials, especially Sam demos, to support a wide range of teaching and learning activities.*

These developments should position StatPlay as a powerful tool for achievement of our educational and reform aims.

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