CHANGING SCHOOL STATISTICS

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School statistics has been viewed in the past as a series of topics for inclusion in mathematics courses. We now need to think about statistics more broadly and consider its relationship to the practice of statisticians, to school mathematics, to the mathematical processes, to other curriculum areas, to the general aims of education, and to what we know about learning and teaching. With these thoughts in mind it is clear that change is needed in school statistics and to do this we need to consider the development process for ourselves as teachers, and for the curriculum at both the national and the classroom level. This paper is intended to stimulate thinking about where statistics in schools might be going and some ways we might move to achieve the desired change, while at the same time accepting the complexity of the development process.

INTRODUCTION

During the last thirty years statistics has moved from being virtually nonexistent in school programmes to where in many countries it ranks alongside number, measurement, geometry, trigonometry, algebra and calculus as a significant part of school mathematics. This change has occurred at the same time as university mathematics departments have changed their names from ‘mathematics’ to ‘mathematics and statistics’, and in many cases have now become two separate departments. This increasing emphasis on statistics at university means that intending mathematics teachers now have often studied statistics as part of their mathematics degree.

The statistics that was first introduced into schools was conservative because the decision makers in the mathematics curriculum development process were usually former teachers whose own formal education finished some years before statistics had a significant profile in universities. Now, each time a curricula come up for review the situation is different because more teachers and curriculum officials have been exposed to some form of statistics education

In the past the introduction of statistics focussed on a series of topics that were comparatively new for many teachers. This was acceptable because it required changes to be made only in terms of content and not with respect to the fundamental nature of the subject or how it might be learnt or taught. The topics appealed, especially with middle school teachers, because they related to everyday rather than academic knowledge.

Future reviews should provide opportunities to look at other aspects of school statistics including its changing nature, the work of practising statisticians, statistics

similarities to and differences from mathematics, the emerging influence of the ‘mathematical processes’ and the comparable statistical processes, the other curriculum areas, the aims of education, and principles of learning and teaching.

STATISTICS AND STATISTICIANS

The traditional statistical topics that were introduced to school courses were data collection, statistical graphs, central tendency, dispersion, probability, distributions, regression and correlation and these tended to be taught using a mathematical approach.

From a search of four recent curriculum documents, Australia (Australian Education Council, 1991), England (Department for Education, 1995), New Zealand Mathematics Curriculum (Ministry of Education, 1992 and 1993), and the United States of America (1989), looking particularly at the content for students from 14 to 16-years-old, the emphasis now appears to be towards: doing practical and experimental work, using data from real-world situations, simulating and modelling, using computers, exploring data and probability, formulating questions, planning and carrying out statistical investigations, making sensible judgements, and communicating findings and writing reports. While these changes are evident in the curriculum, they may not be as evident in schools, and even if they are, we still need to ask the question ‘is the curriculum catching up with statistical practice or is it falling further behind?’

Three points in particular suggest to me that schools may not be keeping up. Firstly the teaching still uses an algorithmic approach rather than a conceptual one as schools do not use calculators and computers in the same ways as statisticians do. Secondly, the international change of emphasis to statistical literacy seems only partly emphasised in the curriculum with the increased stress on writing reports and on presenting data — it does not yet includes aspects such as using databases and spreadsheets for doing much of our statistics rather than specialist statistical packages. Thirdly, other topics such as time series, bootstrapping, resampling, quality assurance, performance indicators, and Bayesian approaches to probability all need to be considered for inclusion yet before they can be considered people need to trial the ideas and see if they are acceptable in schools.

STATISTICS AND MATHEMATICS

While statistics and mathematics have become two subjects at the tertiary level, teachers are faced with the dilemma of what to do at school. Should the subject be split

because one part is concerned with certainty (though only relative from a constructivist point of view) and the other is concerned with uncertainty? Will the students be more likely to appreciate the difference if the two topics are together or separately?

At the same time there is a need to wrestle with the practical problem in schools: more and more subjects pushing for status; student learning becoming more and more fragmented; and who would teach statistics (usually the people who have specialised in statistics have mathematics as their other major subject but internationally there seems to be a shortage of well qualified mathematics teachers and this situation may be exacerbated if statistics stood alone). Finally, faced with more options, I would be concerned that fewer students might do any statistics because only a few may opt for a full statistics course while most might consider the mathematics course which would then not include a significant amount of statistics as the mainstream one. I therefore believe that we should not at present consider statistics as a separate subject, and if we want to continue to increase its weighting in elementary and high schools courses then we are best to work within mathematics.

STATISTICAL AND MATHEMATICAL PROCESSES

I have written previously (Begg, 1991, 1995, 1997) about how the emphasis in school statistics and mathematics is changing from an emphasis on ‘knowing’ to ‘doing’, that is, on considering more what statisticians (and mathematicians) do, rather than on what they know. This change in emphasis is evident from mathematics curricula that list topics such as reasoning, communicating, problem solving, modelling, making connections, and using technology alongside the traditional content topics.

These processes suggest a different view of statistics (and mathematics). Most teachers believe that they are taking on this different approach, but many treat the processes as topics rather than integrating them into the teaching of content. There are probably four reasons contributing to this. Firstly the processes are usually listed separately in the curriculum. Secondly, there is only a limited amount of resource material available and this has not been trialed and personalised by teachers expected to make the changes. Thirdly, the professional development opportunities available to help teachers make the changes are enough for governments to say that they are doing something, but are inadequate in terms of helping teachers make significant changes to how they see their subject and how they teach it. Fourthly, there is the influence of the assessment industry

which seems to be in a behaviourist paradigm that finds it easier to test content topics rather than processes and continues to exert a conservative influence against change.

