

BUILDING THE CAPACITY OF MATHEMATICS AND SCIENCE TEACHERS TO TEACH STATISTICS

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Capacity building in statistics teaching requires teachers who wish to improve their pedagogy and knowledge to be, or become, artists, scientists and literists. This is because learning from data, the lifeblood of statistics, is an art and science: reporting any conclusions or findings in a trustworthy way requires a high level of writing skills. Consequently, continuing professional development (CPD) courses in statistics need to provide for teachers to be able to become better in these three areas in relation to many aspects of teaching and learning statistics. In this paper we describe the development of a CPD course, Certificate in Teaching Statistics up to Pre-university Level, first accredited as a professional qualification by the Royal Statistical Society in 2006, and its incarnation into masters-level modules that are now part of the Plymouth University International Masters Programme and can lead to the award of MA in Teaching Pre-university Mathematics and Statistics.

INTRODUCTION

Porkess (2011, 2013) noted an urgent need for development of the statistics provision in the United Kingdom (UK) to improve school-aged learners' problem solving and decision making skills to prepare them for university, the world of work and for life in general – when important decisions have to be made. For everyone decision making is increasingly based on real data produced in a large number of different subject areas, with the decisions invariably being made to solve a wide range of problems in those subjects.

A crucial part of the problem solving process involves consideration of statistical evidence and it is important that at school students are statistically educated in the skills needed to be able to solve problems for themselves. Currently this is not common practice in UK schools or colleges, either as enrichment activities or as part of formal school level qualifications.

Holmes, (2003) traced the development of statistics qualifications in English schools back to 1953 and noted that when A levels were introduced in 1963 they were developed by mathematicians, with related examinations testing mathematical concepts, rather than practical ability with applications of statistics. This is still the case in 2014.

Statistics is a practical subject that uses technology and innovative software to help draw trustworthy conclusions and solve problems from complex, real data sets. In spite of these, even in 2014 assessment regimes at A level in the UK concentrate on what can be done in two- or three-hour hand-written examinations, with little or no regard for real data. Even if technology is used to teach and do the subject, it is nowhere to be seen in A level assessment regimes – indeed it is often banned from the examination environment.

ISSUES

A national survey conducted as part of a project carried out by the Royal Statistical Society Centre for Statistical Education (RSSCSE) in 2006 for the then Qualifications and Curriculum Authority (Marriott and Davies, 2006) found that, in England, just over 20% of heads of mathematics had qualifications that did not include statistics, about one third of them did not think that their knowledge of statistics was “excellent” or “very good” and about 25% declared themselves to be “not fully confident” at teaching statistics at Key Stage 3 (students aged about 14). The same project provided strong evidence that mathematics teachers needed a programme of Continued Professional Development (CPD) to improve their statistics knowledge and pedagogic skills. Furthermore, it recommended that statistics teaching should be changed to reflect how statistics is done in practice: the subject should be taught using a problem solving approach (PSA). This approach requires a range of extra cognitive skills not often needed in mathematics. Learning

from data is an art and science: it requires ability in literacy, writing, discussing, and skills to 'read' graphs and tables.

Davies et al (2012) found that many mathematics trainee teachers had poor statistics knowledge, received little or no pedagogic training in statistics and often worked with teachers in their placement schools who had little enthusiasm for teaching statistics other than as a branch of mathematics. This provides further evidence for the need for statistics teaching CPD for mathematics trainees and even experienced mathematics teachers. This is also recognised in Porkess (2013) where he recommends that all school and college mathematics departments should appoint or nominate people with the expertise to be the authorities on statistics within and between all subjects within their institutions.

A curriculum can be regarded as having four parts: specified; taught; learned; and assessed. However it is the assessed curriculum that dominates schools in England: they are judged by students' examination performance, and so teaching and learning is driven by assessment regimes. In statistics, because the assessment regime reflects only statistical mathematics, and pays lip-service at best to the practical and problem solving nature of the subject, there is little incentive for teachers to teach these latter skills. Capacity building in statistics through CPD has little importance in the minds of teachers.

Holmes (2003) noted:

How well it (statistics) is taught and learned will depend on the teachers and their resources. Teachers need to be enthused and trained to teach new topics and this takes time and money. When good enthusiastic teachers are given freedom to experiment, they can change the curriculum for good and enthuse both their pupils and other teachers.

