SOLVING THE PROBLEM OF TEACHING STATISTICS?

Liz Gibson, John Marriott and Neville Davies
Royal Statistical Society Centre for Statistical Education
Nottingham Trent University, Nottingham NG11 8NS UK
(john.marriott@ntu.ac.uk)

1 Introduction

The state of mathematics education in the United Kingdom has been an issue of concern for some years. Following a commission by the UK government, Smith (2004) published a report into post-14 mathematics provision. His report made wide-ranging recommendations for improving mathematics education in schools in England. Following one of the recommendations, in 2005 the Qualifications and Curriculum Authority (QCA) commissioned the Royal Statistical Society Centre for Statistical Education (RSSCSE) to review the position of the teaching of statistics in the national curriculum for England. Indeed Smith had suggested that statistics education might be improved by teaching it through other subjects, such as science and geography, rather than from its current position in the mathematics curriculum.

In section 2 we describe the national survey we carried out with a summary of the key findings. In section 3 we discuss how the resources were created and in section 4 we provide an example. Section 5 discusses teaching statistics using a problem solving approach at undergraduate level.

2 The Survey

In autumn 2005 the RSSCSE/QCA Review (the Project) carried out a national survey of heads of mathematics, geography and science in schools in England to determine their views, needs and capabilities within the statistics area. A 20% proportionally allocated stratified sample survey of English secondary schools was used. An analysis of the results showed that teachers of science and geography appeared more confident than mathematics teachers when teaching school students to understand and interact with statistical concepts and ideas - skills that are fundamental in developing statistical literacy.

An examination of the approach to the teaching and learning of statistics within the science, geography and other curricula revealed that the key differences between the approach adopted within these subjects and that used within mathematics were in the application of statistics to real contexts and problems arising from within each subject. The Project recommended that the teaching of statistics should be seeded through real world examples drawn from science, geography and other subjects but should be retained within the mathematics curriculum. It seemed that teachers of mathematics were confident in teaching statistical tools – or techniques – but teaching students how to use them and when, was more difficult because many of the contexts explored in the mathematics lessons were artificial and manufactured. By embedding the statistical concepts within *real* contexts and problems, the inherent need for the tools becomes self evident. This resonates with the growing body of evidence that supports the view that statistics is best taught through problem solving. Consequently the Project developed a set of learning and teaching resources for use in mathematics lessons by mathematics teachers which use a statistical problem solving approach (PSA) and draw on real problems in real contexts. Other key recommendations of the Project relevant to the discussion in this paper are now summarised.

- Continuing professional development (CPD): a programme of CPD should be developed for Heads of Mathematics with particular regard to teaching how the PSA can best be taught.
- Teaching materials: a comprehensive range of teaching materials should be developed and made available to Heads of Mathematics designed to use real data from other subject areas and should embrace the PSA.
- Future strategy for teaching and learning Statistics: the QCA should promote the teaching and learning of statistics and handling data through the statistical PSA.
- Resources for teaching and learning Statistics: the QCA should promote the development of a database of examples of the use of the statistical PSA.

3 Resources Development

In the light of the survey results, the need to create new resources was at least two-fold. First, to provide support for mathematics teachers in highlighting areas that statistical techniques are necessary and usable, and second to provide professionally presented, user friendly material which can be usefully deployed in the classroom.

In order to develop the materials, we invited a selection of mathematics teachers, as well as teachers of other subjects, to the RSSCSE to discuss and share ideas about features we believed would be useful and necessary ingredients for the resources. It was felt that all materials should be easy to use, easy to adapt, reinforce the statistical PSA and help students appreciate that whatever they do within statistics and handling data, they are contributing to the process of problem solving. The New Zealand *CensusAtSchool* project materials are particularly good examples of teaching resources and we used them, with permission, as the foundations for the development of our materials. See www.censusatschool.org.nz/resources/.

