SOME LESSONS TO BE LEARNED FROM CURRICULUM DEVELOPMENTS IN STATISTICS

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Over the past 40 years or more there have been many attempts to improve the curriculum in school statistics. They have had varying degrees of success. Referring mainly to experience in the UK, but also noting developments in the USA, I shall try to identify the lessons to be learned if such curriculum development is to be successful.

INTRODUCTION

In the time available I can only give a bird's eye view of what has happened in forty years and, of necessity, have had to be very selective. I am aware that I have not touched on developments in many parts of the world – particularly Australia and New Zealand. For the developments in England I have drawn heavily on Holmes (in press).

THE FIRST INTRODUCTION IN ENGLAND FOR 16–19 YEAR-OLDS

The first widely taken qualification in probability and statistics was introduced into the school system in England in 1961 as an alternative to theoretical mechanics for students aged 16 to 19 who were specialising in mathematics. The aim was to provide a relevant application of mathematics to those whose main subject interest was in fields such as geography, psychology, biology etc. The courses were developed largely by mathematicians. No specialists from the user subjects were involved with the syllabus development. The syllabuses had to be seen as mathematically respectable since they carried a qualification in Mathematics and showed some obvious weaknesses. The questions often tested mathematics rather than statistics. Little emphasis was given on the practical implications of any calculations. User subjects found the course much less useful than they had hoped and the courses did not develop the expertise required in carrying out a full statistical investigation.

These courses still exist, though their content and approach has changed somewhat to become more practical and to take in more of the real needs of these user subjects. Many have compulsory projects that are assessed. In the 1970's courses with half the material were introduced. Some of these had much more emphasis on data and statistics in real life applications.

Some Lessons to Learn

- Involve applied statisticians in the syllabus development
- Take advice from the user subjects as to the nature of the statistics they need
- Practical statistical skills need developing as well as theoretical ones.
- If you want project work to be taken seriously you must assess it and it must not be an option.
- Different subjects require different approaches and different topics.

SCHOOL DEVELOPMENTS IN ENGLAND IN THE 1960'S

The 'modern mathematics' movement in the 1960's was much more pragmatic in England than in continental Europe and the United States. There were significant developments in statistics at both primary and secondary level.

In the primary schools there was a growth of practical data collection, representation and intuitive inference. This was actively promoted by Her Majesty's Inspectors (Biggs, 1971, 1972; Schools Council, 1965). They ran many in-service courses for primary school teachers where there was an emphasis on collecting data for yourself, representing it graphically and drawing (elementary) inferences from the data. There was also a major curriculum development for primary school mathematics at this time funded by the Nuffield Foundation (1967, 1969). This included many activities in probability and statistics.

In secondary schools there were also major developments; the most influential was the School Mathematics Project (SMP). SMP, and others, introduced probability and statistics into the mathematics courses for secondary pupils (aged 11 to 16). The material emphasised theoretical probability and was weak on practical statistics. It tended to be focussed on statistical techniques rather than the practical uses made of statistics in everyday life (School Mathematics Project, 1969).

Some Lessons to Learn

- Primary Schools children can learn and enjoy elementary probability and statistics.
- It is possible to begin to develop early ideas of probability and inference at this age.
- Pupils learn concepts better if introduced in a practical way and calculations are deferred.
- Statistics is more than a set of techniques.
- We need to think out what is an appropriate education in statistics for all.
- Interesting activities are not enough; the teaching must hang together.

THE SCHOOLS COUNCIL PROJECT ON STATISTICAL EDUCATION (POSE)

This major project (see Holmes, 1986) was set up to investigate and develop materials for the main secondary school (pupils aged 11 to 16). The philosophy behind the project was that pupils should become aware of and appreciate both the role of statistics in society - the many and various fields in which statistical ideas are used – and the nature of statistical thinking - the power and limitations of statistical thought (Schools Council Project on Statistical Education, 1980a). This was based on broad reasons for including statistics in the school curriculum for all pupils. These reasons were that Statistics is an integral part of our culture, such thinking is an essential part of numeracy, exposure to real data can aid personal development and decision making, statistical ideas are widely used at work after school and early exposure can give sound intuition which can later be formalised.

