Developments in Promoting the Improvement of Statistical Education

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1 Introduction

The Royal Statistical Society Centre for Statistical Education (RSSCSE). www.rsscse.org.uk, exists to promote the improvement of statistical education, training and understanding for people of all ages. Over the last seven years it has started and/or completed several projects with this aim. In this paper we describe key features and outcomes of a number of them.

In section 2 we describe four schools-based projects, including the RSSCSE's flagship *CensusAtSchool* project that has been adopted and implemented in four other countries. In the same section we provide evidence from a UK-government sponsored project that leads us to believe strongly that teaching statistics through a problem solving approach is the best way to motivate learners and get them excited by the subject. In section 3 we discuss the importance of continuing professional development for teachers of the subject at all levels and focus on a distance learning course in statistics pedagogy that is suitable for statistics teachers in Higher Education. Experience with providing train-the-trainers courses and accreditation of statistics departments in countries outside the UK is also presented. In section 4 we describe projects that are planned and/or have just started. One of these is designed to capitalise on activities associated with the Olympic and Paralympic Games in London in 2012. This project could provide the statistics education community worldwide with a unique opportunity to improve the statistical literacy of a wide range of people, from learners in primary and secondary schools, to university undergraduate and postgraduate students to adult learners and people in the workplace.

2 Promoting Statistical Literacy for school learners

2.1 The *AtSchool* Projects

There is much research evidence to suggest that the best way to get people to learn is through engaging their interest through activities they can see, undertake and relate to. In statistics there is further research that shows students of all ages are motivated by *real world* data about subjects they are interested in, particularly data concerned with features and characteristics about themselves and their peers. Relevant references include Garfield (1995), Cobb and Moore (1997) and Graham (2006). When the same data are used to create teaching and learning resources that combine a variety of Information and Communication Technology (ICT) techniques, in particular including the Internet, teachers are stimulated to improve their own skills, knowledge and pedagogy. These, in turn, can have very positive knock-on effects on students' attitudes to mathematics, applications of statistics and other subjects.

Snee (1993) noted that: '… the collection and analysis of data is at the heart of statistical thinking. Data collection promotes learning by experience and connects the learning process to reality.' The RSSCSE has adopted this philosophy in the development of its school-level projects. A number of these are aimed at improving the statistical literacy and knowledge of learners *and* teachers. Four RSSCSE school projects are now summarised.

1. *CensusAtSchool* (www.censusatschool.ntu.ac.uk) started in the UK in 2000 and collects real data from and about school students in a class 'census' unit. It returns the raw data & specially designed teaching and learning resources to the class teacher via the Internet. It is also implemented in four other countries: South Africa, Australia, New Zealand and Canada.
2. *ExperimentsAtSchool* (www.experimentsatschool.ntu.ac.uk) is designed to collect data from experiments done at school in science, geography, psychology, etc. It was re-launched in March 2005 and has been adopted as the central ICT theme of the new Centre for Effective Learning in Science (CELS) at Nottingham Trent University.

3. *IssuesAtSchool* (www.issuesatschool.ntu.ac.uk) promotes discussion on controversial biomedical issues: class debate is followed by seeking students' opinions and views and collecting them using online questionnaires; teaching & learning resources are produced from these.
4. *SurveyAtSchool* (www.surveyatschool.ntu.ac.uk) enables the creation of surveys by school learners using the Internet and provides easy access to data responses. Data analysis can be done in Excel or a statistical package. Registration gives a school ownership and the space on a server to create on-line surveys.

The *AtSchool* projects enrich the curriculum for learners and yield innovative and dynamic ways of motivating pupils and produce a rich source of continuing professional development (CPD) in mathematics for teachers across a broad range of subjects in primary and secondary schools. The projects are growing in popularity every year as more and more teachers adopt their use in the classroom. Statistics New Zealand, The Australian Bureau of Statistics and Statistics Canada are using *CensusAtSchool* in their countries to raise awareness of the importance of their national censuses amongst the population as a whole.

