MAKING THE CHANGE TO STATISTICAL EDUCATION THE PRACTICALITIES, PITFALLS AND SUCCESSES

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The introduction of revised senior mathematics syllabusses, in Queensland, Australia, created an immediate need for in-service training of 'traditional' high school mathematics teachers. By far the most difficult aspect has been 'statistical thinking'. A wide variety of teacher activities are reported, that were designed to help teachers in accepting and working with the apparently new, and to many threatening, area of applied statistics. The range of activities includes seminars, workshops and additional written material. The most effective approach for successfully inducting teachers is shown to involve active teacher participation in a structured class situation. Within the session teachers must initially identify real world situations whose solution is facilitated by a statistical approach, and then simplify the situation to a format suitable for a class work program.

INTRODUCTION

In 1993 a new Senior Mathematics syllabus was introduced into Queensland high schools. This was the first major change to the syllabus in twenty years, and represented the culmination of five years concerted effort by the Senior Mathematics Sub Committee of the Queensland Board of Senior Secondary School Studies (BSSSS). Prior to 1993, a trial was carried out in which 17 high schools introduced one or more of the three subjects, Mathematics A, Mathematics B and Mathematics C, using the pilot/trial syllabusses. Numerous monitoring programs, both formal and informal, were implemented throughout the trial period with a specific evaluator appointed to oversee questionnaire surveys of students and staff. This process provided ongoing feedback, culminating in revision of the syllabusses prior to their final release in 1993.

In keeping with recommendations in the *National Statement on Mathematics for Australian Schools* (AEC, 1990), the challenge for the revised Senior Mathematics was to encourage: *innovation and experimentation so that all learners have a positive experience of mathematics* (AEC, 1990, p i). Mathematical content was to be presented within life-related situations, to show students its value as a tool with varied roles in the real world. All students have a right to an education which provides them with the ability to make *informed decisions* which impinge on their everyday life; for example, in determining

whether or not to use a particular drug with stated side effects; in deciding which to select of a number of loan agreements with different interest rates and fees.

Emphasis in the data analysis components was to be on *description and interpretation from the point of view of the recipient rather than the presenter* (BSSSS, 1993). This approach was reinforced with the introduction of a specific assessment criterion of *communication.* It was recognised that a number of the approaches and topics within the new syllabusses would be unfamiliar to many teachers. If this new approach to mathematics education was to be delivered as intended, training for teachers in how to implement the new syllabusses was critical. In a document following a regional mathematics conference, the President of the Cairns Sub-Branch of the Queensland Association of Mathematics Teachers wrote: *The old syllabus is deeply entrenched and a major Inservice effort will be needed to change current practices* (Payne, 1992).

MAJOR AREAS OF CONCERN

The evaluation of the pilot trial identified a number of key areas of concern. These included: problem solving; finding real examples; difficulties in having understanding rather than 'rote' knowledge of maths; a fear of, and resistance to, change; an ongoing belief that *it is good for you* is sufficient justification for teaching maths; a lack of text books. Within the specific content, the topic, *statistical inference,* was causing great concern amongst a population of teachers who had little if any training in any aspect of statistics except the formal mathematics of probability theory, and who regarded areas of descriptive data analysis as trivial, *mickey mouse* or *veggie-maths,* appropriate only for students weak in mathematical skills. Clearly, education was urgently needed for these teachers to show them that statistics is more than mathematics; that it is a way of thinking which is critical in many everyday decisions. Feedback (Peckman *et al.* 1992) showed that teachers were having problems in understanding the written problem, identifying variables, identifying the specific question within a problem, finding real examples, and dealing with uncertainty, errors and tales! Many of them were frightened, and felt threatened by the loss of *the familiar* and the introduction of material about which they knew very little, and in many cases regarded as being 'not real' mathematics. They, like many pure mathematicians who enjoy the beauty of their exact science with its black and white solutions, found it hard to cope with the 'grey' areas of statistical inference.

Teachers were experiencing high workloads and anything that would add to their commitments, especially if it involved change, was unwelcome.

INITIAL INSERVICE APPROACHES

Within this environment, a number of academics, teachers and curriculum officers began a variety of activities to provide in-service training to the teachers throughout Queensland. The activities ranged from two to three day mathematics conferences involving multiple seminars and/or workshops on various areas identified as problematic, through one-off evening seminars organised by specific high schools or regional groups, to workshops provided within a university context. Some activities were funded by the teaching authority or subsidised by teacher associations or individual high schools; others required an attendance fee of participants to cover costs - all were non-profit exercises.