To show how these principles worked in practice the project team produced a large amount of material (Schools Council Project on Statistical Education, 1980b) that was highly innovative and was well tested in a wide variety of schools. It was well received by those who used it. It was not, however, part of the examined curriculum; it did not lead to a qualification at the end and it did not easily fit into mathematics lessons so was not widely taken up.

Some Lessons to Learn

- Producing innovative material is costly in time and people.
- To change the teaching in schools requires more than good material; you need to find the levers in the system and use them.
- Major changes of philosophy may take some time to be accepted; a long-term strategy for acceptance is needed.

A STORY FROM SCOTLAND

In the late 1970's Professor David Silvey, Head of Department of Statistics at Glasgow University, took a proposal for an O-Grade in Statistics, based on a similar philosophy to POSE, to the appropriate authorities in Scotland. It was considered by the mathematics committee and turned down. The basis of the rejection was that any such syllabus must include the Normal distribution, this meant that there needed to be a grounding in continuous probability distributions, hence there needed to be earlier work on discrete and continuous probability. If all this was to be included there was not time for all Silvey's suggested work on data collection and interpretation!

Lesson to Learn

- Statistics is not mathematics and mathematicians may not appreciate the breadth of the subject.

SOME DEVELOPMENTS IN THE USA

Here I can only touch on some of the developments and draw general lessons. In 1968 the American Statistical Association (ASA) and the National Council of Teachers of Mathematics (NCTM) set up a joint committee on education chaired by F. Mosteller. Their first priority was to

make clear to the public what sort of contributions statisticians make to society so as to explain why more statistics needed to be taught at school. They produced the very popular and influential *Statistics: A Guide to the Unknown* (Tanur, Mosteller, Kruskal, Link, Pieters, Rising, & Lehmann, 1989). This was followed up by four books under the general title *Statistics by Example* where they took some of the stories in Tanur et al, added others, and developed them into teaching material for older school pupils or first year college students. (Mosteller, Kruskal, Link, Pieters, & Rising, 1973a, 1973b, 1973c, 1973d). The committee continued this pattern of producing material for teaching under the Quantitative Literacy Project (See Scheaffer, 1991) and initial books by Gnanadesikan, Scheaffer and Swift (1987), Landwehr and Watkins (1987), Landwehr, Swift and Watkins (1987) and Newman, Obremski and Scheaffer (1987). The United States is fortunate in having a major funding body, the National Science Foundation, which has funded a lot of the development work. The Quantitative Literacy Project (QLP) did not attempt to produce a complete course in statistics for schools because of peculiarities in the US school mathematics courses. They did, as did others, see the importance of training teachers to be able to teach the material (Burrill, 1991; Perry & Kader, 1993). All this groundwork was useful but a major factor in getting statistics accepted widely as an important part of the school curriculum was the NCTM (1989) publishing its standards for school mathematics. Although these were only advisory they were widely accepted and influential. A more recent initiative, Advanced Placement (AP) Statistics (similar to the English A-Level but with more emphasis on real data) has been hugely successful in recruiting teachers and students.

Some Lessons to Learn

- It is important to develop a good attitude to statistics by showing how it is used positively in practice.
- To put philosophy into practice it is necessary to produce material for teachers to use.
- Initially you may have to work within national constraints. These constraints may need tackling at the national level.
- It is important to train teachers at the same time as introducing new material. It is not feasible to wait until a new well-trained body of teachers emerges from new courses.
- New initiatives can be greatly facilitated by the existence of a broad-visioned funding body.

CENTRES FOR STATISTICAL EDUCATION

The first national Centre for Statistical Education with a brief for school statistics was formally set up in 1983 in Sheffield, England. (The Indian Statistical Education Centre, which celebrated 50 years of existence in 2000, was set up with a very different brief. This was to train government statisticians). The Sheffield Centre had many projects developing material for use in schools (Davies 1993a, 1993b; Hammond, 1990; Holmes, 1985; Rouncefield & Holmes, 1989; Holmes & Rouncefield, 1989) and, since being re-launched in Nottingham as the Royal Statistical Society's Centre for Statistical Education in 1995, has continued this tradition with a major initiative called CensusAtSchool. A few years after the start of the Sheffield Centre, and with its encouragement, a five-university Centre for Statistical Education was set up in Italy. The main Centre is at Perugia. This Centre has also carried out curriculum development projects and also research into the effectiveness of different teaching methods. The American Statistical Association (ASA) also has a Centre that runs a poster competition, has a regular newsletter, oversees many of the developments from the Quantitative Literacy project and helps with new proposals for funding. The Spanish Centre, at the University of Granada, has concentrated more on research into how pupils and students learn statistics, and some of the misunderstandings that occur and why. It is also this Centre that is the hub for the activities of the *IASE Statistical Education Research Group*. Each Centre is able to respond to national needs as they arise and seeks improve the teaching of statistics in its own country. The most active ones are those that have regular funding and at least one permanent employee.

