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Editorial

Stochastics Education: Growth, Goals, and Gaps in a Maturing Discipline

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The beginning of the 1990s marked a significant turning point for the teaching of stochastics and the study of stochastics education. The four-year period 1989 to 1992 saw the publication of key curriculum documents, including *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989) in the United States, *A National Statement on Mathematics for Australian Schools* (Australian Education Council, 1991) in Australia, and *Mathematics in the New Zealand Curriculum* (Ministry of Education, 1992) in New Zealand. All three documents explicitly identified statistics and probability as significant components of the mathematics curriculum. Furthermore, topics from within these areas were recognised as being appropriate for a wider age range of students than ever before. This emphasis on chance and data gained even greater impetus as the 1990s progressed, with the increased focus on numeracy and the recognition of the importance of "statistical literacy" within this.

These changes—the increased emphasis on stochastics generally, and the need to identify what is meant by statistical literacy more specifically—made it imperative to gain a better knowledge of the way stochastics is learned and taught. In the past decade there has been growing interest in this area, with research conducted around the world and with significant contributions by Australasian researchers. The publication, due in mid-2004, of the Mathematics Education Research Group of Australasia's four-year review of Australasian mathematics education research contains a chapter (Pfannkuch & Watson, in press) whose reference list of over 100 papers indicates the depth and breadth of research conducted in probability and statistics learning in this region.

It seemed timely, at the beginning of 2003, to take stock of this area of mathematics education, to showcase the growth of research in this area, and to bring the key issues more sharply into focus for the wider mathematics education community. This was particularly important since much of the early research in stochastics education was reported in the statistics education, psychology, and economics literature. Consequently we proposed that a Special Issue of the *Mathematics Education Research Journal* be devoted to this topic. Researchers were invited to make contributions in any aspects of the teaching and learning of stochastics, including statistics, probability, statistical literacy, the role of technology, and socio-cultural aspects. We received a total of 13 submissions, of which five are published here.

There are a number of interesting aspects to this collection. The first is that there is a significant gap: none of the papers considers probability teaching and learning. Although most of the early research in stochastics education was related to probability, today it appears there are fewer researchers in this area in comparison to statistics education. Whether this is related to the perceived difficulty of the topic, to the belief that the interesting problems have been solved, to the rise of Exploratory Data Analysis with its de-emphasis on links to probability, or to a chance outcome of papers accepted for this issue, is difficult to determine. We feel, however, that it is an unfortunate circumstance, as chance understanding is a particularly important area of statistical literacy. We would like to use this editorial to call for increased research related to this topic. The restricted scope of the papers is recognised in our revised title for the collection: a Special Issue on Statistics Education.

On a more positive note it is pleasing to see the move to studying capability and the development of understanding. Many of the earlier approaches to research in stochastics education (see, e.g., Garfield & Ahlgren, 1988; Hope & Kelly, 1983; Kahneman, Slovic, & Tversky, 1982; Mevarech, 1983) focussed on identifying misconceptions and difficulties, and determining where intuition interfered with correct conceptions. In some respects, these were "deficit investigations", examining what students did not understand or could not do. More recently, research has considered the development of understanding, and seen misconceptions in the context of stages in this growth. This view is reflected in the papers in this collection.

The studies also consider a diverse range of students, from upper primary to tertiary level. This may well reflect the fact that statistics is now widely recognised as an important component of the curriculum for all ages. At the primary school level two of the studies examine students' graphical interpretation and representation skills. At the other end of the educational age spectrum, the consideration of conceptual issues for tertiary students in two of the studies is particularly encouraging.

In each of the studies we see an investigation of how students take part in some aspect of a statistical investigation or enquiry. What they are asked to do is to engage in a statistical task and transform it in some way. We are reminded of the term *transnumeration* introduced by Wild and Pfannkuch (1999) in their four-dimensional model of statistical thinking during statistical enquiry. For them the term encompasses changes in representational form that lead from a problem stated in terms of data to some other form that will allow analysis in terms of known statistical techniques. The degree and complexity of transnumeration relates to the statistical experience of the solver and hence the techniques available for use. It is therefore possible to consider aspects of transnumeration across the educational spectrum as represented by the five papers in this issue.

The first two papers deal with students at the middle school level. Aoyama and Stephens consider the responses of students in Grades 5 and 8 to tasks allowing for the extraction of qualitative information from quantitative information, or the creation of new information from that given. The ultimate goal of the transformation process is the creation of dimensionally new information. In tracing students' progress along this pathway, they employ the SOLO Taxonomy as a theoretical model.

Moritz considers a wider age range, with students in his study in Grades 3, 5, 7, and 9. The transformation task he gives students relates to constructing a graph to represent data about temperature change over time. Informed by the SOLO model he develops a four-step hierarchical framework to describe the students' progress in attempting the task. He also discusses the association of performance on this task with that on tasks that begin with a graph and ask for verbal and numerical interpretations.

Based on interviews with students at the transition between secondary and tertiary study, Groth analyses responses to tasks that allow students to design studies that would answer different quantifiable questions. Again the SOLO model is used to structure the sophistication of the response in transforming a question into a plan for research.

At the first year university level, Lipson asks questions about conceptual understanding of statistical inference and finds that an appreciation of the idea of sampling distribution appears to be an important contributing factor in success. Using concept maps, three increasingly sophisticated categories of integrating the sampling distribution into the schema for statistical inference are identified. Whereas conceptual knowledge is associated positively with the schema categories, procedural knowledge does not have the same relationship to them.

Finally, moving to the third year university level, Reid and Petocz examine their own practice with the aim of improving student learning. They report on the integration of their research findings into a course on regression analysis and judge outcomes based on students' conceptions of statistics and of the professional practice of statistics. Judgements of both of these conceptions are based on hierarchical profiles arising from earlier research and students' interpretations of statistical analyses. They hence consider the final stages of the transforming process of a statistical investigation.

It is interesting to note that in all five studies the hierarchical nature of statistical understanding and outcomes is acknowledged as useful. This is not surprising given the complex outcomes expected from statistical investigations; the idea of "right" or "wrong" answers, as might have been coded traditionally in statistics courses, is no longer appropriate. It is essential for teachers to be aware of the intermediate growth that is taking place and encourage students to move from one level to the next. As Reid and Petocz discover, this can be a complex process taking into account many aspects of the classroom context. The acknowledgement of the SOLO model in three of the papers illustrates the staying power of the work of Biggs and Collis (1982). Pegg (2002a, 2002b) has elaborated on its current relevance for assessment and its similarity with other cognitive models used in research.

We hope that this collection provides an impetus for further work in the area of stochastics education. It is pleasing that three of the papers come from younger researchers, which augurs well for the future of the discipline.

In preparing this issue we would like to express our special thanks to the many referees who took time to give careful reviews of the submissions and, in some case, of revised manuscripts. Their considered advice, suggestions, and recommendations were of great assistance to us as editors, and, we believe, to the authors as well. These reviewers and those contributing to the other issues of Volume 15, are acknowledged more formally on page 302.

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Editor's note: As from the next issue (Vol. 16, No. 1) this journal will be edited by Helen Forgasz. Please send all manuscripts and correspondence to <Helen.Forgasz@education.monash.edu.au>.