TEACHING STATISTICS THROUGH EXPERIMENTSATSCHOOL

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In this paper we describe the development of a project to provide Internet-based resources for collecting and disseminating data collected from experiments based on ideas from science and psychology. We discuss how both the website and the method of capturing data have evolved and led to our recent redesign of the ExperimentsAtSchool website (www.experimentsatschool.org.uk). We explain how these interactive experiments, which are both fun and engaging for learners, provide innovative ways for helping them to develop and improve their data handling and statistical skills.

BACKGROUND

The *ExperimentsAtSchool* project was originally launched in 2003 by the Royal Statistical Society Centre for Statistical Education (RSSCSE) with the support of the Department of Education, Specialist Schools Trust and the Association of Science Education. Since 2005 the project has been run in conjunction with the Centre for Effective Learning in Science (CELS) at Nottingham Trent University and in August 2009 the website transferred to the RSSCSE's new server based at the University of Plymouth, the RSSCSE's new home.

The *ExperimentsAtSchool* website (www.experimentsatschool.org.uk) has been designed for learners aged 7 to 16. It aims to help them develop and improve their data handling and statistical skills using the Problem Solving Approach (PSA). This approach is supported by other statisticians such as Chatfield (2002) who maintains "that the driving force in statistics should be a desire to *solve problems*." On the website are a number of experiments for the children to do which come with downloadable teachers' notes and pupil worksheets; these give the objectives of the experiment and suggest useful investigations the children could undertake. Most of the experiments are interactive, online activities with instructions built into the content. The data generated is securely stored on databases and can be retrieved from a Random Data Sample page on the website or by an online request form.

EXPERIMENTS AND DATA COLLECTION

The original *ExperimentsAtSchool* website contained six experiments covering a range of topics from Life Sciences to Geography and Mathematics. The experiments were carried out in the classroom and the subsequent results were submitted through a web-based form. To submit or retrieve data, participants were required to log in using two codes to uniquely identify the school – a three digit code for the Local Education Authority (LEA) and four digit school code or establishment number. The numbers were based on those used by the Department of Education (www.edubase.gov.uk) for schools in England and Wales. Schools from outside these areas could still take part by requesting a set of codes which the *ExperimentsAtSchool* team generated.

After a review of the usage of the site, it was redesigned and re-launched to coincide with National Science Week in March 2005 (figure 1). A new emphasis was given to interactive on-line experiments which were fun and designed to engage the learner, enhancing the learning experience. The revamped website still adhered to the basic RSSCSE principle of 'real data for real learning' but allowed pupils to generate and quickly access the results of their experiment. Participants were still required to log in to submit data. A review of usage after the re-launch suggested that those experiments that required work away from the computer, prior to data entry, were less likely to be used than 'then-and-there' experiments.

FLASH® BASED EXPERIMENTS

From November 2005, the involvement of the CELS (www.ntu.ac.uk/cels) has lead to a greater emphasis on Adobe® Flash® based experiments. The majority of live experiments have been based on how pupils interact with a computer simulation. Data recorded by these experiments

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provide a measurement of a pupil's ability to estimate quantities and outcomes or respond to particular stimuli.

Figure 1. Examples of the website from 2005 & 2009

Members from CELS recognised the potential of *ExperimentsAtSchool* to support the coursework component of GCSE science subjects for UK examination boards; a common format referred to as the POAE framework (Planning, Obtaining, Analysing and Evaluating) allowed the use of secondary data, collaborative work and simulations. However under the direction of the Qualification and Curriculum Authority (QCA) changes were made to GCSE science syllabi for first teaching in autumn 2006. The new science programme of study was based on 'How science works' and focused on the evidence to support or refute scientific ideas and theories. Examination boards were able to offer different options regarding coursework; some permitted candidates to use data from secondary sources whilst others reduced the scope for using external data.