All of the processes are important and should influence what happens in the classroom, but one in particular, using technology, should be causing a revolution in statistics and mathematics. Computer technology can and is to some extent being used for data sources, to simulate experiments, to provide interesting learning activities, but we have not yet confronted the fact nearly all of the statistical (and mathematical) algorithms that we do in schools can be done with a computer. This means that we need to teach for conceptual understanding rather than emphasise the algorithms and procedures that have filled a large amount of our school programmes. I know there are difficulties with respect to costs and assessment, but we can not ignore the technology that exists.

OTHER CURRICULUM AREAS

Other curriculum areas that involve statistics at high school include science (physics, biology, environmental education, health), business studies (economics and accounting), social studies (geography and history), technology (design, workshop, food technology, materials technology, and technical drawing), and physical education. This links with the process ‘making connections’ and requires us to decide who is responsible for helping students develop the relevant skills. Rouncefield (1991) has written about the need for cooperation and/or coordination, but whether one has a statistics coordinator or not, schools need good communication between subject teachers when this overlap occurs. I favour each subject teaching the statistics required but would hope that the mathematics/ statistics teachers are able to help students see the subject coherently.

AIMS OF EDUCATION

In subject curricula there are always a list of aims underlying the teaching of the subject. Behind this are the more general aims and values of education. These have changed through history from idealistic, to work-related, to moral, and to rational. Now they seem to be the responsibility of curriculum technologists leaving teachers and students with a curriculum whose values have been predetermined and appear to be relatively value-neutral. Some countries have made these general aims specific, for example in New Zealand we have an ‘umbrella’ document called a curriculum framework (Ministry of Education 1993). Within this document are listed some principles (p7) which

include ‘become independent and autonomous learners’, and ‘relate learning to the wider world’; the general aims for mathematics (p11) which include ‘making of models’, ‘interpretation of data’, ‘the recognition and communication of related ideas’, ‘collect, organise and interpret data’; and a set of essential skills (p 17–20) that are the responsibility of all school teachers. Included in these skills are ones relating to communication, numeracy, information, problem-solving, self management, social, cooperative, work and study; and these are obviously relevant to statistics education.

The general aims of education should be explicit and negotiated and there is a need to ensure that all curriculum areas, including statistics, make links with them and that teaching contributes to them. For example: building self esteem implies not emphasising place in class; group work implies less emphasis on individual assessment, a respect for indigenous cultures might imply not imposing a western-European/American curriculum on all schools, developing flexibility and creativity would imply less rote learning, and developing autonomous learning skills would imply a reduction in the amount of external assessment in the senior years of school and more emphasis on self assessment.

My concern in looking at the way a statistics (or mathematics) curriculum is developed at the national, regional or school level is that an assumption is often made to focus on the subject rather than on the students. Hopefully this can be avoided as each subjects responsibilities to the general aims of education are made specific.

LEARNING AND TEACHING

Much has been written about learning and teaching with the constructivist viewpoints seeming to be currently in vogue. Cognitive scientists, neurobiologists, philosophers, psychologists, and educators all have points of view and contribute to the debate. Teachers and school communities need to clarify their ideas about learning and teaching and work towards ensuring that high quality teaching and learning occurs.

There are a number of ways that theory often seem to conflict with beliefs: often the teacher is assumed to be responsible for learning rather than sharing this responsibility with students; often abstract ideas are taught without concern for meaningful contexts thereby making it difficult for students to make a bridge to their own experience; often little notice is taken of what students have learned outside school and bring to the classroom. My hope is that when ‘rich learning activities’ are used in

statistics, not only the content that is expected to emerge will be considered, but also the processes that are inherent in the topics, the students prior knowledge, and the theories and beliefs about learning and teaching.

Associated with learning and teaching is assessment. Gal and Garfield (1997) have written extensively on this. While their book considers real-life problems, statistical understanding, statistical thinking, problem solving, projects, and portfolios, there remain other dimensions such as the linking of the assessment of learning activities not just to the statistical topics and processes, but to the other subjects in the curriculum, to the generic skills, and to the general aims of education.

THE DEVELOPMENT PROCESS

In hoping that changes will be made, I am mindful of the development process which involves a complex web of interacting forces. Development involves curricula (at school and regional levels), it involves professional development where teachers take ownership of new ideas and begin to change their practice in terms of both content and teaching approaches, it involves parental and societal views of both the subject and appropriate pedagogy, and it involves resources and assessment. While many good statistics resources exist, these are not always integrated into mathematics textbooks and internationally many schools are limited to one resource for mathematics. Legislating for changes does not make them happen—change depends on the efforts of professional teachers who are willing to push the interpretations of the curriculum and who, after exploring alternatives, share their findings with colleagues. While not having a national curriculum might allow the leaders to push further, a national curriculum does protect students to some extent, but I do wish there was some room in curricula so that teachers would be encouraged to be more adventuresome with curriculum experimentation.

CONCLUSION

Change will happen -my belief is that we need to chart the future, to set a broad agenda, to consider all the alternatives, to encourage experimentation, to share our findings, and to continue to works towards statistics taking a more predominant place in national and school mathematics curricula.

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