These projects can also help to improve statistical thinking, especially as they use real data and are simultaneously linked to using ICT. See, for example, Connor et al (2006). These authors show that using ICT to record, retrieve, and present data is an important stimulus for learning in the real data context. These activities can add value when compared with simply presenting data to students that *someone else* has produced.

2.2 Teaching and Learning Statistics through Problem-Solving

This method of teaching has been gradually gaining support over the last 15 years. Early recognition of the merits of the problem solving approach is provided by Snee (1993). He urged course designers and teachers to act more sensitively in response to real world problems.

Other authors have also argued (see, for example, Stuart, 1995) that statistics should be taught through problem-solving. The same author (Stuart, 2003) has written an introductory level statistics book that advocates and uses this approach for business and industry. Authors of other textbooks in statistics are beginning to recognize the merits of suggesting that students reinforce their learning by doing projects that are problem-based. For example, Agresti and Franklin (2007) adopt a problem-solving approach in an undergraduate introductory statistics text and Clarke and Cooke (2004) list 47 projects and give guidelines for doing them by following the three criteria of: *Aims*; *Collection of data;* and *Analysis*. These criteria are three components of a problem-solving paradigm and, even though many of the projects in Clarke and Cooke do not require a great deal of time to complete, students are encouraged to write a report on their findings in each case.

Garfield (1995) extols the virtue of learners gaining real world statistical experience from solving real problems with real data. She also summarises educational research views on statistical learning which suggest: spending more time developing student understanding; using small group learning activities; employing open-ended problems; making use of practice sessions and experimental work. See also Cobb (1992), Cobb and Moore (1997).

All the activities and resources in the New Zealand implementation of the UK *CensusAtSchool* project (www.censusatschool.org.nz/2005/) were developed using the investigative cycle *Problem; Plan; Data; Analysis and Conclusions (PPDAC)*. This five-stage cycle was advocated and discussed in detail by Wild and Pfannkuch (1999). As is quoted on the NZ *CensusAtSchool* web site, 'Statisticians use this cycle and we think that it is important that students begin to as well'. See, for example, the delightfully simple guide for school students at www.censusatschool.org.nz/2005/resources/how-kids-learn.

We have provided a good deal of evidence that teachers of statistics may be able to be more effective at getting students to learn the subject by adopting a problem-solving approach in their teaching. These and other findings were used in a study commissioned by the UK Qualifications and Curriculum Authority (QCA, www.rsscse.org.uk/qca), and run by the RSSCSE. Following completion of the project it recommended that material for trialling in schools be based on a number of statistics topics and those should be explicitly taught through problem-solving. The problem solving approach advocated is enshrined in the National Curriculum for England and consists of the four stages: *Plan; Collect; Process and Discuss.*

As part of the same QCA project, the RSSCSE undertook a survey of heads of mathematics in schools in England in 2005. This revealed that many of them were less than confident about teaching statistics, even at an introductory level. Further analysis showed that many expressed a need for CPD in the subject, especially in the context of the use of statistics to solve problems that involve *real* data.

The RSSCSE is currently developing a range of materials for teaching and learning that use a problem solving approach. We are currently creating an Internet-based wizard which classroom teachers will be able to use to contribute their own ideas and create similar problems and associated resources using a common

template. Such contributions will be subject to a refereeing process for quality, and will subsequently be added to a national database. This approach has the potential to enable teachers to become more confident at using real data in the problem-solving context. As a consequence teachers should also benefit from CPD, both through teaching statistics this way or through designing and creating *their own* problems for the database.

A key part of the RSSCSE mission is to communicate what it does both nationally and internationally. In this respect, the RSSCSE made major contributions to the 6th and 7th ICOTS conferences in Cape Town, South Africa (2002) and Salvador, Brazil (2006). It made key presentations at the 55th session of ISI and the IASE satellite conferences in Sydney in 2005. The proceedings of these two conferences are available on the IASE web site at www.stat.auckland.ac.nz/~iase/. Full details of the extent and form of its outreach and dissemination activities over the last six years can be found in the six-monthly reports available on the web site (www.rsscse.org.uk/about/directorsreports.asp).

