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TSG

Topic Study
Group 11

TSG 11: Research and development in the teaching and learning of probability and statistics

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Aims and focus

While the teaching and learning of probability has been taking place in the context of mathematics for more than a century, the special challenges it poses when the audience is more broadly defined to include students (and, often, their teachers) at all ages and levels arise most sharply in the context of its application in the field of statistics. Statistics and statistics education are relatively newer disciplines. Statistics has only recently been introduced into the main stream school curricula in many countries. At the university level, there has been a steady increase in the numbers of statistics courses taught to fulfill the growing demand for students and professionals who can use and understand statistical information. Although the amount of statistics instruction at all levels is growing quickly, the research to support statistics instruction is advancing more slowly. The research literature in teaching and learning of probability and statistics is not well known and, hence, not often used. In fact, people working in this field still need to spread its influence – not only to achieve academic recognition, but also to convince others of its usefulness.

Teachers at all levels find that teaching statistics and probability is immensely challenging. Not only are there new developments in and approaches to the subject matter, but also there are opportunities afforded by access to new instructional materials and methods and more advanced educational technology. At the same time, the difficulties that students have in learning statistics and probability pose major problems for teachers. While developments in statistical software and hand calculators have eliminated much of the computational burdens associated with applying statistics and probability, the difficulties posed by the basic worldview inherent in those subjects are just as challenging as ever.

Mindful of these multiple contexts and challenges, we sought to encourage presentations at ICME-10 that would help us grow as professionals involved in this educational effort, that would represent the diversity of the work being done across the globe with students of all ages and contexts, and that advanced our knowledge of the possibilities and challenges facing us as educators. In general, we were successful in all of these goals.

The presentations made for TSG 11 at the meeting in Copenhagen were organized into four sessions:

Session 1: Exemplary work in statistics education

The session began with opening remarks by co-chairs *Joe Wisenbaker* and *Jun Li*, featured an invited address by *Jane Watson*, Australia, and presentations by *Iddo Gal* and *Dani Ben-Zvi*, Israel, and *Susan Starkings*, UK.



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Jane's address provided an overview of much of the work that she has been involved with over the last decade. The work she spoke of, much of it in collaboration with other researchers, included explorations of students' statistical concepts, the products yielded from groups of students working collaboratively, the assessment of teachers' concepts related to statistics and chance, the effect of introducing cognitive conflict into discussions with individual students, students' understanding of variation, and formulating a broader model of statistical literacy. All of her work was presented as ongoing threads of inquiry woven in and around topics critical to the teaching and learning of statistics.

The work presented by Iddo and Dani centered on an examination of the ways that official statistics agencies have explicitly supported statistics education through their websites and a review of the kinds of materials that they have made available. Some part of their work actually revealed instances in which such potentially valuable resources have become more scarce in recent years, perhaps due to funding limitations facing those agencies.

Susan's presentation focused on a collaboration between the United Kingdom's Royal Statistical Society and the National Academy for Gifted and Talented Youth. It explored efforts to encourage some of the brightest and most able students to engage in the study of statistics and to consider careers in the field.

Session 2: Research on reasoning about variation and the use of technology in statistics education

The session featured an invited address by *Mike Shaughnessy*, USA, presentations by *Robert delMas* and *Yan Liu*, USA, *Dor Abrahamson* and *Uri Wilensky*, USA, and a discussion by *Maxine Pfannkuch* and *Dani Ben-Zvi*.

Mike's address centered on the work he and others have been engaged with in terms of students' incorporation of concepts of variability with respect to judgments about representations of distributions of data, both real and contrived. At issue in his work has been the extent and the ways in which students at the secondary level actively talk about variability as they interpret the meaning of distributions of data. This work forms the central theme in his ongoing research program funded by the U.S. National Science Foundation.

The presentation by Robert and Yan focused on students' understanding of factors affecting the value of the standard deviation in a collection of data. It was based on in-depth observations of and interviews with university students enrolled in an introductory course as they worked through a set of tasks based on graphical representations of data distributions that varied in their degree of variation.

Dor and Uri's paper explored the use of a rich, collaborative and interactive computer-based learning environment with which they have been involved for the last five years. It illustrated the ways in which they have exploited that environment and examined students' development of statistical concepts at the elementary level (12-13 year olds).



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Session 3: Teaching statistics from multiple perspectives

The session featured an invited address by *Joan Garfield*, USA, presentations by *Robert Gould* and *Roxy Peck*, USA, *Alejandra Sorto* and *Alexander White*, USA, and a discussion by *Manfred Borovcnik*.