Recently, in the English Curriculum new A level qualifications such as Core Mathematics, Quantitative Methods and Use of Mathematics have been introduced. As these include data handling, statistics topics and coursework, there is now an even bigger and more urgent need for CPD provision for mathematics and other teachers who teach statistics, but have not undertaken training aimed at improving their statistics knowledge and pedagogy

THE RSS PROFESSIONAL QUALIFICATION

The statistics and data handling project conducted by the RSSCSE (Marriott and Davies, 2006), in which teachers themselves appealed for support for gaining knowledge and pedagogy to improve their statistics teaching, led to that organisation designing and producing a CPD course in statistics for UK secondary school teachers of pre-university statistics. The Certificate in Teaching Statistics up to Pre-university Level was created and first accredited by the RSS in 2006.

The aptly named statistics book by Agresti and Franklin (2013) closely captures the philosophy of the course through real world examples, including ways that statistics can help to solve problems. It has been the course text since its first edition appeared in 2004. The course aims to encourage teachers to change the way they teach statistics through adopting the PSA. This philosophy is embedded within the Certificate and is continually rehearsed in capacity building of both the subject knowledge and pedagogy.

The Certificate, in the form accredited by the RSS, attracted 31 students. It was evident from the start that these students (all practising teachers) brought a range of hopes and expectations to the course. A small number simply wanted to attend the four contact days in order to be exposed to a range of pedagogical ideas, teaching materials and resources; many worked hard between contact days to improve their subject knowledge and pedagogy; and for some the aim was to complete all the stages of assessment in order to obtain the certificate.

THE INTERNATIONAL MASTERS PROGRAMME

The RSS Certificate in Teaching Statistics up to Pre-university Level provided the impetus to develop two Masters-level modules that are now part of the Plymouth University International Masters Programme leading to the qualification MA in Education: Teaching Pre-university Mathematics and Statistics. These modules will be available to students internationally through online methods such as typified by specialised personalised online courses (SPOCS).

Students studying one of these pathways choose four modules from Teaching Statistics 1 and 2, Teaching Advanced Mathematics 1 and 2, Teaching Further Mathematics 1 and 2 – with the obvious constraint that module 1 of a pair is a prerequisite for taking module 2. To complete the MA, students then have to write a dissertation.

Each of the four modules is assessed by means of a 5000 word essay, each essay having a different ‘assessment mode’ chosen from the following list:

- Critical Review of a Body of Knowledge
- Developing Practice through a Project
- Understanding the use of Data
- Critical Reflection on Practice
- Making an Argument.

In re-structuring the course from the RSS Certificate to the Plymouth University International Masters Programme, the RSSCSE is taking the opportunity to change the mode of delivery. Whereas previously most of the teaching took place on the four contact days, now the mode of delivery is moving in the direction of the inverted or flipped classroom. Before each contact day, the students receive a detailed learning programme to follow based on Agresti and Franklin (2013), together with online resources and software to use. The contact days focus on what has been learned and how it can be applied in the classroom. To that end, each of these days has four themes: real world contexts and data, the theoretical background, the use of technology to enhance understanding, and pedagogy.

The present mode of delivery for these modules is being further developed into a distance learning provision so these unique qualifications can be offered internationally.

CONCLUSIONS

The evidence was, and still is, that teachers, including those with mathematics degrees, find themselves teaching statistical material, either within a course in secondary mathematics or as supporters of other disciplines (such as the social or physical sciences) without the background knowledge and experience that they would like or need. The underlying philosophy for teaching and learning statistics of the Teaching Statistics Modules 1 and 2 in the Plymouth University IMP provides a basis for developing problem solving techniques which can broadly be put into a modelling cycle and include subject knowledge and pedagogy.

It is our view that in countries like England, that judge schools on the examination performances of their students, directly or indirectly encourage assessment regimes to dominate what is taught and learned. In statistics it is high time that these regimes were changed to better reflect the 21st century use of the subject to make sense of data and solve problems.

Such changes might provide more incentives for teachers in the UK to want to build their capacity in the new statistics knowledge and pedagogy. The two modules in the International Masters Programme we have presented provide opportunities for teachers in the UK and elsewhere to build their teaching statistics capacity.

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