3 Continuing Professional Development

CPD is an activity that is encouraged by a wide range of professions and organisations. For some it is compulsory and others use it as a lever for promotion and increased salary. The extent and form of CPD naturally varies with each body and employer. For its ordinary fellows and professionally qualified statisticians, the RSS has carefully considered what it sees as essential for professional enhancement. The Society's CPD Policy was implemented on 1 January 2004, after some five years of careful development work. More details of what it expects of its fellows can be found on the Society's web pages: www.rss.org.uk. The RSSCSE is proactive in providing CPD through both education and training routes.

3.1 CPD – Education for teachers of statistics

The RSSCSE is involved in the design and writing of material that can help provide CPD for teachers of statistics both in secondary and higher education. In the latter case in 2002 the Centre launched a distance-learning course, the *RSS Certificate in Teaching Statistics in HE,* which is accredited by the Royal Statistical Society. The web site for this course can be viewed at www.rsscse.org.uk/activities/tsinhe.asp. The course enables teachers in HE to enhance their pedagogy, assuming they already possess adequate knowledge and skills in the subject. Comments from successful certificands are available on the web site, including a portfolio of activities submitted (successfully) for assessment.

Encouraged by the success of this HE Certificate, the RSSCSE is currently developing two versions of a *Certificate in Teaching Statistics at Secondary Level* that will focus on both knowledge/skills enhancement in statistics *and* its pedagogy. One aim of these proposed schoolteachers' certificates will be to get the participants to think about and adopt methods for teaching statistics through the approach described in section 2.2. See www.rsscse.org.uk/activities/tsise.

3.2 CPD - Training in Africa

Over the last six years the RSSCSE has provided unique CPD opportunities through training trainers of statisticians in National Statistics Offices in African countries. It has also been involved with the RSS in helping to accredit the academic and general statistics provision in the Department of Statistics at Kuwait University.

The RSSCSE has now provided two teams of statisticians in Malawi and The Gambia with the necessary knowledge, skills and course management material to teach the syllabus that can enable trainees to sit the RSS Ordinary Certificate (OC) examinations. The reports of these visits included:

1. a course management document;
2. detailed recommendations about nominating a course leader;
3. a procedure for setting up a course committee;
4. the establishment of a teaching team;
5. recommendations to purchase key teaching resources.

However, the most important activity involved the teaching team receiving a two-week intensive training session on how best to deliver the syllabus for the RSS OC.

Competencies and key skills in areas such as communication, the use of ICT, working in teams, self-improving in learning and performance, problem solving and individual project work are all important in statistics. They are very important attributes for *practising* statisticians. In both instances the trainees from the respective government statistical departments can also be awarded the Royal Statistical Society

Certificate in Key Statistical Skills, provided they study appropriate material and pass the coursework requirements specified by the RSS.

We recommend that the OC course should take up to 24 two-day sessions. These should be run before May in any year in time for the date on which the RSS OC examinations are taken. Half of the time should be devoted to teaching, while during the remaining time students should receive tutorial support and guidance on problem solving, project work and communication skills. Some extra topics tailored to the specific needs of the country, such as elementary demographic and economic statistics, are included and are assessed as part of the RSS Certificate in Key Statistical Skills. The Universities of Malawi and the Gambia took part in the training in their respective countries with great enthusiasm. Other central statistical offices in Africa could benefit from implementing similar procedures in order to provide statistical knowledge and skills enhancement for their staff.

3.3 Accrediting academic and general statistics provision in universities

In two joint visits, the first in 2005 and the second in 2006, staff from the RSSCSE and the RSS assessed the provision of statistics within two undergraduate academic programmes at Kuwait University. At the same time, but with different criteria, the wider provision of resources, environment and teaching and learning were assessed. Each of these visits was over five days.