Lesson to Learn

- A national centre for statistical education is very useful in promoting good attitudes and good practice in teaching school statistics. Different nations have different needs and

priorities at any time so the ISI could help by encouraging more countries to establish such Centres.

THE NATIONAL CURRICULUM IN ENGLAND AND WALES

In the early 1980's the government set up an enquiry into the teaching of mathematics in schools under the chairmanship of Sir W. H. Cockcroft (1982). The brief of the committee included probability and statistics. Their findings on probability and statistics were strongly influenced by POSE from whom they received evidence. In its turn this report influenced the government who decided, for the first time in British history, that there should be a National Curriculum. This came into force in 1989.

Initially the National Curriculum for Mathematics had 4 of 14 strands on probability and statistics (called data-handling) spanning all ages from 5 to 16 (Department for Education and Science, 1988, 1989). In order to check the effectiveness of the National Curriculum, there were very detailed assessment tests so that each pupil could be identified as having reached a particular level. Over a couple of years or so, the assessment tests came to dominate the teaching. Teachers had to make sure that their pupils could answer the test questions so taught to the test. This meant that, in statistics, there was great emphasis on teaching the techniques; any global view of the importance of statistics and the nature of statistical thought was disregarded.

Since its first introduction there have been several changes. The statutory programme of study, which indicates how the material is to be taught, is now based on a four-stage cycle. This is 'Specify the problem', Collect the data', 'Process and represent', and 'Interpret and discuss'. The assessment process is to be based on these Programmes of Study.

A section entitled 'Breadth of Study' at the end of the work for 11-14 year-olds includes the statement that pupils should be taught knowledge, skills and understanding through practical work in which they draw inferences from data and consider how statistics are used in real life to make informed decisions and that address increasingly demanding statistical problems. There is a section emphasising the strong links to be made to the use of statistics in society (Department for Education and Employment, 1999).

Some Lessons to Learn

- If you assess atomistically you will get atomistic teaching.
- If you do not assess global skills and understanding they will not get taught.
- School statistics can be taught through a practical broad-based approach.

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In every step of the curriculum development process, the most important task is to keep the learner (in this case, youth) in mind and involve them in process. For example, the curriculum team members, who have direct knowledge of the target audience, should be involved in conducting the needs assessment.Â This section explores some of the questions that need to be addressed to define the issue and to develop a statement that will guide the selection of the members of a curriculum development team. The issue statement also serves to broadly identify, the scope (what will be included) of the curriculum content. Most people seem to think statistics is easier, and since I have been having such a hard time trying to wrap my head around this I'm starting to wonder if this is even the right path for me. If anyone's had any similar experiences and managed to pull through, it would make me feel immensely better that I'm not alone...Â My theory is that statistics is just a very different way of thinking. All the way to its core it's different. Your whole math life, numbers have been concrete. All of a sudden, in stats, you learn about probability density functions and expected values and it's just a wholly different system. So, yes, it is that difficult. Another stats thing - you have to learn the symbology, theory, and performing math functions all at very rapid rate. It's tough. permalink. ICOTS6, 2002: Holmes SOME LESSONS TO BE LEARNED FROM CURRICULUM DEVELOPMENTS IN STATISTICS Peter Holmes Nottingham Trent University UK Over the past 40 years or more there have been many attempts to improve the curriculum in school statistics. They have had varying degrees of success. Referring mainly to experience in the UK, but also noting developments in the USA, I shall try to identify the lessons to be learned if such curriculum development is to be successful. INTRODUCTION In the time available I can only give a birdâ€™s eye view of what has happened in forty years and, of necessity, have had to be very selective. I am aware that I have not touched on developments in many parts of the world â€“ particularly Australia and New Zealand.