Because of health issues, Joan's presentation was actually delivered by her colleague, *Robert delMas* from detailed notes and discussions with her at the University of Minnesota just prior to ICME. It centered on the use she and her colleagues have made of the Japanese Lesson Study approach in thinking about statistics instruction, its goals for students, and ways in which lessons might be made more effective for them. Rather than using learners as the primary information source, this approach elicits ideas from the perspectives of experienced statistics educators with student feedback in the form of their success (or lack thereof) in learning from the various lessons planned for them.

Alejandra and Alexander's presentation focused on the issues surrounding requirements that mathematics teachers use to teach units in statistics to their students. Although reforms have done much to promote the teaching of statistics across the mathematics curriculum, the simple fact is that many practicing teachers lack the same skills and concepts as their students. They talked about their efforts to assess the content and pedagogical knowledge such teachers bring with them and the kinds of problems such teachers have with that material.

Robert and Roxy's presentation extended those ideas by focusing on their work in creating a new professional development program to help existing secondary mathematics teachers become more effective in teaching statistics. Their presentation illustrated the work they have done, an assessment of its effectiveness, and their plans for further development

Session 4: Exploring issues of reasoning about distribution, data and graphs

The session began with an invited address by *Koeno Gravemeijer*, The Netherlands, presentations by *Yingkang Wu*, Singapore, *Helen Chick*, Australia, *Carlos Monteiro*, Brazil, and *Janet Ainley*, UK, *Maxine Pfannkuch*, *Stephanie Budgett*, *Ross Parsonage* and *Julia Horring*, New Zealand, and closing remarks by *Joe Wisenbaker* and *Jun Li*.

Koeno's address focused on students' development of the concept of data distributions. He described a guided reinvention approach for instruction whereby students, using visualization tools, started with a set of measurement values and moved through ideas of data points and density towards understanding the concept of a density function. He argued that students should start with comparing data sets and that data sets should be tailored towards significant statistical issues.

Yingkang's paper examined Singapore secondary students' understanding of statistical graphs. The work was based on students' performance on a formal assessment of a variety of concepts based on a framework encompassing graphical reading, interpretation, construction and evaluation assessed from the standpoint of final answers and processes employed. It revealed both the level of students' current understanding and suggestions for modifying instruction to improve that understanding.



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Helen's work looked at students (aged 11-13) and how they attempted to represent associational relationships in a set of data using graphs. Students' efforts were seen as clearly indicating some readiness for working with concepts generally not covered till late in high school. Students also differed considerably in the approaches they used suggesting the potential value in having these kinds of topics addressed through explicit instruction even for student as young as these.

Carlos and Janet's presentation focused on primary students' interpretation of graphs especially in the context of what has been termed 'Critical Sense' – the analysis of information beyond the initial assertions made by authors. In looking at the interpretations made by primary school student teachers, they concluded that encouraging a 'Critical Sense' of information will demand explicit efforts to focus students' attention on a wider array of considerations than only those that might be easily tied to material drawn from the context of everyday living.

Finally, the presentation made by Maxine of her work with colleagues in New Zealand examined difficulties encountered by 15-year-old students in interpreting data plots as part of the curriculum. Their work on creating a framework that teachers might use to embed the teaching of such concepts was seen as providing a context more encouraging of students' learning of formal inference.

There were several excellent papers chosen for presentation by distribution. Many of them were directly related to the themes around which we organized our sessions. Some added their own, unique perspective on the issues. Everyone is strongly encouraged to examine the submissions made by *José Carmona*, Spain, *Christine Duller*, Austria, *Sibel Kazak* and *Jere Confrey*, USA, *W. M. Luh*, *J. H. Guo*, China Taipei, and *J. M. Wisenbaker*, USA, *Mike Perry* and *Gary Kader*, USA, *Milo Schield*, USA, and *Ödön Vancsó*, Hungary. These contributions have been posted to the conference web-site on the main page for TSG 11.

The presentations were highly stimulating, generating a wealth of questions and comments that greatly exceeded the limited time available for the formal portion of TSG 11's part of the program. Discussions often spilled out into the hall and carried on with small, informal groups of presenters and attendees. Although no single meeting could possibly achieve all of the goals we had in mind as we organized the sessions, it was highly successful in promoting the discussion of important issues and, we hope, collaboration among the international workers who care so much about the teaching and learning of probability and statistics.

This report was written by Joe Wisenbaker and modified by Jun Li, Maxine Pfannkuch, Dani Ben-Zvi, and Manfred Borovcnik. They are happy to be contacted at wisenbak@bellsouth.net and lijun@math.ecnu.edu.cn respectively, for further information on the work of this TSG.