Following recommendations to the RSS Professional Affairs Committee (PAC), it formally accredited the Department of Statistics and Operations Research at Kuwait University in respect of the academic content of its BSc degree programmes in Applied Statistics and in Applied Statistics & Operations Research and in respect of the general nature of its provision. For the degree accreditations it means that a graduate from Kuwait University with either of these qualifications can apply for the professional award of *Graduate Statistician* (GradStat) from the RSS. Accreditation means that Kuwait University graduates are exempt from sitting the RSS Graduate Diploma examinations, which is the normal way to get the award. The accreditation at Kuwait University has aroused much interest in the Middle East. A number of other universities in the region are exploring similar opportunities to become accredited by the RSS.

4 Future Activities

In this section we describe some new ideas the RSSCSE is developing for promoting statistical literacy. The first of these is prompted by the Olympic and Paralympic Games being awarded to London in 2012. It has the potential to be implemented in all countries in the world that are involved in sending representatives to the Games. In that respect the project could have enormous potential for improving the statistical literacy of all who take part.

4.1 The Olympics

The Olympic and Paralympic Games are coming to London in 2012, and there will be huge interest, especially among the young in many countries. We believe the Games could be used to involve students of all ages in a large-scale project that answers real questions, using real data, which involves and interests all of them. This personal involvement can break down their fear of statistics and motivate their learning.

The Olympic Games usually motivates people of all ages. The young, in particular, may find fresh aspirations to participate and succeed in sporting activities. Some young people, barely into their teens at the moment, may become competitors by 2012. Also, students and their teachers are likely to be stimulated by Olympics-related activities that are fun to do, but that also promote a designed approach to participating in sports. Measuring and keeping track of their own ‘personal best’ performances is just one example. Doing all these requires a serious amount of design, data collection, analysis and interpretation. But that is what statistics is for!

The *AtSchool* projects described in Section 2 provide evidence that projects designed around collecting meaningful data can help improve knowledge, skills and statistical thinking for students. They motivate learning and emphasise how real data and information are important for many subjects across the school curriculum. *OlympicsAtSchool* (www.rsscse.org.uk/olympicsatschool) is a project designed to collect data from school age learners who participate in enjoyable activities related to the Olympic Games.

We believe that a data-driven project that uses the Internet to collect meaningful data on variables that students can relate to, but that are also relevant to some or all of the Olympic Sports, will have real benefits for everyone involved. Similar to *CensusAtSchool*, the proposal is that, following the creation of a number of clearly-posed questions, sport-related and lifestyle data within the Olympics context should be collected from the students themselves and the problem-solving paradigm used to carry out purposeful investigations. To illustrate the potential, we could ask the general question ‘What can you do to get better at participating

in sports?' To solve this problem a number of related questions need to be carefully planned in order to get useful data. Variables such as diet, health, life-style, fitness, dedication and enjoyment can affect performance in sports. Measuring these variables and relating them to Olympic values will produce a wide range of activities for people of all ages to get involved in.

In practice questions will be designed and constructed after consultation with representatives from the Olympics and Paralympics movements, previous Olympic athletes and colleagues from subjects that include sports science, physical and biological sciences, citizenship, mathematics and statistics. Persuading schools, colleges and universities to become involved in the project will be a key objective. For illustration, here are examples of a few specific questions that provide starting points for producing useful data.

1. In what ways will the London Olympic and Paralympic Games motivate you to take part/improve in sports? (Providing a list for them to choose from).
2. How can you and your school/college/university help to contribute to the London Olympics?
3. What sports (list) do you like best (i) taking part in (ii) watching?
4. How many hours of exercise do you do per week?
5. How many portions of fruit and vegetables do you eat per day, per week?
6. What is your pulse rate (i) resting (ii) after 2 minutes of exercise? What is your time to recovery?
7. How fast can you run 20, 50, 100, 200 metres?