Nevertheless, members of the *ExperimentsAtSchool* team continued to develop resources and materials based on topics covered in science lessons. In 2009, the website was transferred to a new server based at the University of Plymouth and adapted to work on Joomla!, an open-source content management system (CMS). The *ExperimentsAtSchool* website currently gives access to thirteen experiments, eight of which are listed in Table 1 (the number of responses for each experiment is given in parenthesis).

USING RANDOM DATA SAMPLES

A number of experiments include data captured from another project run by the RSSCSE, *CensusAtSchool* (www.censusatschool.org.uk), the origins of which are described by Connor et al.(2000). At the end of the *CensusAtSchool* online questionnaire, learners take part in experiments matching those on the *ExperimentsAtSchool* website. The RSSCSE team has developed a Flash®-based online database interrogation tool or *DataTool* which communicates dynamically with the AtSchool data. The tool has a drag-and-drop facility, for selecting variables, and provides a useful and appealing way for learners to interact with data. Users can quickly obtain multiple random samples of data from *ExperimentsAtSchool* and investigate results from the live databases.

Some 30,000 participants took part in the original Angle Estimation experiment where they were presented with three pie charts and asked to enter the angle of a given sector - estimated to the nearest 5˚. With the *DataTool*, learners can obtain random samples to investigate possible patterns and quickly test their own hypotheses. For example if they are given a statement such as "Boys are more likely than Girls to over estimate the size of an angle", the *DataTool* can be used to collect two samples and plot the results concurrently (figure 2).

Table 1. Descriptions of interactive online experiments at *ExperimentsAtSchool*

Experiment	Description
Colour Maker (967)	By mixing electronically red, green and blue (RGB) in different quantities, a palette of millions of possible colours can be created. In this experiment, learners mix different amounts of 'RGB' represent various fruits and vegetables. Variation in the colours created can be investigated numerically.
Candle Combustion (144)	When a burning candle is trapped underneath a jam jar, the candle lasts for a while before going out. In this experiment, data are collected to enable the following questions to be answered: Do candles inside larger jars burn for longer? Does the shape of the jam jar influence the time the candle lasts?
All about me (1167)	Children inherit some characteristics or genetic traits from each parent. Traits that we inherit include tongue rolling, attached earlobes, freckles and dimples. In this experiment, learners find out how common different traits are? They investigate how many other people have the same combination as themselves.
Length estimation (19395)	How good are you at guessing the length of a line? Are females better than males at estimating length? This Flash® based experiment presents varying lengths of shelves from which learners estimate the number of boxes it will hold.
Angle estimation (108483)	How good are you at guessing angle size? Do you make more errors when estimating larger angle size than smaller angle size? Are females better than males at guessing angle size? This Flash® based experiment presents learners with random angles, in different orientations, to estimate.
Time estimation (4351)	This experiment is designed to test your ability to estimate the passing of time. How good are you at guessing how much time has passed? Do people make more errors when estimating longer or shorter periods of time? Are females better than males at estimating time?
Number recognition (416)	Is it simpler to recognise 5 dots in a pattern rather than haphazardly? Do you make more errors with larger numbers? Learners are shown random or patterned collections of dots (3-12) for a fraction of a second; they estimate the number of dots they were shown.
Reaction time (29784)	How quickly can you react? Are you quicker with the hand you normally write with? Do you get quicker with practice? This Flash® based experiment is based on a set of traffic lights – the learner has to respond with a mouse as soon as the lights turn green.