The resources themselves were developed using Microsoft PowerPoint, with colour coding and symbols used to highlight each section of the PSA. In addition to the colour coding, a map was introduced to punctuate the presentation and to consistently reinforce the format of, and approach used in the resources. They are designed so that the PowerPoint presentation is the main resource, teachers' notes are embedded in the presentation and quick activities are integrated to aid understanding at different stages. In addition to the presentation, supporting resources include a pupil worksheet that mirrors the structure of the presentation and in most cases, supporting data are provided.

4 An example

In this section we present brief details of some of the teaching materials developed for one of the problems, 'How Safe is Your Area?' This and seven other problems (the four original problems and an additional four which were developed later) can be found at www.rsscse.org.uk/qca/resources0.htm. Figures 1 to 4 illustrate the colour coding that reinforces the current position within the four-stage PSA – this is highlighted by similarly coloured bars at the top and bottom of the screen.

Figure 1 Setting the scene during the planning stage of the PSA

Figure 2 Planning to collect data

Figure 1 shows an example of a teaching prompt for the Plan stage of the PSA and so, for example, in this case the class would begin with a quick discussion of the media and their reporting of crime – some example questions could be:

- What was the most recent crime that made the headlines?
- What kinds of crimes tend to make the headlines?
- Why do they make headlines?

Figure 2 shows a teaching example for collecting information and data. The supporting resources include comprehensive notes to guide the teacher through different data sources. Figure 3 is a typical graphical display generated at the Process stage and Figure 4 forms the background to class discussions of what can be inferred from the data. At the last stage it is a good idea to get students to practice by writing a report of their discussion and overall findings.

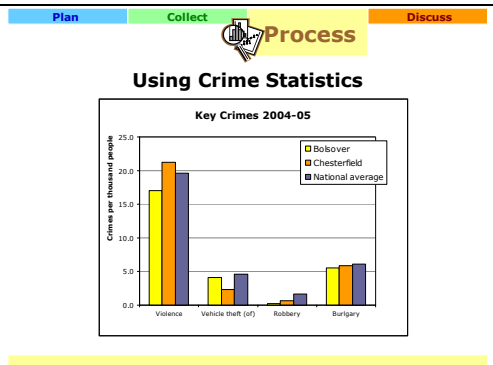

Figure 3 Part of the Process stage of the PSA

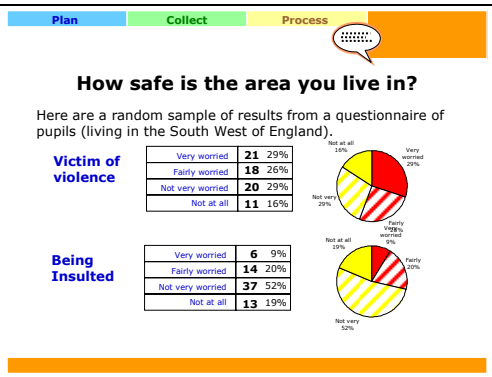

Figure 4 Part of the Discuss stage of the PSA

5 The PSA for undergraduate teaching

In the previous sections we have described how the Project led to the development of resources for teaching and assessing statistics through the statistical problem solving approach. The target audience for these was school-age learners up to the age of 16. In this section we argue that there is substantial evidence of a pressing need for similar materials to be developed for use by university undergraduates, at least for their first encounter with statistics, and its further use within their chosen degree subject. We rehearse the case for this development within the social sciences and illustrate how the resources could be adapted. We would argue, however, that the ideas discussed here could be extended to other application areas and levels of study. See, for example, Stuart (2003).

Over the last few years there has been a growing concern within the UK social science community about the lack of quantitative literacy in the undergraduate student population. In 2001, Rice et al. (2001) reported the results of an enquiry into the use of numeric datasets in learning and teaching within UK higher education. The research was sponsored by the Joint Information Systems Committee (JISC) and looked into barriers faced by undergraduate teachers (among others) who wanted to use empirical datasets in the classroom. Among the recommendations emerging from this report were the following:

1. a broad initiative is recommended to promote subject-based statistical literacy for students, coupled with tangible support for academic teaching staff who wish to incorporate empirical data into substantive courses;
2. the development of high-quality teaching materials for major UK datasets must be funded adequately, in order to provide salience to subject matter and demonstrate relevant methods for coursework.