Other questions could, of course, be targeted at specific Olympic and Paralympic sports. But *all* the data collected will offer support and opportunities to carry out case studies based on interesting questions posed by students and teachers. This will be done by interrogating the database of responses that will grow as the project progresses. Participating students and teachers could, in turn, provide knock-on benefits through carrying out related cross-curricular activities. Associated learning and teaching resources will be created to enrich education in many subjects, not just mathematics and statistics. These will be freely returned to teachers and students for teaching and learning.

Added value for a country's success at the Games could come from more advanced applications of statistics that could help with identifying talented athletes through scrutiny of appropriate data collected for each sport. Students and teachers at all levels of education could benefit from participating in an Olympics-related project that is implemented over the next six years and beyond. In the short and long term it could help to make statistics a more motivating subject and improve its image with a lot of people. If anyone is interested in getting involved, please make contact. I am particularly keen to hear from: (i) countries that are interested in getting their school-aged learners to contribute data and (ii) organisations that would like to invest in or sponsor the data-based *OlympicsAtSchool* project I am proposing.

4.2 Dynamic Resources Using Interesting Data

The dynamic worksheet generator using real data is a web based facility provided by the *Dynamic Resources Using Interesting Data* (DRUID) project. The facility allows a teacher to generate a unique worksheet and data set for each member of a class. Furthermore a solution sheet, with guided instructions, is generated for each worksheet. The worksheets and solution sheets are generic in that any statistical package may be used to perform the analysis.

A dynamic worksheet generator using real data is useful to make the worksheet more interesting and challenging, and to encourage individual work. In addition the worksheets may be used for assessment purposes and can help to deter plagiarism, and the solutions provided can aid the marking of assessments. Each unique pair of worksheet and solution sheets are provided as Word documents (RTF) to download or preview online. PDF versions will be provided in future versions. The unique data are provided as a csv file which may be downloaded into any statistical package.

5 Conclusions

The RSSCSE runs or promotes a number of projects that are designed to hook people of all ages into wanting to become more skilled at the art and science of learning from data. In the case of school-aged learners this is helped by (i) their being motivated by *real* data that they can relate to and (ii) invariably getting excited by the prospect of exploring interesting issues with fellow students in the classroom. In turn, their teachers are motivated by innovative use of technology for improving their own knowledge and pedagogy. For government statisticians it is clear that they too are enthused to learn more statistics when *real* data, that relate to their day-to-day jobs, are used to teach them new methodology and statistical problem solving techniques.

It is inevitable that in the 21st century the use of statistics will become indispensable in evidence-based decision-making: the subject provides trustworthy procedures to get information from data that enables ever

more complex decisions to be made with confidence. For members of the public to be comfortable with the reasons for collecting and analysing data that lead to important decisions made on their behalf it is imperative that they have the opportunity to become more statistically aware. To that end the RSSCSE is working hard to ensure that school-aged learners, their teachers and the general workforce have access to ways they can become more statistically literate: this could contribute to their becoming part of a more statistical-informed society.

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RESUME

We describe some of the activities of the Royal Statistical Society Centre for Statistical Education in delivering its aim to promote the improvement of statistical education for people of all ages. At school level this includes: (i) activities that involve pupils from at least five countries in contributing meaningful real data to international databases, coupled with the creation of learning and teaching resources from those data; (ii) the results of a major UK government-funded project to review statistics and handling data within the school mathematics curriculum for pupils up to age 16. At university level we describe the development of the Royal Statistical Society-accredited distance learning course 'Certificate in Teaching Statistics in Higher Education' and how it can help teachers in Higher Education to improve their pedagogy in statistics. For workplace activities we present details of a number of projects undertaken outside the UK, including delivering train-the-trainers programmes for government statistical clerks in Africa. Finally, we look to the future and describe a project proposal to exploit interest in the Olympic Games that could deliver an improvement in the quantitative literacy of individuals in countries that take part.