The activities were traditional in that the presenter provided information usually with written material to supplement oral delivery, using numerous examples to illustrate the topics. Presenters were a mixture of academics, teachers and curriculum developers who had been involved in the pilot study or the preparation of the syllabusses, and practitioners who provided a real-life viewpoint on the topics. Unfortunately, although teachers enjoyed these activities and left feeling motivated (as evidenced in formal evaluations), most lacked the confidence to extend what they had been given. Typical statements are illustrated in the report by Payne (1992): *Great starting place - now I need follow up while I'm still enthused; Many new topics in this syllabus - I need help with the Content* and *Need help writing programs, finding resources that are suitable and available*. Many teachers returned to their own school's established workplan, and an environment where it was very difficult to implement change. Whilst some adopted specific examples provided at the seminars, they were unable to extend the material and include examples relevant to their own student needs and interests; their understanding of the newer concepts was, at best, beginning. Clearly the one-off sessions of one to two hours were inadequate to provide the necessary re-education; it was not enough to just give the teachers some notes and a few examples, and a brief motivational session. Something was needed that would provide an environment in which the teachers would really learn the new approaches and content, and gain the confidence and competence to deliver them in their own teaching.

How could teachers with an ongoing commitment of daily teaching duties, be given the skills needed to develop real confidence in the new material that would enable them to implement changes in their everyday teaching programs?

INSERVICE THROUGH INTEGRATED MODELLING PROBLEMS

A series of one day workshops was developed, that provided an integrated approach by using a basic format for mathematical modelling and problem solving. Genuine research problems were used to show how the integration of the concepts of mathematical models and statistical models can be used to solve real problems. Special purpose software was developed, which could be used not only to plot and compare a variety of mathematical functions, but which also enabled the fitting of various curves through real data. Some of the examples used included using sample data from the weather bureau to determine the week of the year a particular location was likely to have its minimum rainfall; using sample data from the local tourist authority to describe the trend in 'bed occupancy' throughout the year; using sample water quality data to describe seasonal trends and to determine total quantities of pollutants in a stream. This integration of deterministic equations and real data variation developed through the statistical model and its associated data synthesis, helped teachers to see the role played by statistical inference. These workshops were very well received and teachers went away keen to implement the approach and content from the workshop, and with good intentions to try new examples relevant to their own classes. However, follow-up evaluation showed that whilst the teachers were certainly implementing the examples from the workshops, they were unable to create their own examples, particularly where it was necessary to obtain data to simulate an apparently realistic setting relevant for their students.

Although a variety of methods were being used and the experts providing the information were dedicated and competent (as seen repeatedly in the formal evaluations), the in-service training was not working at a level needed to ensure the new syllabusses were implemented effectively. Most teachers were responding only to 'chalk and talk' presentations; they still lacked confidence and were putting in little action of their own; the complaints of *how?, what? and why?* continued; *there are still no textbooks* was an ongoing cry.

How could teachers be given the confidence and knowledge to develop real life examples? What skills are needed to formulate an example? Can these skills be taught to teachers? Can teachers be taught to recognise a suitable example (for example, from a newspaper article), and having recognised it, transform it to a level appropriate for their classroom? What role can simulation play in this process? Some teachers doubted that data could be created with simulation, believing that this approach would be 'cheating'.

THE TEACHER BECOMES A STUDENT

A different type of one day workshop was developed in which teachers were not given prepared examples, but were required to create their own examples under guidance from a team including academics, practising teachers and curriculum developers. The workshop reported here was dedicated to the specific topic: *statistical inference - the hypothesis test*, the concept being introduced and developed for the test of a proportion.

After a brief introduction by one of the presenters, participants worked individually and within groups to develop examples suitable for the specific topic. Materials were supplied in the form of a worked example, a proforma which listed the steps needed for an example, and a range of current newspapers, magazines and popular journals. In addition, teachers were encouraged to use their own imagination to dream up examples. Within their groups, the teachers discussed their ideas and helped each other to create examples at an appropriate level. A plenary session allowed the teachers to present their individual examples to the whole class for discussion, with the organisers providing immediate feedback and advice. Finally, all examples were collected and photocopied for all participants prior to their being edited and developed into a book: *Binomial Examples for High Schools Teachers by High School Teachers*.

These workshops were extremely demanding on the presenters who had to: ensure adequate materials were available; act as facilitator to a group who were used to being given all the details; interact on the spot to assist with unexpected examples from almost any area; provide instant corrections in a diplomatic way. Initially most participants were anxious and doubted their ability to cope, however, without exception, all gained a great deal as was evidenced in the formal evaluations where responses included statements such as *I finally understand statistical inference*; *making real examples is not difficult - this will really help my teaching*; *when is the next workshop!* The positive outcomes from the workshops have been astounding. A number of participants have had continuing contact

with the presenters in a variety of ways. Some have arranged for talks by the presenters to their classes; many have continued to send examples they have created for checking; students have been brought to the university for Mathematics Excursions which involve demonstrations by researchers who use mathematics especially statistics; students have been sent along for work experience; participants have begun enquiries about further study in the area of statistical education. The following are some of the examples developed by the teachers during the workshop on hypothesis testing:

- Is it true that 80% of feral cats in south east Queensland have FIV, a feline version of HIV? (Source: local newspaper article)
- Is the incidence of asthma in the teacher's school the same as it is throughout the rest of Queensland? (Source: teachers concern based on own observations)
- Has the proportion of cyclones which cross the Queensland coast changed in the last five years? (Source: recommended learning experience in the syllabus)

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