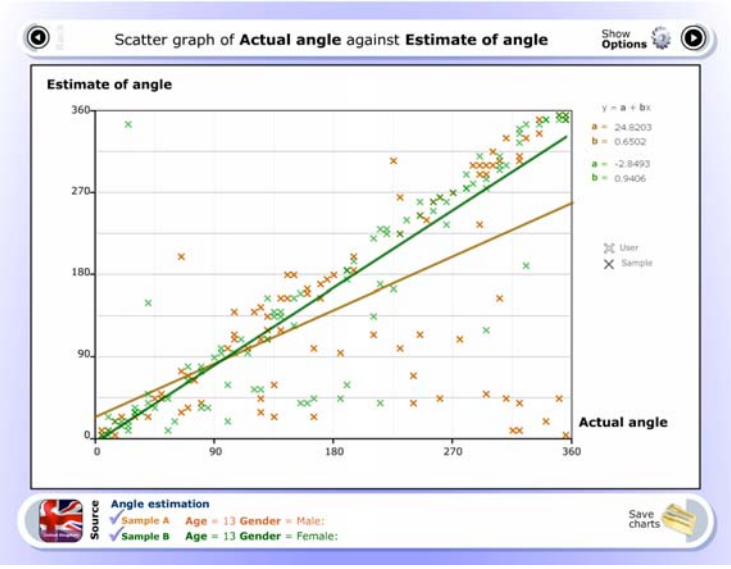

Figure 2. Chart showing target (actual) angle and estimate made by 13yr boys and girls

Although the *DataTool* has been designed to allow rapid visualisation of data, the raw data used by the tool can be exported to spreadsheets and statistical packages for further analysis. As we have developed the *DataTool*, we have also adapted some of the original experiments; for example with the original Angle Estimation experiment, participants were presented with a pie chart as a flat circle. We have redesigned this experiment and now can display the target angle in one of a series of pie chart projections from flat to 3D (figure 3). This development has been in response to a request from a school teacher who wanted their class to test the reliability of using 3D charts.

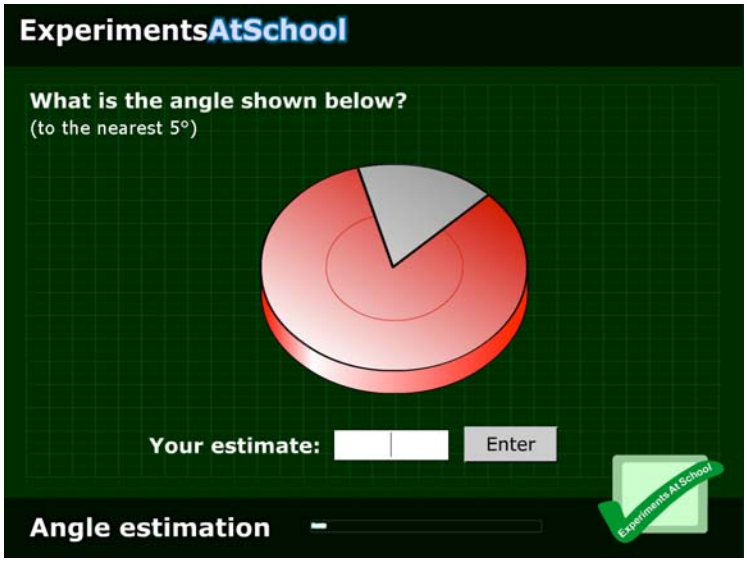

Figure 3. Example screenshot from Angle Estimation experiment

FUTURE DEVELOPMENTS

The *ExperimentsAtSchool* project was created as a collaborative project with participants sharing their data over the internet. Unlike its sister project, *CensusAtSchool*, the data have little to do with the personal details of the learners who carry out the experiments. Whilst both activities are fun and engaging, the experiments can be seen to be simpler and quicker for participants to carry out. We believe that allowing dynamic interaction with both sets of databases, through the *DataTool*, has enormous potential to enhance learners in their understanding of statistics and data handling. Chance et al. (2007) report how technology allows students to focus on interpretation of results and understanding concepts rather than on computational mechanics.

Our recent transfer to a new content management system, Joomla!, provides another dimension to the involvement of teachers and their learners. Most websites have a small dedicated team of web authors and developers however with Joomla! a large number of registered users can be given 'Contributor' status. The website can take on properties of a Wiki and allow teachers and learners to upload and share innovative teaching ideas. Furthermore such a community of contributors could design their own experiments and, with the continued support of the RSSCSE, allow learners to investigate more open-ended questions.

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