In reporting their research into the problems faced by education and sociology students Murtonen and Lehtinen (2003) concluded that many of these students view statistics with some trepidation and found quantitative methods more difficult than qualitative methods. Williams et al. (2004) came to the conclusion that there is a crisis in the production of quantitative academic output in Sociology in the UK and relate this, through problems faced by students, to a “societal problem of numeracy”.

In 2006 the Economic and Social Research Council (ESRC) in the UK, in collaboration with the funding councils for higher education, issued a number of calls for proposals to address the perceived need for the development of undergraduate curricula in quantitative methods. The ESRC indicated that they would consider a broad range of ideas and included the following among the examples they cited:

- the development of undergraduate curricula which takes account of contemporary and topical examples to show the value of quantitative research - these should draw on students’ own interests;
- a need to develop curricula in order to demonstrate to students that they already have the skills needed to understand the foundations of quantitative research, by building upon their GCSE experience and their computer skills;
- curricula which encourage students to conduct their own surveys and to analyse the results as part of their course work;
- curricula which encourage applicants to carry out their own research projects through the use of secondary data.

When viewed against this background, the approach adopted for the materials produced by the Project is a timely development that would appear to have the potential to meet many of the needs of undergraduate students. First and foremost is the need to approach social science problems through an evidence-based decision making process - this is a major component of social scientific research methods and is as important to the engagement of first year undergraduates as it is to PhD theses and postdoctoral academic research. The use of the PSA in teaching quantitative methods could go a long way towards meeting this need. The

example we use here shows how one of the problems developed for the Project could be adapted for first year undergraduate tuition.

We use the 'How Safe is Your Area?' example from Section 4 because its subject matter will be one of considerable interest to newly arrived undergraduates at university. The undergraduate teaching programme could start with a discussion of the safety problem, decide the questions the students feel should be addressed, followed by revision of the statistical PSA, which they will have met at school within GCSE mathematics. At the 'collection' stage of the PSA, possibly in their first seminar, the students could complete a questionnaire comprising three demographic questions, with date of birth, and three or four other questions taken from the British Crime Survey (BCS, www.statistics.gov.uk/ssd/surveys/british_crime_survey.asp). The results could be entered into a spreadsheet and the students would revise the data presentation aspects of the statistics they studied at school, summarise the evidence from their seminar group and draw tentative conclusions. In the following week they could return to the 'analyse' stage of the PSA, now armed with the summary results from all the other seminar groups. Opportunities to introduce new measures of spread, not studied at school, could be taken here at the 'analysis' stage. The discussion now could involve commenting on how each individual seminar group compares with the whole cohort. The safety problem then naturally leads to two distinct further questions: first, what do other people think; and second what is the actual crime profile of the area they live in? The first of these can be developed into a study of survey design, which could include the critical appraisal of the BCS questionnaire with the students proceeding to conduct their own surveys containing questions specifically related to what they would like to discover. The second could lead into a new problem that necessitates the collection of secondary data from, for example, the Crime Statistics for England and Wales (www.crimestatistics.org.uk/output/Page1.asp). In these ways the students are always involved in the process of formulating problems, collecting data that will help them to address questions that they have posed, followed by careful analysis and discussion.

Our view is that, although the materials developed for the Project may have the look and feel of resources suitable for younger learners, the problem solving paradigm and processes involved are the same. Therefore the Project resources could provide excellent templates for older learners who need to study statistics through the good practice of the PSA: it would be especially useful for those who need to become consumers of statistics through their undergraduate careers and beyond.

6 Conclusions

In this paper we have described the development of teaching and learning material for school-aged learners to carry out the PSA as a key component of their statistical education. We have also suggested ways in which a similar approach can be used with university undergraduates using the template we have developed for school-aged learners.

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RESUME

In this paper we report the results from a major UK government-funded project, started in 2005 and completed in 2006, to review statistics and handling data within the school mathematics curriculum for students up to age 16. New teaching materials that explicitly use a problem-solving approach through other subjects have been developed. We will report extensive trialling of these and how these work in the classroom. Extensions of this approach to the teaching of undergraduates will be discussed.